Energy Vision 2020

EXECUTIVE SUMMARY

Integrated Resource Plan
Environmental Impact Statement

TVA

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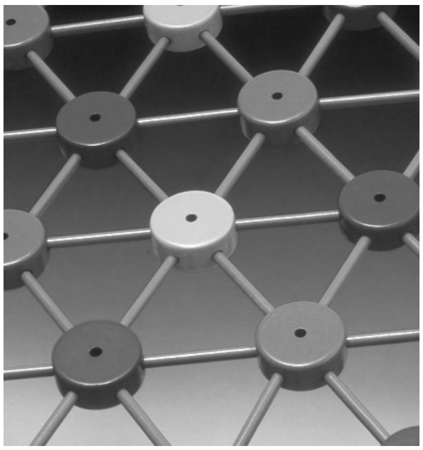
Executive Summary, Energy Vision 2020
Integrated Resource Plan/Environmental Impact Statement



In presenting the action plans of Energy Vision 2020, TVA is again demonstrating that best business practices can be compatible with environmental responsibility—that economic growth and improvements in the quality of life are compatible—and that innovation and creativity are integral to remaining successful in a competitive market.

Introduction to Energy Vision 2020

Energy Vision 2020 is TVA's roadmap for meeting the energy needs of its customers during the next 25 years with economical and environmentally sound energy choices. These are important challenges for TVA, which is the largest single producer of electricity in the United States. With a generating capacity of 28,000 megawatts, TVA provides wholesale power to 160 distributors and directly serves 60 large industrial and federal customers. In partnership with the distributors, the TVA power system serves 7.7 million people in an 80,000-square-mile area that covers parts of seven southeastern states.

TVA is expecting important changes in the relationships between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a competitive marketplace. TVA is at the forefront of this change and welcomes the opportunity for growth and improved service and responsiveness to the needs of its current and new customers. By identifying the best energy choices for current and future consumers, Energy Vision 2020 will guide TVA as it enters this competitive marketplace.

Moreover, Energy Vision 2020 goes beyond the issue of how TVA can provide competitively priced power. The plan also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are the means by which TVA can provide competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

The TVA Board has already taken several strategic actions in part based on information and analyses performed in conjunction with Energy Vision 2020.

These are:

- Reversed TVA policy on nuclear plant construction.
- Placed an internal limit on new capital debt and announced a debt-reduction program.
- Kept TVA's electric rates steady for a ninth consecutive year.
- Introduced TVA to the global energy market through international bond offerings.
- Commissioned a major study to identify strategic actions that will strengthen TVA's position in an open marketplace.

The result of these efforts is that TVA's self-supporting power system is financially strong. TVA's electric power production and operating costs are competitive with utilities in the regional market. The same is true for the electric prices paid by consumers in the TVA service area.

Energy Vision 2020 provides the TVA Board with a flexible energy supply plan that will help guide the strategic actions necessary for TVA to serve its customers efficiently, and to compete and succeed in the electric utility marketplace of the future.

Launched in the winter of 1994, Energy Vision 2020 includes an unprecedented effort by TVA to involve the public in TVA's energy planning process. Environmental, consumer, and energy industry representatives were appointed to a citizen group to provide input on the formulation of the plan, and public meetings were held throughout the TVA service area to gather public comments and suggestions. Interviews were also conducted with elected officials and opinion leaders. The open process produced a stronger partnership with the more than 7.7 million people who use the electricity produced by TVA.

Energy Vision 2020 identified a viable mix of conservation programs and options for power plant operations that will be used to responsibly and economically provide energy for sustainable economic growth. For all resource options, the environmental consequences and economic impacts were considered as part of TVA's effort to encourage sustainable economic growth in the region. Strong public support for various options, such as demand-side management, also was considered.

Overall the key recommendations of Energy Vision 2020 are:

- Invest in up to 3,000 megawatts of flexible purchases of power
- Convert Bellefonte to an alternative fuel source such as natural gas or coal
- Implement up to 1,450 megawatts of energy efficiency and load management
- Research and develop renewable energy resources - wind, biomass, solar photovoltaics

Additional recommendations, which the TVA Board of Directors has asked the staff to include, are:

- Begin additional flexible demand-side management programs with a potential of 750 megawatts
- Investigate the development of a flexible wind project, a biomass refinery, and a combined garbage and biomass energy facility

Because TVA has a unique mission to supply electric power and encourage sustainable economic development in its service region, Energy Vision 2020 has the flexibility to shift priorities as the marketplace evolves and changes influence the viability of power supply options. When changes in energy options are necessary, TVA will remain focused on making economical and environmentally sound energy choices.

Energy Vision 2020: The Report

Energy Vision 2020 is the culmination of more than 24 months of work and research by TVA staff and leading national experts in power planning and the integrated resource planning process. The final plan offers a portfolio of resource options that have met the evaluation criteria established by TVA and TVA's customers and stakeholders.

Resource options identified in Energy Vision 2020 will guide TVA in meeting the demand for energy through the next 25 years.

The recommendations in Energy Vision 2020 are the result of an extensive process to identify and consider all factors necessary to ensure a sound future for TVA and the Tennessee Valley region.

A draft resource plan, Energy Vision 2020, was issued for public review and comment on July 26, 1995. The public comment period closed on October 15, 1995. Following this public review period, TVA produced a final plan and will begin implementing short-term actions that will enable TVA to meet the demand for energy for the near future. These short-term actions will also establish the groundwork for a Long-Term Plan that will serve TVA and the consumers of TVA power through the year 2020.

The Energy Vision 2020 report is a three-volume publication. Volume 1 provides a comprehensive overview of TVA's resource plan and provides information about the issues on which recommendations were based. Volume 2 contains technical documents that provide in-depth information on specific areas of interest. Volume 3 contains TVA's responses to the public comments it received during the draft plan review period.

Resource options identified in Energy Vision 2020 will guide TVA in meeting the demand for energy through the next 25 years.

Those interested in receiving a copy of any of these publications may do so by calling (615) 751-6172 or writing Kathy Heck, Tennessee Valley Authority, MR 3H, 1101 Market Street, Chattanooga, Tennessee 37402.

To better understand the issues involved in the planning process for Energy Vision 2020, one must first be aware of TVA's current situation and existing resources and the proposed changes in the utility industry.

An Overview of TVA Today

TVA is one of the largest producers of electricity in the United States, generating 4 to 5 percent of all the electricity in the nation. Some 7.7 million people in a 7-state region depend on the power provided by TVA.

TVA's power system includes 5 nuclear generating units, 11 coal-fired plants, 29 hydroelectric dams, 48 combustion turbine units, and 1 pumped-storage facility. The system is linked by approximately 16,000 miles of transmission lines throughout the 7-state region. TVA's electric system is self-financed, as are other electric utilities, and receives no subsidies from the federal government.

With its low average utility rates, TVA ranks 30th in a comparison of 130 utilities in the nation. TVA's rates have remained constant since 1987 because of improved productivity and efficiency.

Operating revenues were $5.4 billion for fiscal year 1994, with net income for 1994 of $151 million. Total energy generated was 134 billion kilowatt-hours for 1994, an increase of 3.4 percent over 1993.

TVA's power system serves about 8 million people in a 7-state region encompassing some 80,000 square miles.

The size of TVA's power system and its influence on the Tennessee Valley's economy make integrated resource planning especially important. The decisions TVA makes today will have a significant impact on tomorrow's quality of life for millions of residents of the Valley, as well as on the competitive success of area business and industry.

FIGURE 1. **TVA's Power System**

Changes in the Utility Industry

A second factor affecting the development of Energy Vision 2020 is the tremendous amount of change occurring in the utility industry. Historically, TVA and regulated electric utilities have had well-defined, protected markets or service areas. Utilities have controlled their transmission systems, choosing whose power they purchase for resale, whose power they will transport or "wheel" through their service areas, and how much they will charge for wheeling. All that is changing.

TVA's low average utility rates rank it 30th in a comparison of 130 utilities in the nation. TVA's rates have remained constant since 1987 because of improved productivity and efficiency. The size of TVA's power system and its influence on the Tennessee Valley's economy make integrated resource planning especially important. The decisions TVA makes today will have a significant impact on tomorrow's quality of life for millions of Valley residents, as well as on the competitive success of area business and industry.

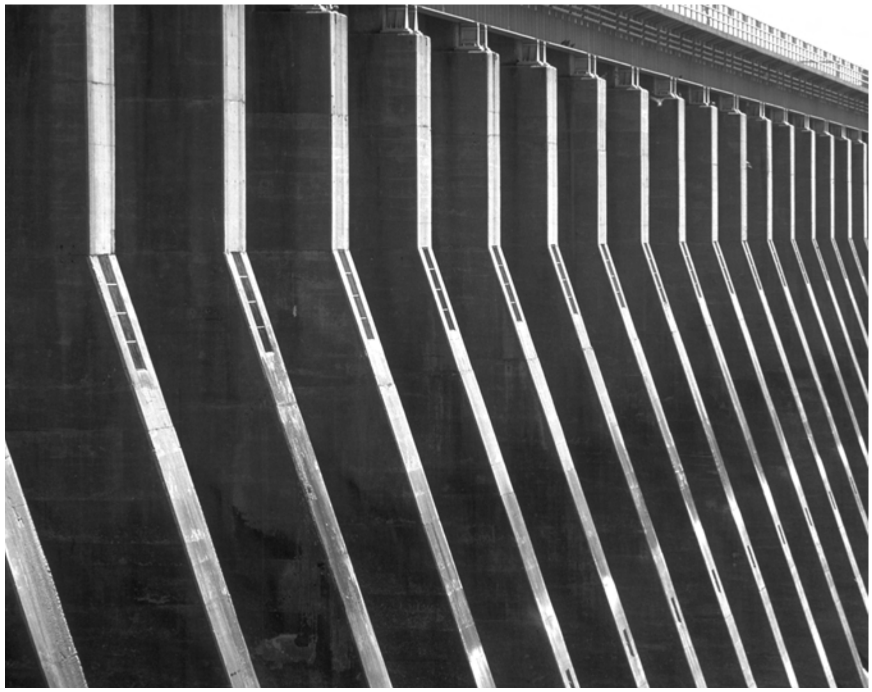
OPEN ACCESS

The National Energy Policy Act of 1992 and related Federal Energy Regulatory Commission regulations introduced the concept of open access, a dramatic change for the industry. Open access provides wholesale customers and suppliers access to virtually all of the nation's transmission systems. With open access, competing utilities can better use existing generating facilities, bring more cost-effective options to the market, and provide electric utilities and their customers with more competitive choices.

THE FENCE

The potential impact of open access on TVA is heavily influenced by the "fence" surrounding TVA's power service area. In 1959, Congress amended the TVA Act to allow TVA to use power revenues to finance future expansion of generation and transmission facilities. Although the amendment passed, investor-owned electric utilities feared competition from TVA. To allay those fears, Congress limited TVA's market to its current service area. This border around TVA's market is called the "fence."

The "fence" essentially restricts the area in which TVA can sell power, but permits TVA to sell power to utilities with which it was interconnected in 1957.



Because TVA is prevented by this one-way fence from generally selling power outside its existing service area, open access could enable other utilities to come into TVA's area to serve customers, but prohibit TVA from offering service to their customers.

TVA'S POSITION IN A COMPETITIVE ENVIRONMENT

TVA realizes that many of its customers may want the choice of shopping for energy services in a competitive marketplace. To examine this situation, TVA commissioned a study of its competitive condition, called "The Ties That Bind: TVA in a Competitive Electric Market." This study recommends eliminating the "fence" to allow TVA to enter the emerging competitive environment on an equal footing with other suppliers.

Resource Integration Process

The recommendations in Energy Vision 2020 are the result of an extensive process to identify and consider all factors necessary to ensure a sound future for TVA and the Tennessee Valley region.

TVA, unlike almost any other electric utility in the nation, has a broad mission that includes the continued development of the TVA region. Providing a reliable and economical supply of energy is certainly primary to this development, but other considerations also come into play. The strong bond between TVA

and its customers and stakeholders means that TVA carefully considers any effects that its actions may have on the environment, the economy, and the quality of life for the millions of people who make their home in the Tennessee Valley.

TVA, unlike almost any other electric utility in the nation, has a broad mission that includes the continued development of the TVA region.

With these considerations in mind, TVA developed a five-step process:

1. Public involvement to identify stakeholder issues and concerns
2. Development of evaluation criteria and related measurements to ensure that these issues and concerns were considered
3. Identification of all possible resource options to meet consumer energy needs
4. Evaluation of key uncertainties about future conditions that could influence the use of various energy resource options
5. Design of numerous strategies for ultimate evaluation

A complete description of the integrated resource planning process is given in Energy Vision 2020, Volume 1.

The public participation process used in the development of Energy Vision 2020 was of special importance to TVA because of TVA's commitment to be customer focused and sensitive to the needs and values of its stakeholders. TVA sought to incorporate a broad base of public input in the planning process.

PUBLIC PARTICIPATION

During the first phase of public participation, TVA used four techniques to gain broad public input: interviews with opinion leaders, a series of 12 public meetings throughout the TVA region, a stakeholders' review group, and opportunities for the public to submit written comments. In each case, the goal was the same: to encourage people to share their views on issues they believe should be important to TVA as it plans for future energy needs.

TVA is well positioned to enter the competitive market, and Energy Vision 2020 will guide TVA in making business decisions to meet the long-term energy needs of our customers.

Of special interest was the stakeholders' review group. The Energy Vision 2020 Review Group was formed to provide TVA with in-depth, ongoing input as the plan progressed. Group participants represented business and industry, distributors of TVA power, minority businesses, environmental organizations, state agencies, academia, and civic organizations.

As a result of this initial public participation process, about 600 written comments were received, for a total of more than 1,300 oral and written comments from approximately 375 individuals and organizations. These comments were used by TVA to better define the full scope of its plan. Major issues identified through the first phase included concerns about TVA's debt, the nuclear program, the ability to remain competitive, and the privatization of TVA. Other

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comments focused on the use of specific energy resource options such as renewable energy sources.

The second phase provided an opportunity for the public to comment on the draft resource plan, Energy Vision 2020, which was issued on July 26, 1995. In addition to accepting written comments, TVA held nine public meetings throughout the Tennessee Valley, so that the public could present their views on the draft plan. Over 250 people or organizations made 2,000 comments. The public comments and TVA's responses are in Volume 3 of Energy Vision 2020.

PUBLIC INPUT GUIDED TVA

TVA developed 42 evaluation criteria, or measurements, to reflect the values of the public expressed during the first phase, as well as TVA's goals and objectives.

Potential resource options were measured against these criteria, which included impact on rates, TVA's debt, the environment, and other concerns voiced by the public. The resource options determined to best meet these evaluation criteria were included in a portfolio of resource options.

These resource options were also analyzed to determine how well they would perform under a variety of uncertainties that could occur in the future. For example, low load growth, significant increases in the price of natural gas (a fuel source for several resource options), or more stringent environmental regulations, would make particular resource options more or less attractive.

Because of these uncertainties, options recommended in TVA's Long-Term Plan had to be proven to be robust, meaning that they would work well under a variety of possible future situations; or flexible, to allow TVA to easily and economically modify its resource mix as necessary.

From information gained during the initial review and analysis of various resource options, TVA identified workable strategies to guide its future energy resource choices.

The public's comments on the draft plan were generally spread over a number of different issues. A number of the commenters concentrated on three issues: the viability of Watts Bar Nuclear Plant Unit 1 as a current and future resource choice; the need for implementing more demand-side management options; and the need for a stronger commitment to developing renewable resources, (e.g., solar, biomass).

When appropriate, Energy Vision 2020 was changed, and TVA's responses to these issues and other public comments are provided in Volume 3 of Energy Vision 2020.

FIGURE 2. Long-Term Plan

This long-term plan is defined to meet key objectives. The plan is organized by supply-side options for the short term (1996 – 2005) and the long term (2006 – 2020), customer service options and actions which hedge key uncertainties.

Develop a preferred portfolio of resource options for the long term from key strategies. Objectives of the portfolio are:

1. Balance costs, rates, environment, debt, and economic development.
2. Provide a robust set of resource options or flexibility to adapt to uncertain load growth, future market prices, changes in environmental regulations, and changes in market regulations to manage risk.

Strategies

- J – Bellefonte Coproduct, Renewables, IPPs
- M – Combined DSM and Off-System Sales
- O – Bellefonte Coproduct, More DSM, More Off-System Sales
- Q – Flexible Strategy with External Options
- R – Flexible Strategy with Internal Options
- S – Low Cost, Low Rates, Improved Environment
- T – Low-Cost Renewables, Low-Price DSM, Repowering, Bellefonte Coproduct Partnership

Options		1996 –2005	2006 –2020
Supply	Peaking	• Combustion turbines, purchases of peak power, and call options on peaking power	• Compressed air energy storage (CAES)
	Base Load	• Call options on base-load power • Improvements to existing hydro system • Combined cycle with pre-siting and engineering • Purchases from independent power producers with and without cogeneration • Combined cycle repowering of coal-fired plants • Renewables—landfill methane and refuse-derived fuel • Coalbed methane • Bellefonte coal gasification and coproducts with partners • Additional coal unit at Shawnee • Improvements in existing system • Nuclear partnership	• Wind turbines • Coal refinery • Cascaded humidified advanced turbine (CHAT) • Integrated gasification combined cycle (IGCC) • Integrated gasification with CHAT (IGCHAT)
Customer Service		• DSM—low price and cost (examples of programs)	• Residential new construction • Commercial and industrial comprehensive finance • Industrial motors
		• Beneficial Electrification (examples of programs)	• Residential heating, air conditioning, and water heating • Commercial cooking • Industrial electrotechnologies
		• Flexible DSM and Beneficial Electrification	
Environmental		• Pursue a flexible strategy of fuel switches, scrubbers • Global climate challenge—improvements to existing system, biomass cofiring	

RESOURCE ALTERNATIVES TO MANAGE RISK

Uncertainty	Options
• Load Growth	• Call options on purchases from external suppliers • Flexible internal supply options • Small modular options—landfill methane, coalbed methane, and distributed resource alternatives • Flexible DSM options
• Natural Gas Prices/Coproduct Prices	• Integrated gasification combined cycle (IGCC) • Integrated gasification cascaded humidified advanced turbine (IGCHAT) • Bellefonte coal gasification with a chemical coproduct
• Environmental Regulation—Air, Water, CO_2 Regulation	• Renewables—wind, landfill methane, biomass • Coalbed methane • Aggressive DSM and beneficial electrification • Natural gas-based resource alternatives

Long-Term Plan

For the long term, TVA will use a portfolio of resource options that were derived from the best strategies identified during the evaluation process. This portfolio will give TVA the flexibility it needs to respond to the uncertainties of the future. The options have been determined to meet customer needs by balancing cost, rates, reliability, debt, environmental concerns, equity among rate classes, and economic development, while also managing risk.

TVA will need approximately 10,000 megawatts of additional power supply by the year 2010 to meet the Valley's needs. Resource options that may be added to TVA's existing power supply system include:

- Supply-Side Options, which could include exercising call options (the right to purchase power at a set price at some time in the future); purchases of power from independent power producers; looking at new and innovative approaches such as renewable power sources; and partnering to convert the unfinished Bellefonte Nuclear Plant into a coal gasification plant with coproducts that could be sold to supplement power revenues
- Customer Service Options, including demand-side management and beneficial electrification could provide up to 2,200 megawatts, or 22 percent of additional capacity by 2010
- Environmental Controls, including fuel switching and the use of scrubbers at TVA's coal-fired plants to further reduce the emission of sulfur and other pollutants

In addition, other supply-side options are projected to be viable for TVA for the years 2006 to 2020. These include a coal refinery, wind turbines, and advanced coal technologies such as coal gasification.

The Long-Term Plan meets customer needs by balancing costs, rates, debt, environmental concerns, and economic development, and also manages risk.

The Short-Term Plan emphasizes those resource options that minimize risk.

Short-Term Actions

The Short-Term Plan is based on the Long-Term Plan and describes the specific actions TVA will undertake to meet customer needs through the year 2002. TVA estimates it will need an additional 3,500 megawatts of capacity to meet the Valley's energy needs during that period. The Short-Term Plan emphasizes those resource options which minimize the risk associated with uncertain load growth and other key uncertainties.

One of the key recommendations in the short-term action plan is that TVA will not, by itself, complete Bellefonte Nuclear Plant Units 1 and 2, Watts Bar Nuclear Plant Unit 2, or restore Browns Ferry Nuclear Plant Unit 1 as nuclear plants. By eliminating the large capital outlays on nuclear plants, TVA will be able to better manage its debt and be more competitive.

For the foreseeable future, Browns Ferry Unit 1 and Watts Bar Unit 2 would continue in an inoperative or deferred status. TVA will keep open alternatives such as completing the units as nuclear through partnering arrangements, converting the units to another technology, or replacing the units with different types of supply and demand-side resource options.

For the Bellefonte Nuclear Plant, converting the unfinished plant to a combined cycle plant that uses either natural gas or gasified coal as the primary fuel has been identified as one of the most viable alternatives. (A coal gasification plant converts coal into a gas that can be used to generate power and make chemical products, such as methanol.) An effort is underway to demonstrate integrated gasification combined cycle technology at Bellefonte through the use of Department of Energy funding under the Clean Coal Technology program. TVA will work with a team of outside, independent experts to develop the Bellefonte conversion plan over the next 18 to 24 months. TVA will continue to be recep-

tive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities in partnership with TVA.

Other short-term actions in the plan include:

- Buying call options—options for TVA to buy power from a seller at a given price at some specified time in the future—that would permit TVA to purchase up to 3,000 megawatts of power from outside sources to meet base-load and peak demand between 1998 and 2002. (This option permits TVA to plan for uncertain load growth. TVA would buy the power only if it is cost effective)
- Investment in siting and pre-engineering work for combustion turbines or other facilities using different technologies
- Continued modernization of TVA's hydro plants, which would add about 100 megawatts to the existing capacity
- Implementation of cost-effective biomass cofiring (using two types of fuel at a generating plant simultaneously such as a combination of coal and wood waste products, commonly sawdust)
- Implementing three types of customer-service options—demand-side management, beneficial electrification, and the sale of power to utilities and others currently outside the TVA power system

Demand-Side Management is a key element of Energy Vision 2020.

FIGURE 3. **Short-Term Action Plan**

Short-Term Actions—Supply-Side	Milestones
Purchase Call Options	
• Base-Load Coverage - 2001–2002	Implement up to 3,000 MW
• Winter and Summer Peaking Coverage - 1998–2002	
Hydro Modernization Projects	
• Invest in hydro modernization projects between 1996–2007	Achieve 150 MW
Bellefonte Nuclear Plant Conversion to Combined Cycle Plant	
• Converting the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel has been identified as one of the most viable alternatives. Such an alternative provides the opportunity to utilize a substantial portion of the Bellefonte non-nuclear plant equipment. However, there is a degree of uncertainty and market risk associated with this alternative which requires further in-depth engineering and financial examination. Accordingly, TVA will use an outside, independent team of technical and financial experts to assess and develop the Bellefonte conversion strategy more fully over the next 18 to 24 months. During the course of the study, TVA will also pursue the evaluation and development of a demonstration gasification plant with the Department of Energy. In the meantime, the Bellefonte plant and Watts Bar Nuclear Plant Unit 2 will continue in a deferred status. TVA will continue to be receptive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities in partnership with TVA.	18–24 month study
• Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.	
Renewables	
• Implement cost-effective biomass cofiring	
- Cofiring precommercial demonstration runs at existing TVA coal-fired plants	1996
- Initiate first commercial wood waste cofiring project operation	1997
• Investigate biomass energy facilities	1996–97
• Implement a flexible wind project	1996–97
• Determine coalbed methane resources feasibility	1996–97
• Inventory sites suitable for landfill methane	1996
• Initiate 25-kW landfill methane fuel cells pilot	1997–98
Additional Capacity Development	
• Acquire three sites and develop preliminary engineering modules suitable for coproduction, combined cycle, combustion turbines, cascaded humidified advanced turbines, and compressed air energy storage	1996–1998
• Investigate cogeneration and other unique energy supply arrangements	1996
Implement a Flexible Phase II Acid Rain Strategy	
• Strategy/Plan Definition	1996
• Initiate early implementation options	1996–97

FIGURE 3. **Short-Term Action Plan** *CONTINUED*

Short-Term Actions—Customer Services	Milestones
DEMAND-SIDE SAVINGS	Up to 650 MW - 2002, Up to 2,200 MW - 2010
Residential	
Full Scale Programs	Revisions in Place
• Heat Pump Leasing / Financing	1996–97
• Ground Source Heat Pump Leasing	1996–97
• New Homes Program	1996–97
• Manufactured Housing - New Construction	1996–97
• Residential Self-Audit	Launch 1996–97
• Load Management	Revisions in Place
- Air Conditioners	1996–97
- Water Heaters	1996–97
Flexible Residential Demand-Side Programs for Selected Market Segments	Launch Phase 1
• Efficiency Products Catalog - Mail Order	1997
• Lighting Products Retail Component	1997
• Low Income Program - Site Visit	1997
• Student Self-Audit - Schools Environmental	1997
• Heat Pump Water Heater Initiative	1997
Commercial and Industrial	
Full Scale Programs	Launch 1996–97
• Commercial and Industrial Energy Services	1996–97
- Comprehensive Measures Financing	1996–97
- Commercial New Construction	1996–97
- Commercial Lighting	1996–97
- Commercial Appliances	1996–97
- Industrial Process Energy Efficiency	1996–97
- Industrial High Efficiency Motors	1996–97
• Commercial Cool Storage	1996–97
Flexible Commercial and Industrial Programs	Launch Phase 1
• Commercial Group Load Curtailment	1997
• Commercial Rooftop Cool Storage Program	1997
BENEFICIAL ELECTRIFICATION	
Residential	
• HVAC and Water Heating applications to improve consumer value	1996–97
• Initiate Flexible Security Lighting and Lawn Mower Programs	Launch 1997
Commercial and Industrial	
• Commercial Space Conditioning and Water Heating	Launch 1996–97
• Commercial Cooking and Security Lighting	Launch 1996–97
• Industrial Electrification Programs for Processing Heating, Food Processing, and Environmental Technologies	Launch 1996–97
• Flexible Industrial Electrification Options for Curing & Drying applications and Textile processes	Launch Phase 1 - 1997
General Research and Development	
• Develop telecommunication supported demand-side management programs	Launch 1996
• End-use renewables, market transformation, load management new technologies, targeted distributed generation, photovoltaics, electric vehicles	Launch 1996–97

Demand-side management options would add up to 650 megawatts by 2002 and potentially 2,200 megawatts by 2010. This would include for immediate implementation the expansion of some of TVA's current programs, such as the *energy right* heat pump program and the *energy right* new homes and manufactured homes programs. It would also include new programs for commercial customers such as cool storage, a technology that allows a cooling source, such as ice, to be produced and stored for space cooling, and financing programs to assist customers in making energy efficiency improvements. TVA will also begin several flexible demand-side management programs. These programs will include a low income program, heat pump water heater program, and several programs in the commercial sector.

New technologies provide the means to maintain competitive rates, improve the environment, and increase economic development.

Beneficial electrification options offer customers opportunities to improve energy efficiency and to reduce energy costs. In the short term, TVA will consider programs such as residential and commercial heating and air conditioning (primarily the use of various types of electric heat pumps) and industrial electrotechnologies (providing technical assistance and financing programs that would allow industrial customers the opportunity to improve productivity and efficiency through the use of improved or new electric processing equipment).

TVA plans to continue to sell power off-system when market conditions make such sales beneficial to TVA and its existing customers.

Implementation of the short-term actions would begin in 1996, enabling TVA to meet the demand for energy in the near future while laying the groundwork for TVA's Long-Term Plan.

Concurrent with the short-term actions outlined above, TVA also proposes that research and development programs be put into place to evaluate emerging new technologies that show promise for the future. Such projects would include:

1. Developing new capacity using such technologies as cascaded humidified advanced turbines, distributed generation, and fuel cells. An explanation of these technologies is given below.
   - A cascaded humidified advanced turbine is a gas turbine with a unique configuration that allows the unit to have efficiencies similar to a conventional combined cycle plant (a type of plant that generates electricity first from the heat produced by burning gas and then again from heat extracted from exhaust steam), but without the addition of a steam turbine and associated equipment. The cascaded humidified advanced turbine should have a capital cost somewhat less than for a combined cycle installation of similar generating capacity.
   - Distributed generation refers to the location of smaller-scale power generating units near the power consumer. Examples would be gas turbines or diesel generators located in power transmission substations or installed adjacent to large industrial or commercial power consumers. The close proximity of the power generator to the power user significantly reduces the losses associated with the transmission of power.
   - Fuel cells are devices similar to batteries, except they are capable of generating power rather than simply storing power. A fuel and a form of air or oxygen are consumed in the cell by a chemical reaction that creates electricity.

2. Developing renewable energy options to include investigations and research into the possibility of using wind resources, landfill methane, coalbed methane, and biomass energy projects.
   - Large wind turbines (windmills) have the potential to be a viable generation source, subject to the availability of wind at speeds and durations capable of supporting this type of generating equipment. Short-term actions by TVA will include a flexible wind project at a selected site in the TVA service area. The first phase will determine the potential for this technology.
   - Methane (gas) from sanitary landfills offers another possible option as an innovative fuel source. Landfills are filled with organic waste material and sealed (covered) in such a way that air cannot gain admittance to the material. As the material decomposes, methane is produced. The methane can be collected by a series of wells drilled into the waste layers. Once collected, the methane can be used as a fuel by conventional power generation equipment such as internal combustion engines, gas turbines, or fuel cells.

Renewable energy resources include wind turbines, photovoltaics, and landfill methane.

- Coalbed methane is produced in the same way as methane from a landfill. As the organic material in the coalbed decomposes to form coal, methane is produced as a byproduct. The methane can be collected from the coalbed prior to opening the coal seam for mining by a series of wells drilled into the seam. Like landfill methane, this gas can be used as a fuel in conventional power generation equipment.
- The biomass energy facilities include a biorefinery that uses refuse-derived fuel, wood waste, and energy crops, and a combined garbage and biomass energy plant.

3. Conduct research and development for demand-side management and beneficial electrification. Some examples include research and development efforts to explore new load management technologies, the use of photovoltaics (to collect solar energy), and the use of electric vehicles. Photovoltaics is a technology that converts solar energy into electricity. TVA will investigate the use of photovoltaics for end-use applications at remote sites where electricity is not readily available.
4. Investigate cogeneration and other unique energy supply arrangements.

TVA will pilot several demand-side management programs such as new load management technologies, energy-efficient products, and the use of electric vehicles.

Summary

Throughout its 62-year history, TVA has conducted its business in a unique way—demonstrating flexibility and initiative similar to that of private enterprise and protecting the environment and natural resources as would a government body. TVA has accomplished these objectives through innovative approaches in meeting the demand for energy and exploring and testing new technologies that provide environmental benefits to the region and the nation.

In presenting the action plans of Energy Vision 2020, TVA is again demonstrating that best business practices can be compatible with environmental responsibility—that economic growth and improvements in the quality of life are compatible—and that innovation and creativity are integral to remaining successful in a competitive market.

Printed on recycled paper.
12/95

Energy Vision 2020

VOLUME ONE

Integrated Resource Plan
Environmental Impact Statement

TVA

Energy Vision 2020

VOLUME ONE

Integrated Resource Plan Environmental Impact Statement

Tennessee Valley Authority
December 1995

Energy Vision 2020—An Integrated Resource Plan and Programmatic Environmental Impact Statement

( ) Draft (**X**) Final Environmental Impact Statement

Responsible Federal Agency: Tennessee Valley Authority (TVA)

Proposed Action: In Energy Vision 2020 TVA has identified and proposes to select a long-range strategy that will enable TVA to meet the additional needs of its customers for electricity from 1996 to 2020. TVA has identified a portfolio of energy resource options from seven alternative strategies that best meet TVA's evaluation criteria regarding costs, rates, environmental impacts, debt, and economic development while meeting customer energy needs. The plan is designed to be flexible to protect TVA and its customers from the uncertainties that the electric utility industry and TVA will face in the future.

Existing TVA generating plants would continue to be the backbone of its power supply system for the planning period (1996-2020). Additional needs would be met by the following actions:

Long-Term Actions: TVA's portfolio of new generation (supply-side) options includes combustion turbines, power purchases, and "call" options for peaking power to meet peaking power requirements for 1996-2005. Compressed air energy storage would be added to the portfolio to meet additional peaking power needs in the 2006-2020 timeframe.

Nine options could supply base-load power for 1996-2005. These include call options on base-load power, improvements to the existing hydro system, siting and engineering for a combined cycle plant, purchases from independent power producers, combined cycle repowering of existing coal-fired plants, renewables (landfill methane, refuse-derived fuel, and coalbed methane), conversion of Bellefonte Nuclear Plant to a coal gasification with coproducts facility, and an additional coal-fired unit at Shawnee Fossil Plant. Base-load power for 2005-2020 could be supplied by wind turbines, a coal refinery, cascaded humidified advanced turbine (CHAT), an integrated gasification combined cycle plant (IGCC), and integrated gasification with CHAT.

TVA would also use demand-side management (DSM) and beneficial electrification options to meet customer and TVA system requirements. Demand-side management options include energy efficiency improvements, residential new construction programs, and commercial and industrial DSM finance plans. Beneficial electrification includes residential heating, air conditioning, and water heater programs; commercial cooking programs; and industrial electrotechnology programs.

Short-Term Actions: The primary focus for the short-term is flexibility. TVA would buy "call" options, including base load in 2001-2002 and peaking for winter and summer in 1998-2002. TVA would not complete by itself three nuclear units (Bellefonte Units 1 & 2, Watts Bar Unit 2), or restart Browns Ferry Unit 1. TVA would convert the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel. Additional evaluation would then be done to determine the best approach for further development at Bellefonte. DSM programs would be expanded to save up to 2,200 megawatts by 2010. Research and development actions would be taken by TVA to support the timely development of other supply-side and customer service options defined in the long-term plan.

Jurisdictions Affected by Proposed Action: Primarily the TVA power service area that includes almost all of the state of Tennessee and parts of Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia.

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Technical documents that provide more in-depth information on specific areas of interest are found in Volume 2 of this set:

- Technical Document 1, Comprehensive Affected Environment
- Technical Document 2, Environmental Consequences
- Technical Document 3, Existing Power System
- Technical Document 4, Evaluation Criteria
- Technical Document 5, Load Forecast
- Technical Document 6, Supply-Side Options
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Responses to public comments on the draft Energy Vision 2020 published on July 26, 1995, are found in Volume 3 of this set.

Energy Vision 2020 — Summary

Purpose of and Need for Action

Energy Vision 2020 is TVA's roadmap for meeting the energy needs of its customers during the next 25 years with economical and environmentally sound energy choices. These are important challenges for TVA, which is the largest single producer of electricity in the United States. With a generating capacity of 28,000 megawatts, TVA provides wholesale power to 160 distributors and directly serves 60 large industrial and federal customers. In partnership with the distributors, the TVA power system serves 7.7 million people in an 80,000-square-mile area that covers parts of seven southeastern states.

TVA is expecting important changes in the relationships between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a competitive marketplace. TVA is at the forefront of this change and welcomes the opportunity for growth and improved service and responsiveness to the needs of its current and new customers. By identifying the best energy choices for current and future consumers, Energy Vision 2020 will guide TVA as it enters this competitive marketplace.

Moreover, Energy Vision 2020 goes beyond the issue of how TVA can provide competitively priced power. The plan also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are the means by which TVA can provide competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

The TVA Board has already taken several strategic actions in part based on information and analyses performed in conjunction with Energy Vision 2020. These are:

- Reversed TVA policy on nuclear plant construction.
- Placed an internal limit on new capital debt and announced a debt reduction program.
- Kept TVA's electric rates steady for a ninth consecutive year.
- Introduced TVA to the global energy market through international bond offerings.
- Commissioned a major study to identify strategic actions that will strengthen TVA's position in an open marketplace.

The result of these efforts is that TVA's self-supporting power system is financially strong. TVA's electric power production and operating costs are competitive with utilities in the regional market. The same is true for the electric prices paid by consumers in the TVA service area.

Energy Vision 2020 provides the TVA Board with a flexible energy supply plan that will help guide the strategic actions necessary for TVA to serve its customers efficiently, and to compete and succeed in the electric utility marketplace of the future.

Launched in the winter of 1994, Energy Vision 2020 includes an unprecedented effort by TVA to involve the public in TVA's energy planning process. Environmental, consumer, and energy industry representatives were appointed to a citizen group to provide input on the formulation of the plan, and public meetings were held throughout the TVA service area to gather public comments and suggestions. Interviews were also conducted with elected officials and opinion leaders. The open process produced a stronger partnership with the more than 7.7 million people who use the electricity produced by TVA.

Energy Vision 2020 identified a viable mix of conservation programs and options for power plant operations that will be used to responsibly and economically provide energy for sustainable economic growth. For all resource options, the environmental consequences and economic impacts were considered as part of TVA's effort to encourage sustainable economic growth in the region. Strong public support for various options, such as demand-side management, also was considered.

Overall the key recommendations of Energy Vision 2020 are:

- Invest in up to 3,000 megawatts of flexible purchases of power
- Convert Bellefonte to an alternative fuel source such as natural gas or coal
- Implement up to 1,450 megawatts of energy efficiency and load management
- Research and develop renewable energy resources—wind, biomass, solar photovoltaics

Additional recommendations, which the TVA Board of Directors has asked the staff to include, are:

- Begin additional flexible demand-side management programs with a potential of 750 megawatts
- Investigate the development of a flexible wind project, a biomass refinery, and a combined garbage and biomass energy facility

Because TVA has a unique mission to supply electric power and encourage sustainable economic development in its service region, Energy Vision 2020 has the flexibility to shift priorities as the marketplace evolves and changes influence the viability of power supply options. When changes in energy options are necessary, TVA will remain focused on making economical and environmentally sound energy choices.

ENERGY VISION 2020

The purpose of TVA's Energy Vision 2020 is to identify, with extensive public involvement, long- and short-term actions TVA can take to provide flexible, competitive energy choices. TVA has used the best industry practices in integrated resource planning, which include looking at a broad range of sup-

ply-side and customer service options, using multiple evaluation criteria, considering future uncertainties, and seeking public input. Energy Vision 2020 also includes a programmatic environmental impact statement on the proposed alternative strategies.

Through Energy Vision 2020, TVA developed a comprehensive evaluation system that reflects TVA's goals and objectives, as well as the concerns and values of the public. The evaluation criteria that were used to compare energy resource strategies include:

- Long-Run Cost and Value Criteria
- Short- and Mid-Term Rates
- Reliability
- Environment
- Economic Development
- Financial Requirements
- Risk Management
- Equity Among Rate Classes

These criteria and associated measures became the quantitative basis for ranking supply-side and customer service options. They were later used in the multi-attribute trade-off analysis to evaluate and improve TVA's strategies. Using the multi-attribute trade-off analysis allowed TVA's planners to improve strategies to mitigate potential adverse impacts on the evaluation criteria.

NEED FOR ADDITIONAL POWER

TVA's existing power system currently provides 25,600 megawatts of dependable generating capacity, consisting of 57 percent coal plants, 16 percent hydro facilities, 13 percent nuclear, 8 percent combustion turbines, and 6 percent pumped storage-hydro. TVA will add two nuclear units in (Watts Bar Unit 1 and Browns Ferry Unit 3) in 1996, which will bring the total generating capacity to 28,000 megawatts.

TVA's existing coal-fired plants will continue to provide the largest part of TVA's generating supply during the Energy Vision 2020 planning period. Although the 1990 Clean Air Act Amendments imposed significant requirements on utilities, TVA has taken the necessary actions to meet or exceed these requirements. TVA operates 16,000 miles of transmission lines, which carry power from 42 generating sites to 750 wholesale delivery points. TVA also connects with 13 neighboring utilities at 57 different locations.

In 1994, TVA sold 123 billion kilowatt-hours of electricity—84 percent was sold to distributors at wholesale rates, with the balance retailed to directly served industrial and federal customers. The total revenue from these sales was 5.4 billion dollars.

The need for additional power is based on an analysis of the ability of TVA's existing power facilities to meet the projected electricity needs of its customers in the future. The need for power varies from season to season, day to day, and even minute to minute. Thus, TVA developed two types of power needs forecasts—one for annual system peak load (the maximum single-event demand)

and one for annual system energy requirements. To deal with uncertainty in forecasting, TVA developed a range of forecasts—high, medium, and low.

TVA has determined that in order to meet the medium load forecast it will need an additional 800 megawatts by 1998 and an additional 16,500 megawatts by 2020. Based on the high load forecast, additional capacity will be needed by 1997 and will continue to increase after that. Under the low load forecast, TVA will not need additional capacity during the period 1996 out through 2020.

Alternative Strategies

TVA created an extensive list of generating options to meet new peaking, intermediate, base-load, and storage power supply needs through the year 2020. These included traditional technologies (i.e., coal plants, combustion turbines), as well as potential renewable and advanced combustion facilities. In addition, TVA identified options that would give TVA greater flexibility in its planning. These included purchasing competitively priced power from other suppliers (i.e., independent power producers, cogenerators), buying options on future power delivery, and entering business partnering arrangements. Overall, TVA characterized and considered over 100 supply-side resource options based on their performance, cost, and environmental impacts.

Energy Vision 2020 also considered the actions that end-use customers can take on their side of the electric meter to obtain energy efficiencies and improve their productivity and quality of life. Customer service options also include load management actions that reduce TVA's need for power during periods of high demand.

TVA considered over 60 customer service options, which included traditional demand-side management (i.e., energy efficiency and load management), self-generation, beneficial electrification, and rate options. TVA has included the existing and emerging technology and electric rate options into a variety of program packages to meet the changing needs of its customers and the TVA power system.

KEY STRATEGY ALTERNATIVES

The resource integration phase of Energy Vision 2020 identified over 2,000 strategies using various mixes of supply-side and customer service options. From an extensive series of evaluations, seven strategies emerged that offer low cost, lower debt, and improved environmental and economic development performance. These strategies also provide hedges against the key uncertainties, namely load growth, natural gas prices, possible environmental regulations for air and water, and nuclear performance. The seven strategies, along with a "No Action" or reference strategy, are summarized in *Figure S-1*.

PREFERRED ALTERNATIVE

Energy Vision 2020's long-term plan is a portfolio of options drawn from the seven key strategy alternatives. These options were chosen because they are

projected to best meet TVA's objectives and to be the most robust and flexible given the key uncertainties mentioned above. This preferred combination or bundle of options is described in *Figure S-2*.

Initial steps that could be taken to implement this long-term plan are described in *Figure S-3*. The short-term action plan (1996-2002) relies heavily on the flexible supply-side options of purchased power and "call" options to purchase power.

FIGURE S-1. **Key Alternative Strategies**

	Strategies							
	D	J	M	O	Q	R	S	T
SUPPLY-SIDE OPTIONS								
Bellefonte Conversion IGCC w/ Coproduction		•		•	•	•	•	•
Combustion Turbines	•	•	•	•	•	•	•	•
IPP Combined Cycle	•	•		•	•	•	•	•
IPP Coal	•							
Purchasing Peaking Capacity					•	•		
TVA Flexible Base Capacity Option					•	•		
TVA Flexible Peaking Capacity Option					•			
TVA Combined Cycle	•					•		
Repower Coal Units w/ Gas Combined Cycle								•
Pulverized Coal			•					•
Pulverized Coal w/ Scrubbers			•					
Clean Coal Technologies	•	•	•	•	•	•	•	•
Landfill & Coalbed Methane		•	•	•	•	•	•	•
Hydro Modernization		•	•	•	•	•	•	•
Wind								•
Compressed Air Energy Storage								•
CUSTOMER SERVICE OPTIONS								
DSM Block 1 (Low Price Options)	•	•	•	•	•	•	•	•
DSM Block 2 (Low Cost Options)				•				
Low-Level Beneficial Electrification						•	•	
Off-System Sales			•		•	•	•	
ENVIRONMENTAL CONTROLS (SO_2)								
Gas Repowering of Selected Fossil Units								•
Add Scrubbers to Selected Fossil Units	•	•	•	•	•	•	•	
Switch to Lower Sulfur Coal	•	•	•	•	•	•	•	•
ENVIRONMENTAL CONTROLS (CO_2)								
Cost Added for Dispatch of Emitting Units								•
Biomass (waste wood) Cofiring (0.3%)		•	•	•	•	•	•	•

Strategies

D	Reference/"No Action"	Q	Flexibility w/External Options
J	Bellefonte Coproduct/Renewables/IPPs	R	Flexibility w/Internal Options
M	DSM/Off-System Sales	S	Low Cost & Rates, Improved Environment
O	Bellefonte Coproduct/More DSM/Off-System Sales	T	Bellefonte Coproduct/Repowering/DSM

FIGURE S-2. Long-Term Plan

This long-term plan is defined to meet key objectives. The plan is organized by supply-side options for the short term (1996 – 2005) and the long term (2006–2020), customer service options and actions which hedge key uncertainties.

Develop a preferred portfolio of resource options for the long term from key strategies. Objectives of the portfolio are:

1. Balance costs, rates, environment, debt, and economic development.
2. Provide a robust set of resource options or flexibility to adapt to uncertain load growth, future market prices, changes in environmental regulations, and changes in market regulations to manage risk.

Strategies

- J – Bellefonte Coproduct, Renewables, IPPs
- M – Combined DSM and Off-System Sales
- O – Bellefonte Coproduct, More DSM, More Off-System Sales
- Q – Flexible Strategy with External Options
- R – Flexible Strategy with Internal Options
- S – Low Cost, Low Rates, Improved Environment
- T – Low-Cost Renewables, Low-Price DSM, Repowering, Bellefonte Coproduct Partnership

Options		**1996 –2005**	**2006 –2020**
Supply	Peaking	• Combustion turbines, purchases of peak power, and call options on peaking power	• Compressed air energy storage (CAES)
	Base Load	• Call options on base-load power • Improvements to existing hydro system • Combined cycle with pre-siting and engineering • Purchases from independent power producers with and without cogeneration • Combined cycle repowering of coal-fired plants • Renewables—landfill methane and refuse-derived fuel • Coalbed methane • Bellefonte coal gasification and coproducts with partners • Additional coal unit at Shawnee • Improvements in existing system • Nuclear partnership	• Wind turbines • Coal refinery • Cascaded humidified advanced turbine (CHAT) • Integrated gasification combined cycle (IGCC) • Integrated gasification with CHAT (IGCHAT)
Customer Service		• DSM—low price and cost (examples of programs)	• Residential new construction • Commercial and industrial comprehensive finance • Industrial motors
		• Beneficial Electrification (examples of programs)	• Residential heating, air conditioning, and water heating • Commercial cooking • Industrial electrotechnologies
		• Flexible DSM and Beneficial Electrification	
Environmental		• Pursue a flexible strategy of fuel switches, scrubbers • Global climate challenge—improvements to existing system, biomass cofiring	

RESOURCE ALTERNATIVES TO MANAGE RISK

Uncertainty	Options
• Load Growth	• Call options on purchases from external suppliers • Flexible internal supply options • Small modular options—landfill methane, coalbed methane, and distributed resource alternatives • Flexible DSM options
• Natural Gas Prices/Coproduct Prices	• Integrated gasification combined cycle (IGCC) • Integrated gasification cascaded humidified advanced turbine (IGCHAT) • Bellefonte coal gasification with a chemical coproduct
• Environmental Regulation—Air, Water, CO_2 Regulation	• Renewables—wind, landfill methane, biomass • Coalbed methane • Aggressive DSM and beneficial electrification • Natural gas-based resource alternatives

Affected Environment

The study area for Energy Vision 2020 includes the TVA power service area and the Tennessee River watershed. It covers 58 million acres within the 201-county jurisdictions of seven states. The location of a TVA power plant outside the primary study area on the Green River in Kentucky, is also included.

The assessment region for air quality is larger than this study area. There are pollutant emissions originating outside the region, pollutants leaving the area, and pollutant effects such as haze, ozone, and acidic precipitation that TVA recognized as regional issues.

Since Energy Vision 2020 is a regional, strategy-level analysis, the assessments of potential effects were made at a programmatic level, rather than on a site-specific basis.

SOCIOECONOMIC ENVIRONMENT

The population in the power service area was 7.7 million in 1994. The region had an economy of $146 billion in total personal income, 3.6 million people in total non-farm employment, and $175 billion in gross product sales. The region is considerably rural, and the economy depends much more on manufacturing than the nation does as a whole. A large manufacturing base, however, has helped the Tennessee Valley outperform the U.S. economy in recent years.

After the year 2000, the region's growth is projected to slow, as newer manufacturing industries reach maturity. The region's service sector is expected to remain somewhat underdeveloped relative to the nation's. Thus, with the slowing down of manufacturing growth, the whole regional economy is expected to proceed at a slower tempo.

PHYSICAL ENVIRONMENT

Natural resources include regional air, water, and land resources. Overall, regional air and water quality are good and have been steadily improving. Land resources are adequate for siting energy supply facilities.

Regional Air Resources

Good air quality is necessary in order to protect human health and natural resources. Regional compliance with the Federal National Ambient Air Quality Standards serves as a key indicator of how well human health and the environment are protected. These standards set limits on the emissions of six pollutants to protect human health and the environment. Following the enactment of the Clean Air Act of 1970, the overall air quality in the study area has improved as indicated by a decrease of areas that are in non-attainment with the National Ambient Air Quality Standards.

Sulfur Dioxide

For the purpose of Energy Vision 2020, sulfur dioxide (SO_2) is one of the more important pollutants because it produces sulfates that contribute to acidic deposits and fine particles, which can impact natural resources and impair visibility. TVA electric generation accounts for 76 percent of the sulfur dioxide emissions pro-

FIGURE S-3. **Short-Term Action Plan**

Short-Term Actions—Supply-Side	Milestones
Purchase Call Options	
• Base-Load Coverage - 2001 – 2002	Implement up to 3,000 MW
• Winter and Summer Peaking Coverage - 1998 – 2002	
Hydro Modernization Projects	
• Invest in hydro modernization projects between 1996 – 2007	Achieve 150 MW
Bellefonte Nuclear Plant Conversion to Combined Cycle Plant	
• Converting the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel has been identified as one of the most viable alternatives. Such an alternative provides the opportunity to utilize a substantial portion of the Bellefonte non-nuclear plant equipment. However, there is a degree of uncertainty and market risk associated with this alternative which requires further in-depth engineering and financial examination. Accordingly, TVA will use an outside, independent team of technical and financial experts to assess and develop the Bellefonte conversion strategy more fully over the next 18 to 24 months. During the course of the study, TVA will also pursue the evaluation and development of a demonstration gasification plant with the Department of Energy. In the meantime, the Bellefonte plant and Watts Bar Nuclear Plant Unit 2 will continue in a deferred status. TVA will continue to be receptive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities in partnership with TVA.	18 – 24 month study
• Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.	
Renewables	
• Implement cost-effective biomass cofiring	
- Cofiring precommercial demonstration runs at existing TVA coal-fired plants	1996
- Initiate first commercial wood waste cofiring project operation	1997
• Investigate biomass energy facilities	1996 – 97
• Implement a flexible wind project	1996 – 97
• Determine coalbed methane resources feasibility	1996 – 97
• Inventory sites suitable for landfill methane	1996
• Initiate 25-kW landfill methane fuel cells pilot	1997 – 98
Additional Capacity Development	
• Acquire three sites and develop preliminary engineering modules suitable for coproduction, combined cycle, combustion turbines, cascaded humidified advanced turbines, and compressed air energy storage	1996 – 1998
• Investigate cogeneration and other unique energy supply arrangements	1996
Implement a Flexible Phase II Acid Rain Strategy	
• Strategy/Plan Definition	1996
• Initiate early implementation options	1996 – 97

FIGURE S-3. **Short-Term Action Plan** CONTINUED

Short-Term Actions—Customer Services	**Milestones**
DEMAND-SIDE SAVINGS	Up to 650 MW - 2002, Up to 2,200 MW - 2010
Residential	
Full Scale Programs	Revisions in Place
• Heat Pump Leasing / Financing	1996–97
• Ground Source Heat Pump Leasing	1996–97
• New Homes Program	1996–97
• Manufactured Housing - New Construction	1996–97
• Residential Self-Audit	Launch 1996–97
• Load Management	Revisions in Place
- Air Conditioners	1996–97
- Water Heaters	1996–97
Flexible Residential Demand-Side Programs for Selected Market Segments	Launch Phase 1
• Efficiency Products Catalog - Mail Order	1997
• Lighting Products Retail Component	1997
• Low Income Program - Site Visit	1997
• Student Self-Audit - Schools Environmental	1997
• Heat Pump Water Heater Initiative	1997
Commercial and Industrial	
Full Scale Programs	Launch 1996–97
• Commercial and Industrial Energy Services	1996–97
- Comprehensive Measures Financing	1996–97
- Commercial New Construction	1996–97
- Commercial Lighting	1996–97
- Commercial Appliances	1996–97
- Industrial Process Energy Efficiency	1996–97
- Industrial High Efficiency Motors	1996–97
• Commercial Cool Storage	1996–97
Flexible Commercial and Industrial Programs	Launch Phase 1
• Commercial Group Load Curtailment	1997
• Commercial Rooftop Cool Storage Program	1997
BENEFICIAL ELECTRIFICATION	
Residential	
• HVAC and Water Heating applications to improve consumer value	1996–97
• Initiate Flexible Security Lighting and Lawn Mower Programs	Launch 1997
Commercial and Industrial	
• Commercial Space Conditioning and Water Heating	Launch 1996–97
• Commercial Cooking and Security Lighting	Launch 1996–97
• Industrial Electrification Programs for Processing Heating, Food Processing, and Environmental Technologies	Launch 1996–97
• Flexible Industrial Electrification Options for Curing & Drying applications and Textile processes	Launch Phase 1 - 1997
General Research and Development	
• Develop telecommunication supported demand-side management programs	Launch 1996
• End-use renewables, market transformation, load management new technologies, targeted distributed generation, photovoltaics, electric vehicles	Launch 1996–97

duced by human activity within the region or roughly one-quarter of the total sulfur dioxide emissions in the region. Since 1976, concentrations of this pollutant have been reduced 40 percent in the TVA study area; TVA's sulfur dioxide emissions have been reduced approximately 70 percent since 1976.

TVA's contribution to regional visibility impairment is primarily associated with fine sulfate particles. TVA sulfur dioxide emissions have a relatively small contribution to visibility impairment in the Great Smoky Mountains National Park because sulfate production from sulfur dioxide in the atmosphere is slow. Areas further downwind from TVA sources are more likely to benefit from TVA emission reductions than will southern Appalachia.

The Environmental Protection Agency is considering a new standard for short-term exposure to sulfur dioxide because short-duration high concentration exposures can cause short-term problems for some sensitive individuals.

Nitrogen Oxides

Nitrogen oxides (NO_x) emissions contribute to the formation of acid rain and ozone. Nitrogen oxides emissions from TVA power plants accounted for 36 percent of total human-produced nitrogen oxides in the study area. Emissions from TVA facilities will be reduced as TVA installs pollution control equipment to meet the 1990 Clean Air Act Amendments. However, overall nitrogen oxides emissions in the region may not decline due to expected increases in motor vehicle nitrogen oxides emissions.

Ozone

Ozone is produced in the presence of sunlight from the primary emissions of nitrogen oxides and volatile organic compounds. Human health impacts are most severe when ozone concentrations are high. At sufficient concentrations, ozone can also harm vegetation and some building materials. Nashville, Tennessee is the only metropolitan area in the TVA Region classified as a non-attainment area for the ozone standard. Adverse resource impacts have been noted in the Class I parks and wilderness areas, but the significance of these impacts is not well understood and is undergoing extensive analysis through the Southern Appalachian Mountain Initiative (see Cooperative Research and Assessment Programs in Volume 2, Technical Document 1, Comprehensive Affective Environment).

The Environmental Protection Agency is considering revisions to the standards to better address impacts from extended exposures to ozone and cumulative impacts on crops and forests. In addition, it is investigating the effects of inter-regional transport of ozone or ozone precursors on ozone attainment in the Northeast U.S. and other urban areas. Reductions in allowable nitrogen oxides emissions may be needed to help reduce ozone levels. This has important implications for TVA because coal-fired plants are a source of nitrogen oxides emissions.

Water Quality

Water quality is critical to protecting, preserving, and restoring finite water resources. These resources include aquatic ecosystems and aquatic life, recreation, and domestic and industrial water supplies. Discharges from sewage treatment facilities, industrial plants, and coal-fired and nuclear power plants are regulated by state agencies and the Environmental Protection Agency.

Coal-fired and nuclear power plants use water to produce steam and for cooling purposes, and release heated water into surface water (e.g., rivers). TVA plants meet the temperature requirements stated on their permits, either by plant design or by limiting operations to be in compliance.

Another water quality issue is non-point source pollutants—run-off from agriculture, urban uses, and mined land—that results in stream or lake pollution. Pollutant concentrations in the air, and subsequently in rain, can also affect surface water and aquatic habitats. The potential concentrations of toxic substances from the mining of coal and coal-fired plant operations can also be a water quality issue and affect future resource decisions.

Another water quality concern is low dissolved oxygen levels in stream reaches below TVA dams. Damming the rivers and releasing oxygen-consuming pollutants are the principal causes of low-dissolved oxygen levels in the TVA reservoir system. TVA has initiated a program to improve dissolved oxygen levels in water discharged from its dams. TVA addresses this problem further in its l990 environmental impact statement, *Tennessee River and Reservoir System Operation and Planning Review*.

Land Use

Land use includes management of the natural ecosystem, agriculture, forestry, urban and industrial use, and recreational use. Minimizing impacts on soil, groundwater, wildlife, sensitive or threatened ecosystems, threatened and endangered species, cultural resources, and terrestrial environments, such as wetlands and forests, is important in order to support and preserve these uses.

TVA affects land resources through site selection for power plants, transmission lines, fuel procurement, air emissions, radioactive waste management, and solid waste management. Most land resource impacts are site-specific in nature, and therefore are not addressed in detail in this document. Subsequent site-specific reviews will consider such impacts. The amount of land taken up by the final seven selected and “No Action” strategies is identified.

Wastes

Wastes are also an environmental concern. Combustion of pulverized coal in power plant boilers produces solid wastes such as fly ash and bottom ash. Depending on quality and market conditions, these wastes can be sold and used to make several commercial products (e.g., blocks, paving). TVA sold almost 20 percent of the nearly 6 million tons of ash it produced in 1994.

Nuclear waste is an issue that was raised by the public and is addressed in Energy Vision 2020. Almost all (99 percent) of high-level waste from commercial nuclear plants is used fuel that has released most of its energy. After removal from the reactor, spent fuel is initially stored at nuclear plant sites in steel-lined concrete vaults filled with water, or in dry, above-ground concrete or steel containers. Spent fuel has been stored safely since the 1950s.

TVA plans to continue to store spent nuclear fuel on-site at plant locations where generated until the Department of Energy accepts physical custody by shipment off-site to a designated location. Current spent fuel storage capacity is sufficient at Sequoyah Nuclear Plant until 2003, at Browns Ferry Nuclear Plant until 2007, at Watts Bar Nuclear Plant until 2009, and at Bellefonte Nuclear Plant until at least 2020. TVA plans to continue to use the Barnwell facility for low-level waste disposal until the Southeast Compact Commission's North Carolina facility is completed. Should either or both of these facilities close unexpectly, low-level radioactive waste will be stored in on-site facilities at the TVA nuclear plants.

Environmental Consequences

One of the most important conclusions to be drawn from TVA's Energy Vision 2020 evaluation is that TVA's existing coal-fired units are responsible for most of TVA's contribution to the identified environmental impacts. TVA's contribution to many environmental problems, however, has been substantially reduced over the years and is being reduced still further.

Energy Vision 2020 focuses primarily on what additional energy resource options, if any, should be added to TVA's system in the future. TVA's final strategies were compared to the "No Action" alternative—Reference Strategy D—for several key environmental measures.

AIR QUALITY IMPACTS

In addition to quantifying (measuring) the emissions of the most important pollutants, TVA developed quantitative approaches to measure four important air-related impacts and integrate them with other criteria: They include:

- Human Health Through Inhalation
- Visibility Impairment
- Forest and Crop Productivity
- Materials Damage

A number of conclusions can be derived from Energy Vision 2020's assessment of potential air resource impacts:

- Although coal usage is projected to increase under all of TVA's alternative strategies, sulfur dioxide and nitrogen dioxides emissions are expected to decrease compared to 1995 levels.
- Sulfur dioxide emissions are projected to decrease from 1995 levels by 40-50 percent in 2005 and 51-57 percent in 2020, depending on the strategy.

- Nitrogen oxides emissions are projected to decrease by 10-20 percent by 2000, then increase but still remain some 4-16 percent below 1995 levels.
- For all alternative strategies, absolute decreases in TVA's contributions to human health impacts, visibility impairment, forest and crop productivity, and materials degradation are expected.
- TVA's contribution to ozone-related impacts is expected to be reduced under all strategies, but TVA's reductions are likely to be offset by emission increases elsewhere in the region. (Mobile source emissions are projected to increase substantially.)
- Among the final strategies, only Strategy D (the reference strategy) and Strategy T (including low-cost renewables) show a noticeable difference in air resource impacts. The reference or "No Action" strategy uses the most coal and has greater impacts for most environmental categories. Strategy T repowers several existing coal-fired units and uses the most natural gas and renewable resources. This results in a reduction in TVA's contribution to most environmental impacts ranging from 9 to 13 percent. However, land resource impacts increase.
- Greenhouse gas emissions are expected to increase in total during the planning period but compared to the expected increase associated with the reference strategy would be reduced by 7-13 percent. Although total emissions would increase, greenhouse gas emissions (as reflected by equivalent carbon dioxide emissions) per kilowatt-hour actually decline. This means that the TVA system would be producing electricity in a more environmentally efficient way.

POTENTIAL WATER RESOURCE IMPACTS

Three water-quality impacts were considered:

- Human health by ingestion
- Water supply and waste assimilation
- Fish, aquatic life, and aquatic biodiversity

A number of conclusions can be derived from Energy Vision 2020's assessment of potential water resource impacts.

There are only slight differences among TVA's final seven strategies and reference strategy for most water resource impacts. Since less coal is burned under Strategy T (low-cost renewables), it shows the best performance for water resource quality.

The effects of damming rivers and operating the existing hydroelectric units is responsible for the more important water resource impacts. However, since no new dams are proposed in the final strategies or the reference strategy, this impact is the same across all strategies.

Increasing the capacity of TVA's existing hydroelectric plants is environmentally beneficial. This produces new capacity without constructing new plants and allows the use of new turbine designs, which add oxygen into the water as it flows through the turbine. This increases dissolved oxygen and helps combat the low dissolved oxygen problem that exists today below a number of TVA dams.

Because TVA's existing coal-fired plants contribute to water pollution, cost-effective repowering of selected less-efficient coal-fired units provides some of the best options for maintaining water quality.

Repowering or adding capacity at any existing facility is preferable from a water resource impact perspective because it lessens the risk of impacts to those resources.

POTENTIAL LAND RESOURCE IMPACTS

Although land use impacts tend to be site-specific, certain conclusions or observations can be made at this programmatic level of review based on the generic attributes of various energy resource options.

Resource options that involve expansions at existing plants or the repowering of existing units have little or no land resource impacts.

From the standpoint of land consumption, Strategy T uses the most land. This is due primarily to the extensive acreage that is needed to support coalbed methane recovery systems and wind turbines.

The 2,000 megawatts of wind energy capacity in Strategy T is estimated to require 50,000 acres of land at high elevations where the wind resource tends to be found in or close to the TVA region. Wind turbines are also visually prominent and would have some of the most important aesthetic impacts among the various resource options.

All of TVA's final proposed strategies, including the reference strategy, expand TVA's use of coal. Coal mining and coal combustion waste disposal are two indirect land uses that have undesirable land resource impacts. Total coal use rises about 35 percent in most of the final proposed strategies compared to current coal use. Only Strategy T is noticeably different, using about 12 percent less coal than the reference or "No Action" strategy.

There is sufficient land in the TVA region to allow energy resource options to be put in place without impacting sensitive land resources such as wetlands or endangered species. Land resources should not be a constraint on putting any of the energy resource options identified in TVA's final proposed strategies in place, with the possible exception of wind turbines.

Chapter One

Overview and Objectives

Chapter One: Overview and Objectives

TVA is the largest producer of public power in the United States. With a generating capacity of 28,000 megawatts, TVA provides wholesale power to 160 distributors, and it directly sells power to over 60 large industrial and federal customers. Together with the distributors, TVA's power system serves nearly 8 million people in a 7-state region that covers some 80,000 square miles.

Like other utilities, TVA is expecting important changes in the relationship between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a more competitive marketplace. TVA is at the forefront of this change and welcomes the opportunity for growth with improved, responsive services to best meet the needs of its current and new customers.

TVA's integrated resource plan--Energy Vision 2020--will guide TVA in entering this competitive marketplace by identifying the best energy resource choices for the current and future generation of consumers.

Energy Vision 2020 goes beyond simply providing for competitively priced power. The plan, built with extensive public involvement, also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are among the means TVA will use to achieve its goals: competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

In the process of developing Energy Vision 2020, several issues developed that are important to TVA and its customers. These include TVA's debt; competition, including the legislative restrictions on TVA sales (e.g., the fence); electric rates; privatization of TVA; and TVA's nuclear program, including the consequences of completion of Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3. Each of these issues is addressed in Energy Vision 2020.

This Chapter Includes:

- Introduction to Energy Vision 2020
- A Brief Description of TVA
- Purpose of and Need for Integrated Resource Planning
- Energy Vision 2020 Objectives
- The Changing Electric Utility Industry
- Public Participation in Energy Vision 2020

Overview and Objectives

Introduction to Energy Vision 2020

Energy Vision 2020 is TVA's roadmap for meeting the energy needs of its customers during the next 25 years with economical and environmentally sound energy choices. These are important challenges for TVA, which is the largest single producer of electricity in the United States. With a generating capacity of 28,000 megawatts, TVA provides wholesale power to 160 distributors and directly serves 60 large industrial and federal customers. In partnership with the distributors, the TVA power system serves 7.7 million people in an 80,000-square-mile area that covers parts of seven southeastern states.

Today, TVA is looking ahead to the 21st century, to answer the questions necessary to best serve the future needs of Valley residents: How much electricity will the Tennessee Valley need in coming years? What is the most economical and environmentally acceptable way to provide that energy?

TVA is expecting important changes in the relationships between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a competitive marketplace. TVA is at the forefront of this change and welcomes the opportunity for growth and improved service and responsiveness to the needs of its current and new customers. By identifying the best energy choices for current and future consumers, Energy Vision 2020 will guide TVA as it enters this competitive marketplace.

Moreover, Energy Vision 2020 goes beyond the issue of how TVA can provide competitively priced power. The plan also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are the means by which TVA can provide competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

The TVA Board has already taken several strategic actions in part based on information and analyses performed in conjunction with Energy Vision 2020. These are:

- Reversed TVA policy on nuclear plant construction.
- Placed an internal limit on new capital debt and announced a debt reduction program.
- Kept TVA's electric rates steady for a ninth consecutive year.
- Introduced TVA to the global energy market through international bond offerings.
- Commissioned a major study to identify strategic actions that will strengthen TVA's position in an open marketplace.

The result of these efforts is that TVA's self-supporting power system is financially strong. TVA's electric power production and operating costs are com-

petitive with utilities in the regional market. The same is true for the electric prices paid by consumers in the TVA service area.

Energy Vision 2020 provides the TVA Board with a flexible energy supply plan that will help guide the strategic actions necessary for TVA to serve its customers efficiently, and to compete and succeed in the electric utility marketplace of the future.

Launched in the winter of 1994, Energy Vision 2020 includes an unprecedented effort by TVA to involve the public in TVA's energy planning process. Environmental, consumer, and energy industry representatives were appointed to a citizen group to provide input on the formulation of the plan, and public meetings were held throughout the TVA service area to gather public comments and suggestions. Interviews were also conducted with elected officials and opinion leaders. The open process produced a stronger partnership with the more than 7.7 million people who use the electricity produced by TVA.

Energy Vision 2020 identified a viable mix of conservation programs and options for power plant operations that will be used to responsibly and economically provide energy for sustainable economic growth. For all resource options, the environmental consequences and economic impacts were considered as part of TVA's effort to encourage sustainable economic growth in the region. Strong public support for various options, such as demand-side management, also was considered.

Overall the key recommendations of Energy Vision 2020 are:

- Invest in up to 3,000 megawatts of flexible purchases of power
- Convert Bellefonte to an alternative fuel source such as natural gas or coal
- Implement up to 1,450 megawatts of energy efficiency and load management
- Research and develop renewable energy resources—wind, biomass, solar photovoltaics

Additional recommendations, which the TVA Board of Directors has asked the staff to include, are:

- Begin additional flexible demand-side management programs with a potential of 750 megawatts
- Investigate the development of a flexible wind project, a biomass refinery, and a combined garbage and biomass energy facility

Because TVA has a unique mission to supply electric power and encourage sustainable economic development in its service region, Energy Vision 2020 has the flexibility to shift priorities as the marketplace evolves and changes influence the viability of power supply options. When changes in energy options are necessary, TVA will remain focused on making economical and environmentally sound energy choices.

A Brief Description of TVA

The Tennessee Valley Authority (TVA) was established by an act of Congress in 1933 as a federal corporation to develop the natural resources of the Tennessee Valley region and to improve the lives of the region's population, which was being ravaged by the Great Depression, flooding along the Tennessee River, and erosion of the region's natural resources. From its beginning, TVA's challenge has been to look at economic development and natural resource issues in a comprehensive fashion. TVA has also been expected to demonstrate the unique strengths of "a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise." TVA is managed by a three-member Board of Directors appointed by the President.

BUILDING A POWER SYSTEM

By harnessing the destructive potential of the Tennessee River, TVA created a major tool for improving the quality of life in the Tennessee Valley region—abundant and inexpensive electricity. In 1933, only 3 out of 100 farms in the area had electric lights. During its early years, TVA met the demand for power through its series of hydroelectric dams and completed 12 hydroelectric dams during World War II to provide a massive supply of electricity to meet critical wartime industries' demand, such as aluminum production.

By the early 1950s, however, TVA discovered that demand was quickly outstripping the capacity of its dams and its Watts Bar Fossil Plant, which was completed in 1945. During the next 20 years, TVA built 11 large coal-fired generating plants to meet the region's growing needs. TVA advanced technology by building the largest, first-of-a-kind coal-fired units in the world. The decade of the 1960s brought even greater growth to the region. To meet this anticipated need for more power, TVA expanded its generating resources through an ambitious program of nuclear plant construction.

Despite this growth program, TVA's electric rates remained among the lowest in the nation throughout the 1960s. However, the 1970s brought unprecedented change to the entire utility industry's ability to control costs and rates charged to customers. The change was slow at first—starting with the oil embargo in 1973—and then accelerated during the late 1970s. Coal costs and the costs of constructing nuclear units skyrocketed, forcing TVA and most other electric utilities to increase their rates.

As energy costs across the nation continued to climb in the late 1970s and early 1980s, TVA introduced programs to encourage customers to reduce their demand for electricity. These programs, focusing on energy conservation and reducing peak electric loads, worked in concert with TVA's existing generating resources to meet consumer energy needs.

TODAY'S POWER SYSTEM

Today, TVA is one of the largest producers of electricity in the United States, generating 4 to 5 percent of all the electricity in the nation. TVA's power system serves almost 8 million people in a 7-state region encompassing some 80,000 square miles *(Figure 1-1)*.

With a generating capacity of 28,000 megawatts, TVA's electricity is distributed to homes and businesses through a network of 160 power distributors, including municipally owned utilities and electric cooperatives. In addition, TVA sells power directly to about 60 large industrial customers and government installations.

TVA's power system includes 5 nuclear generating units, 12 coal-fired plants (1 mothballed), 29 hydroelectric dams, 48 combustion turbine units, and 1 pumped-storage facility. The system is linked by approximately 16,000 miles of transmission lines throughout the 7-state region. TVA's electric system is self-financed, as are other electric utility systems.

Today, TVA is looking ahead to the 21st century, to answer the questions necessary to best serve the future needs of Valley residents: How much electricity will the Tennessee Valley need in coming years? What is the most economical and environmentally acceptable way to provide that power?

One way TVA is answering these questions is by developing this integrated resource plan, called Energy Vision 2020. This integrated resource plan identifies resources to meet the electricity and energy service needs of TVA's customers during the next 25 years, through the year 2020.

FIGURE 1-1. **TVA's Power System**

TVA's power system covers some 80,000 square miles in a 7-state region.

Purpose of and Need for Integrated Resource Planning

As with any business, it makes good sense for TVA to do long-range planning. Integrated resource planning helps electric utilities choose the best resource options to generate electricity and other options to meet customer expectations for energy services. Increasing competition, changing technologies, and environmental concerns are among the many issues utilities must consider when developing their plans.

The size of TVA's power system and its influence on the Tennessee Valley's economy make integrated

resource planning especially important. The decisions TVA makes will significantly affect the quality of life for millions of residents, as well as the competitive success of businesses and industries in the Valley.

The National Energy Policy Act of 1992 established requirements that TVA must meet in performing least-cost planning. The focus of a least-cost plan is to provide energy services to customers at the lowest total cost over the long run. TVA's integrated resource planning process, however, goes well beyond conventional least-cost planning. Energy Vision 2020 evaluates the effects of resource options on the Tennessee Valley's environment and its economy, as well as on TVA's future prices of electric energy and future level of debt.

This Act also requires TVA to provide distributors of TVA power an opportunity to participate in the integrated resource planning process. Furthermore, the public must have an opportunity to comment before TVA selects major new energy resources. Thus, Energy Vision 2020 reflects the results of customer participation and extensive public involvement, including the preparation of an environmental impact statement under the National Environmental Policy Act.

TVA has integrated the components of a programmatic environmental impact statement into the overall integrated resource planning process and preferred plan. A programmatic level environmental impact statement was developed as opposed to a project or site-specific environmental impact statement because of the broad strategic nature of integrated resource planning.

TVA used the National Environmental Policy Act guidelines and integrated an environmental impact statement into Energy Vision 2020 in several ways. First, TVA used multi-attribute trade-off analysis, which is recognized as an effective way of quantitatively comparing resource planning issues.

Second, TVA has involved the public extensively in determining the scope of the analysis for Energy Vision 2020. TVA also obtained wide response on its draft energy resource plan. In developing the public participation process, TVA began with the National Environmental Policy Act guidelines, but TVA's public involvement process goes well beyond the minimum requirements of this Act.

Incorporating a programmatic environmental impact statement into Energy Vision 2020 provides TVA with a broad analytical foundation to assist in the development of project-specific environmental reviews. Appropriate project-specific reviews will be conducted for energy resource options that TVA may eventually put in place under its selected strategy.

Energy Vision 2020 Objectives

The ultimate objective of Energy Vision 2020 is to develop a resource plan that will enhance TVA's competitiveness in a manner that meets or exceeds its customers' expectations. This objective is consistent with TVA's four broad strategic goals set by the TVA Board of Directors in 1995: being customer driven, environmentally responsible, growth oriented, and employee sensitive. The Board also established a new vision for TVA that calls for the corporation

to be the recognized world leader in providing energy and related services, independently and in alliances with others, for society's global needs.

Competitiveness, as defined in Energy Vision 2020, goes beyond being the lowest-cost electricity producer. It also means that TVA must be competitive in the quality and value of its electric services delivered to its customers. Competitiveness is also measured in terms of TVA's contribution to economic development in the region and the region's environmental quality.

TVA modified the typical integrated resource planning process to better address the implications of an increasingly competitive environment. TVA also incorporated many more opportunities for public involvement that included regular meetings with a group of stakeholders who worked closely with TVA in reviewing and developing the plan. (Stakeholders are customers, consumers, members of government, and any others who may have an interest in, or be affected by, a utility's resource decisions.)

The Changing Electric Utility Industry

Consumer, legislative, and utility actions are changing the electric utility industry from a regulated monopoly to a more competitive industry. Similar changes have taken place in the airline, natural gas, and telecommunications industries over the past decade. In Energy Vision 2020, TVA considers four key elements of this changing structure:

1. The characteristics of a more competitive environment
2. TVA's current position in the market
3. The uncertainty in future power markets
4. Planning alternative energy resources for the future market

THE COMPETITIVE CHANGES IN THE ELECTRIC UTILITY INDUSTRY

The initial step toward fostering competition in the electric utility industry is focused on changing the ground rules on access to the national grid of independent transmission systems that connects utilities with their customers and with each other. The proposed change would provide what is referred to in the industry as "open access."

Historically, TVA and regulated electric utilities have had well-defined, protected markets or service areas. Such markets also brought the responsibility of meeting the demands for electricity within utility service areas. Utilities have had primary control over their transmission systems, choosing whose power they purchase for resale to their customers, whose power they will transport (or "wheel") through their service area, and how much they will charge for such "wheeling" services.

Open access is defined by the provisions of the National Energy Policy Act of 1992 and by the proposed implementing regulations currently under review by the Federal Energy Regulatory Commission. The initial thrust of the proposed open access provisions is to provide wholesale customers and suppliers access to virtually any part of the nation's transmission system. It is believed

that under open access, competing utilities will be able to make better use of existing generating facilities, bring more cost-effective options to the market, and provide electric utilities and their customers with lower cost electricity.

Implementation of wholesale open access is unfolding throughout the nation. Utilities that own transmission systems are starting to restructure their rates and service agreements to allow open access, while protecting the best interests of their existing customers. Utilities with and without transmission facilities are searching for opportunities to make short- and long-term power supply arrangements with the lowest-cost suppliers to meet their existing and future customer electricity service requirements.

The Potential Impacts on TVA

To understand the potential impacts of open access on TVA, it is important to understand the "fence." In 1959, Congress amended the TVA Act to allow TVA to use power revenues to finance future expansion of its generation and transmission facilities. Although the amendment passed, there was significant resistance from investor-owned electric utilities that feared the competitive threat of TVA. To resolve this concern, Congress limited TVA's market to its existing service area at that time and restricted TVA's power exchange arrangements to 13 other utilities. These restrictions are generally known as the "fence."

The authors of the National Energy Policy Act of 1992 recognized that the intent of the wholesale access provisions could have a uniquely negative impact on TVA and its customers. TVA sells approximately 80 percent of the power it generates to wholesale customers (e.g., municipal utilities and cooperatives), compared to an average of 3 to 4 percent for other U.S. electric utilities. Because of this and TVA's limited ability to sell power outside its existing service area, the National Energy Policy Act of 1992 gave special protection to TVA through an arrangement called an "anti-cherry picking" amendment.

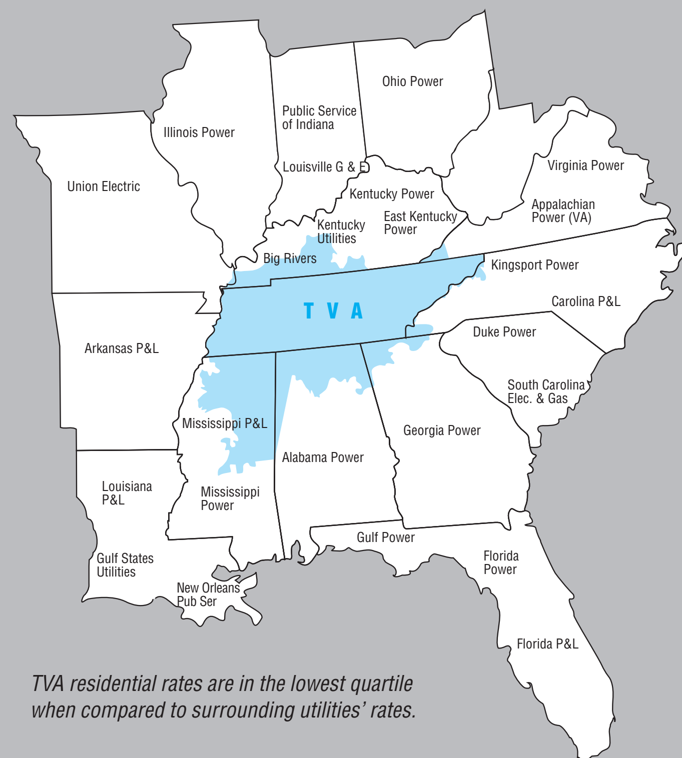
The anti-cherry picking provision exempts TVA from being required to transport power from another utility to TVA's wholesale customers. This reduces the risk of other power suppliers "cherry-picking" selected wholesale customers, who are relatively inexpensive to serve, and leaving TVA's remaining distributors and directly served customers with the large financial burden of supporting an underutilized power system.

TVA also recognizes that many of its customers may want the choice of shopping for energy services in a competitive marketplace. TVA has recently completed a study of the potential ramifications of eliminating the fence. This study, "The Ties That Bind: TVA in a Competitive Electric Market", has concluded that the fence provisions should be changed in two phases. Phase 1 would allow TVA to conduct all conventional types of wholesale business with utilities bordering TVA and beyond. During Phase 1, TVA would not be allowed unbalanced access to traditional non-profit wholesale customers of neighboring utilities with which TVA's relationship has been severely restricted since 1959 and which cannot serve in the TVA territory under the TVA Act. Phase 2 would remove the fence entirely, giving TVA's current wholesale cus-

FIGURE 1-2. **1993 Residential Rate Comparison**

Kentucky Utilities	4.4 ¢/kWh
Kentucky Power	4.9
Kingsport Power	5.1
Appalachian Power (VA)	5.7
Public Service of Indiana	5.8
TVA	**5.9**
Louisville Gas & Electric	6.0
Mississippi Power	6.2
Ohio Power	6.3
East Kentucky Power	6.4 [1]
Gulf Power	6.6
Big Rivers	6.9
South Carolina Elec & Gas	7.1
Alabama Power	7.2
Duke Power	7.3
Union Electric	7.5
Georgia Power	7.8
Louisiana P&L	7.8
Florida Power	7.9
New Orleans Pub Ser	7.9
Florida P&L	8.1
Gulf States Utilities	8.2
Carolina P&L	8.3
Virginia Power	8.6
Mississippi P&L	8.6
Arkansas P&L	9.3
Illinois Power	10.2

1 Using South Kentucky REC Corp. as representative of East Kentucky Power Coop



Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

tomers in the Valley free market access and, at the same time, permitting TVA to seek markets outside the Valley on the same basis that competitors could enter the Valley to provide service.

TVA's Competitive Position in the Market

The 1995 report "The Ties that Bind" found that TVA's electric power production and operating costs are in the lower end of the range of utilities in the huge regional market. TVA's electric rates are very competitive with those of other utilities. Comparisons of TVA's rates with surrounding utilities' rates for residential, commercial, and industrial customers are shown in *Figures 1-2, 1-3,* and *1-4*.

Overall, TVA is ranked 30 in a comparison of 130 utilities in the nation from the standpoint of lowest average rates. On a regional basis, TVA's residential electric rates are lower than most surrounding utilities' residential rates. Of the 27 Southeastern utilities listed in *Figure 1-2*, TVA's residential rates rank as the sixth lowest. Likewise, TVA's commercial and industrial rates are below the median level of other utilities' rates, as shown in *Figures 1-3* and *1-4*. TVA's rates compare even more favorably on a national basis. The inte-

FIGURE 1-3. **1993 Commercial Rate Comparison**

Kentucky Utilities	4.3 ¢/kWh
Public Service of Indiana	4.6
Kingsport Power	5.1
Kentucky Power	5.2
Appalachian Power (VA)	5.3
Ohio Power	5.5
Louisville Gas & Electric	5.6
Gulf Power	5.6
South Carolina Elec. & Gas	5.6
Florida Power	5.8
TVA	**5.9**
Mississippi Power	6.0
Duke Power	6.0
Virginia Power	6.2
Union Electric	6.3
Florida P&L	6.8
East Kentucky Power	6.8 [1]
Big Rivers	6.9
Carolina P&L	6.9
Alabama Power	6.9
Gulf States Utilities	7.3
Georgia Power	7.4
Arkansas P&L	7.6
Louisiana P&L	7.8
Illinois Power	8.3
New Orleans Pub Ser	8.4
Mississippi P&L	8.6

[1] Using South Kentucky REC Corp. as representative of East Kentucky Power Coop

TVA commercial rates are lower than those for more than half the surrounding utilities.

Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

grated resource plan proposed in this report is intended to improve TVA's competitive position with regard to rates in the future.

THE UNCERTAINTY IN FUTURE POWER MARKETS

As regulatory changes occur, the impacts on different parts of TVA's business will probably vary significantly. The generation system is likely to enter an era of tough price competition in which electricity will be bought and sold like other commodities, such as wheat, corn, and natural gas. The transmission system most likely will be a regulated common carrier providing open access under published tariffs or rates. Distributors of TVA power may find themselves in a market similar to the long distance telephone industry, with competition based both on price and value added services.

In an open access environment, TVA generating plants will compete primarily on a price basis. In any time period, plants with lower costs will operate, and those with higher costs will sit idle, earning no revenue. In the current regulated environment, prices are set by a fairly standard analysis of a utility's invested capital costs and operating expenses. In contrast, the price of electricity in an open market will be set by the balance between supply and demand,

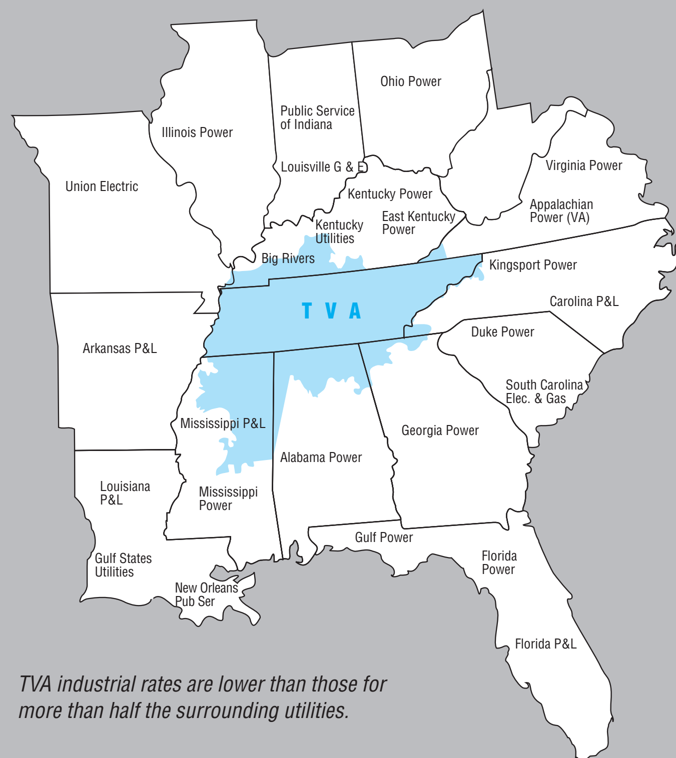
FIGURE 1-4. **1993 Industrial Rate Comparison**

Big Rivers	3.0 ¢/kWh [1]
Ohio Power	3.2
Kentucky Utilities	3.3
Kentucky Power	3.3
Public Service of Indiana	3.4
Kingsport Power	3.5
Mississippi Power	3.6
Louisville Gas & Electric	3.8
Appalachian Power (VA)	3.8
South Carolina Elec. & Gas	3.9
TVA	**3.9** [2]
Louisiana P&L	4.1
Duke Power	4.3
Gulf Power	4.3
Illinois Power	4.4
Virginia Power	4.4
Alabama Power	4.5
Gulf States Utilities	4.6
Georgia Power	4.7
Florida Power	4.8
Union Electric	5.2
New Orleans Pub Ser	5.3
Florida P&L	5.4
Carolina P&L	5.5
East Kentucky Power Coop	5.5 [3]
Arkansas P&L	6.0
Mississippi P&L	6.6

1 Non-Aluminum Industrial is 3.9 cents/kWh

2 TVA's directly served industrial cost is 3.0 cents/kWh and the distributor served industrial cost is 4.6 cents/kWh

3 Using South Kentucky REC Corp. as representative of East Kentucky Power Coop



TVA industrial rates are lower than those for more than half the surrounding utilities.

Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

given transmission constraints. Market prices will vary by hour, day, and season as electricity demand, plant availability, and costs vary across the nation.

In such an environment, a utility's decision to invest in generating facilities, or other services, will depend on whether the utility has the ability to bring the resource to market and make a profit. In an openly competitive environment, a utility's market for generation will no longer be within a well-defined service territory, but will be as large as the transmission cost of electricity will allow.

With retail open access, which is being evaluated as part of electric industry restructuring proposals by state regulatory commissions in some states, such as California, retail consumers will be allowed to choose from whom they will purchase electricity. This will create additional uncertainty in the power markets.

TVA has incorporated assumptions about competition into its electricity demand forecasts. In the range of load forecasts, TVA has identified the potential for the gain or loss of both wholesale and retail customers. These gains or losses are somewhat dependent on changes in future industry regulations such as open access, legislation on the TVA "fence," and potential competition among power suppliers. For more detailed information about TVA's load forecasts, see Chapter 6 and Volume 2, Technical Document 5, Load Forecast.

PLANNING ALTERNATIVE ENERGY RESOURCES FOR A COMPETITIVE MARKET

The increasingly competitive nature of the electric utility industry requires all utilities to consider more carefully the full range of resource alternatives. Sales projections may no longer be based on a load forecast for a protected territory or a given geographic area. Future resources no longer will be built and operated only by a designated utility. A quickly changing marketplace with non-traditional participants will offer a broader range of choices to utility customers.

In Energy Vision 2020, TVA has identified three different types of resource options well suited to address competition: (1) bulk power purchases and sales from other utilities, (2) purchases of power from cogenerators and independent power producers, and (3) market-based alternatives, such as call options on future capacity additions. These resource options are discussed in more detail in Chapter 7.

Public Participation in Energy Vision 2020

In addition to using state-of-the-art methods for analyzing energy resource options, Energy Vision 2020 provided significant opportunities for public participation. TVA purposefully sought to incorporate a broad base of public input into the scope of the planning process. Key analytical elements such as evaluation criteria, resource options, and uncertainties were drawn from public comments during the scoping period. This effort to obtain widespread public review and input was continued after release of the draft plan and environmental impact statement on July 26, 1995.

TECHNIQUES FOR COLLECTING PUBLIC INPUT DURING SCOPING PERIOD

TVA used four techniques to collect public input during the scoping period: (1) "opinion leader" interviews, (2) public meetings, (3) a stakeholders' review group, and (4) written comments.

Opinion Leader Interviews

During the summer of 1994, TVA conducted one-on-one interviews with 96 opinion leaders in the Tennessee Valley. These included elected officials, TVA customers, and other individuals who occupy leadership positions in Valley communities, industries, businesses, and organizations. They were asked to share their views on goals and issues they believe should be important to TVA as it plans to provide future energy services.

Public Meetings During Scoping

From July 28 through November 3, 1994, TVA held 12 public meetings throughout the Tennessee Valley. Notice of these meetings was announced

in local and regional newspapers and other media. The meetings were held in the following cities:

Knoxville, TN	Bristol, TN	Bowling Green, KY
Paducah, KY	Nashville, TN	Jackson, TN
Memphis, TN	Tupelo, MS	Columbus, MS
Muscle Shoals, AL	Huntsville, AL	Chattanooga, TN

At each of these meetings, interactive computer-video displays were available that addressed key issues related to the development of Energy Vision 2020. TVA technical experts also attended every meeting to discuss issues, respond to questions, and help record people's comments. While the meetings were primarily designed as an informal, open-house format, four meetings were supplemented to give participants an opportunity to make public statements about their concerns. Rigorous attendance counts were not kept at the meetings, but TVA estimates that approximately 300 people attended and, of these, approximately 115 individuals provided comments.

Stakeholders' Review Group

Although TVA sought input from the general public and key opinion leaders, it recognized that it would be difficult to get specific and continuous guidance from these audiences as the plan developed. To obtain more in-depth, ongoing discussion and input from different stakeholder viewpoints, TVA established a 17-member Energy Vision 2020 Review Group. The interests represented by the Review Group included business and industry, distributors of TVA power, minority businesses, environmental organizations, state agencies, academia, and civic organizations.

The members of the Energy Vision 2020 Review Group and their affiliations are as follows:

Mike Dalen	Alabama Sierra Club
Ron Fogel	Associated Valley Industries
Jim Navolio	Kentucky Economic Development Cabinet
Susan Gawarecki	League of Women Voters
Carol Crawley	Mid-South Minority Purchasing Council
Chester Smith	Mississippi Department of Economic and Community Development
Eric Hirst	Oak Ridge National Laboratory
Carter Witt	Tennessee Association of Business
Anne Murray	Tennessee Conservation League
Elizabeth Owen	Tennessee Consumer Affairs Division
Stephen Smith	Tennessee Valley Energy Reform Coalition
Allen Cunningham	Tennessee Valley Industrial Committee
Mike Browder	Tennessee Valley Public Power Association
Quentis Fuqua	Tennessee Valley Public Power Association
Bill Pippin	Tennessee Valley Public Power Association
Jim White	Tennessee Valley Public Power Association
Mary English	UT Center for Energy, Environment and Resources

Alternates

Sheila Holbrook-White	Alabama Sierra Club
Sharon Fidler	League of Women Voters
Josh Ellis	Tennessee Association of Business
Ed Passerini	Tennessee Valley Energy Reform Coalition
Darrell Anderson	Tennessee Valley Industrial Committee

The Review Group met monthly with TVA from June 1994 through March 1995 and in June 1995. These meetings were held at various locations throughout the Valley and were open to the public. Opportunities were provided for the public who attended to submit written comments on the topics of discussions or other associated concerns.

At each meeting, TVA facilitated discussions among Review Group members on the issues they believed were important to a successful integrated resource plan. Review Group members' views were collected on the entire range of assumptions, analytical techniques, and proposed energy resource options and strategies.

Given the diversity of the makeup of the Review Group, there were at times a wide range of views on specific issues, such as the value of energy conservation programs, environmental concerns, and the appropriateness of some new technologies. In some cases, open discussions among the members and TVA staff, supported by additional data, brought closer understanding and agreement on particular issues. On some issues, however, members of the Review Group and TVA staff agree that the objective was not consensus, and differing views were honored.

TVA retained several outside consultants to advise Review Group members on their primary issues of concern. These included the accuracy of TVA's load forecast, the cost and operating assumptions about its nuclear generating facilities, and the results obtained from the resource integration portion of TVA's planning process. Review Group members also met with TVA staff in small groups to discuss special areas of interest such as demand-side management and renewable energy options. This provided an opportunity to exchange more detailed information and develop a better understanding of concerns among Review Group members and with TVA staff. During the course of 12 months of meetings, many bridges of understanding and guidance were built that make this a better plan.

Written Comments During Scoping

TVA began the public comment period on the scope of Energy Vision 2020 on February 8, 1994. In addition to publishing an official notice in the Federal Register, TVA announced the start of the process in newspapers, television reports, and other communication media throughout the Tennessee Valley. TVA compiled written comments on concerns and recommendations from the public for approximately nine months (until December 5, 1994). These comments were used by TVA to better define the full scope of its integrated resource

planning analysis. During this period, TVA received approximately 600 written comments from more than 100 people and organizations.

TECHNIQUES FOR COLLECTING PUBLIC INPUT DURING DRAFT DOCUMENT STAGE

TVA primarily used two techniques to collect public input during the draft document stage: (1) public meetings, and (2) written comments.

Public Meetings

From August 28 through October 2, 1995, TVA held nine public meetings throughout the Tennessee Valley. Notice of these meetings was announced in local and regional newspapers and other media. The meetings were held in the following cities:

Muscle Shoals, AL	Huntsville, AL	Knoxville, TN
Bristol, TN	Paducah, KY	Nashville, TN
Starkville, MS	Memphis, TN	Chattanooga, TN

At each of these meetings, TVA technical experts were available to respond to questions, discuss issues, and help members of the public understand Energy Vision 2020. Two mechanisms were used to record public comments: (1) a "hearing" room in which those choosing to comment could address a TVA "hearing" officer and have his or her comments recorded by a court reporter; or (2) a "speed" room in which those choosing to make comments but not wanting to speak in front of others could have their comments recorded by a TVA employee.

At the request of a representative of the Tennessee Energy Valley Reform Coalition, TVA commenced these public meetings in late August (August 28) after the release of Energy Vision 2020 on July 26, 1995, in order to provide the public an ample opportunity to review the draft document before the public meeting process began. The last public meeting was held on October 2. The public comment period formally closed on October 15. Rigorous attendance counts were not kept at these public meetings, but TVA estimates that approximately 350 people attended. Approximately 160 people provided about 1,200 oral comments at these meetings.

Written Comments

TVA provided approximately 80 days for receipt of written comments. This is almost 80 percent longer than the minimum time period required by applicable procedures which implement the National Environmental Policy Act. TVA received approximately 800 written comments. These were either mailed or faxed to TVA, or were provided at one of the public meetings.

INTEGRATION OF PUBLIC SCOPING COMMENTS INTO ENERGY VISION 2020

Overall, TVA received more than 1,300 comments from approximately 375 individuals and organizations either in writing or verbally. All of these comments were collected, categorized, and consolidated into scoping comments for TVA's integrated resource plan and environmental impact statement—Energy Vision 2020.

The comments included a broad range of concerns and issues. Many recommended that TVA consider—or not consider—specific resource options such as renewable energy resources or nuclear plants. Others expressed views on the values that TVA should consider in weighing its options and strategies. People urged TVA to maintain competitive rates, to reduce its debt, and to protect the environment. Some respondents expressed concerns about future uncertainties that TVA should consider in developing strategies. These included loss of customers and electric load due to competition, more stringent environmental regulations, and future fuel prices. TVA also received a number of comments about its mission, organizational structure, workforce, and other activities. All of the comments TVA received were categorized into five broad areas as listed in *Figure 1-5*.

Through this process, TVA was able to incorporate most of the comments into its analysis. For example, the wide array of resource options evaluated during the integrated resource planning process includes either specific public recommendations for resource options or generic variations of resource options. Recommended values were incorporated into TVA's evaluation criteria to compare resource options and strategies. The uncertainties (or possible future events) used in the process capture concerns identified by the public

RESPONSES TO PUBLIC COMMENTS ON DRAFT DOCUMENT

The introduction to Volume 3 of Energy Vision 2020 explains how TVA responded to the comments that it received during the draft document stage. Volume 3 contains TVA's responses to the comments it received. When appropriate, Energy Vision 2020 was changed. Typically this was done to clarify discussions or to correct errors in the presentation of information. Some comments asked that TVA conduct additional analyses or to analyze issues differently. As appropriate, the results of such analyses were either included in the Energy Vision 2020 long- and short-term plans or in Volume 3, Responses to Public Comments.

FIGURE 1-5. **Scoping Categories**

Evaluation Criteria	Total Cost/Customer Value, Rates, Financial, Environment, Economic Development, Risk Mitigation, Reliability, Equity
Options	Supply: Nuclear Conversion to Alternative Fuels, Coal, Clean Coal, Natural Gas, Renewables, IPP/Cogeneration/Purchased Power, Peaking/Storage, Other Customer Service: Energy Efficiency, Load Management, Beneficial Electrification, Self-Generation, Rates, Other New Technology Environment Other
Uncertainties	Market/Load Forecast, Fuel Process Regulatory: Environment, Competition, Other Technology/Option-Related: Cost, Performance
Process	Format of Public Meetings, Input from National Organizations, Outside Review, etc.
Miscellaneous	TVA Administration, TVA Mission, Social Equity, etc.

All of the public comments received during scoping were categorized into five broad areas.

PUBLIC ISSUES NOT TREATED IN ENERGY VISION 2020

Below are a number of public recommendations made that TVA did not address specifically in Energy Vision 2020.

Site-Specific Impacts

TVA received a number of comments recommending that it address potential environmental impacts that may vary from one location to the next. These included the likely impact of energy resource development on endangered species or wetlands, the conversion of prime farmland, or aesthetic impacts. While these potential impacts are very important to consider in the actual siting or deployment of energy resource alternatives, it would be impossible, however, to analyze them at the programmatic or strategy level. Prior to deployment of any option, TVA will conduct an appropriate site-level environmental review.

Monetization of Environmental Externalities

An "externality" is a cost or benefit that results from the production or consumption of goods and services that is not reflected in the prices of those goods or services. For example, driving a car or generating electricity may produce various forms of pollution that can damage vegetation. If such pollution is not controlled at the source such that the cost of control is included in production costs, it is an environmental externality or a cost borne by society. TVA and other federal agencies have long assessed potential environmental externalities in the context of the National Environmental Policy Act reviews they perform.

Several commenters asked TVA to monetize the environmental externalities that may result from the strategies or options in Energy Vision 2020. Monetization involves directly adding the cost of externalities to other costs, such as construction and fuel costs. Given the many difficulties in monetizing externalities, and the lack of a consistent position in the utility industry on the values to be used, TVA has decided to address externalities by using a multi-attribute trade-off approach. More information about various treatments of externalities can be found in Volume 2, Technical Document 4, Evaluation Criteria. In addition, all appropriate environmental issues have been addressed qualitatively as a part of the environmental impact statement component of this plan. A more detailed discussion of these issues is located in Volume 2, Technical Document 1, Comprehensive Affected Environment, and in Volume 2, Technical Document 2, Environmental Consequences.

Unbundling of Services

Many of the functions necessary to ultimately deliver electricity to a home or place of business are generally provided by one company or utility. For some utilities, these functions include the process of generating, transmitting, and distributing electricity to the customer (end user). Utility service also may include specialized energy services that enhance the use of electricity. These may range from personalized energy management services to specialized metering and

billing. The costs for these services are most often consolidated into a standard rate for kilowatt-hours consumed that reflect generalized cost of service estimates among different classes of customers.

The experience with deregulation of electric utilities in other countries and of other industries in the United States, most notably the telecommunications industry, suggests that utilities may need to "unbundle" their operations to be more competitive in the future. Several commenters asked TVA to assess the ramifications of possibly unbundling its services. For TVA, this would largely amount to pricing and offering power generation and transmission as separate services. Since this is predominantly a rate-making issue, it is not addressed directly in Energy Vision 2020. The question of how unbundling services might affect TVA is being studied in a separate analysis that will use results from Energy Vision 2020.

Treatment of Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3

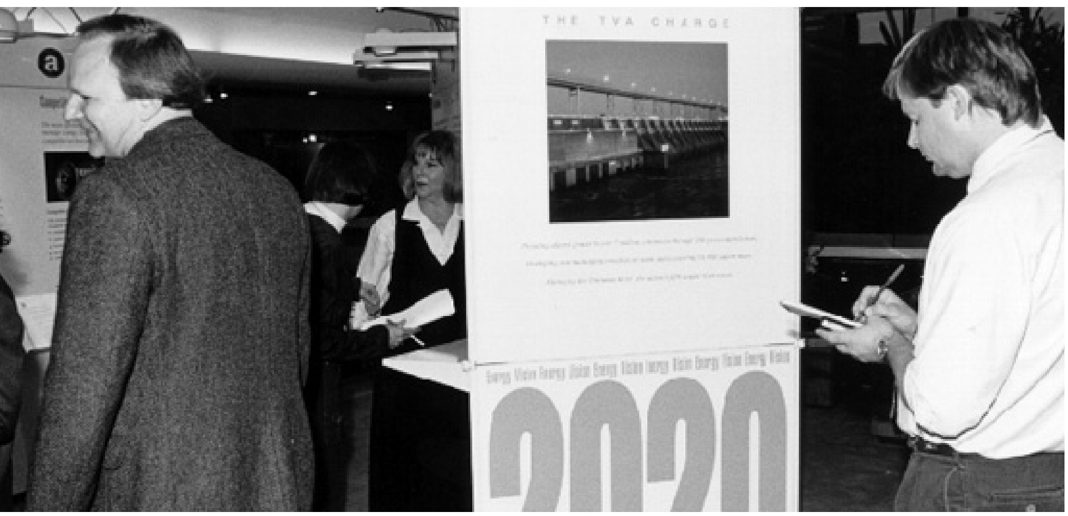
Several commenters asked TVA to include Watts Bar Nuclear Plant (WBN) Unit 1 and Browns Ferry Nuclear Plant (BFN) Unit 3 as resource options in Energy Vision 2020. However, TVA included these units as existing generating resources since these units were important for meeting TVA's near term load requirements and were essentially complete at the start of the Energy Vision 2020 process. Watts Bar Nuclear Plant Unit 1 was granted a license to load fuel and perform low power testing in November 1995. Fuel loading was completed in November, and Watts Bar Nuclear Plant Unit 1 is expected to begin commercial operation in spring 1996. Browns Ferry Nuclear Plant Unit 3 fuel load was completed in October and is scheduled to return to service in early 1996. As with other operating TVA resources, Energy Vision 2020 evaluated the impacts of these units on electric rates, debt, and the environment. For further explanation of the need and economics of Watts Bar Nuclear Plant Unit 1, see the comments and responses on this unit in Volume 3.

Privatization of TVA

Since the purpose of Energy Vision 2020 is to identify the long- and short-term actions TVA can take to meet its existing and future customer energy resource needs, the issue of privatization of TVA's utility operations is not addressed.

Chapter Two

Integrated Resource Planning



Chapter Two: Integrated Resource Planning

Dramatic changes in the electric utility industry since the early 1970s have created a need for more sophisticated planning tools to guide utility resource decisions. Today's integrated resource planning process has improved the concept of least-cost planning, which was introduced in the mid-1980s.

The best industry practices in integrated resource planning include looking at a broad range of supply-side and customer service options, using multiple evaluation criteria, involving the public, and considering uncertainty associated with future events.

TVA's approach to integrated resource planning has built on these best practices. It also includes more extensive planning interaction with stakeholders and with technical experts inside and outside TVA. Energy Vision 2020 also goes beyond the traditional regulatory focus on least-cost plans and demand-side management to consider the growing issue of competition and its potential effects on resource decisions.

This Chapter Includes:

- Integrated Resource Planning History
- Integrated Resource Planning Process Overview
- TVA's Approach to Integrated Resource Planning

Integrated Resource Planning

Integrated Resource Planning History

Through the 1960s, planning for the future in the electric utility industry was straightforward. Growth in the demand for electricity was consistently strong. This allowed for continuing economies of scale for power plant construction, which kept driving down the cost of incremental resource additions. Therefore, electricity rates stayed constant, and during some time periods, actually decreased. Planning consisted primarily of determining the schedule for adding large, bulk-power generators to the system to meet rapidly increasing loads. Simple trending techniques seemed to be sufficient guidance to questions about future resource requirements.

All of this changed dramatically in the 1970s as many factors produced significant volatility in the electric power industry's cost structure. These included the Arab oil embargo, rampant inflation, the regulatory consequences of the Three Mile Island incident, and air emission controls on power plants. As a result of these events, electric rates began to increase significantly, load growth slowed, and the future became far less predictable. In addition, competitive wholesale generation markets began to emerge as a result of the Public Utilities Regulatory Policy Act of 1978. By the 1980s, energy conservation evolved into the concept of demand-side management, focusing on the long-term efficient use of resources. All of these issues required new planning approaches and techniques to help utilities integrate these changes into their planning process.

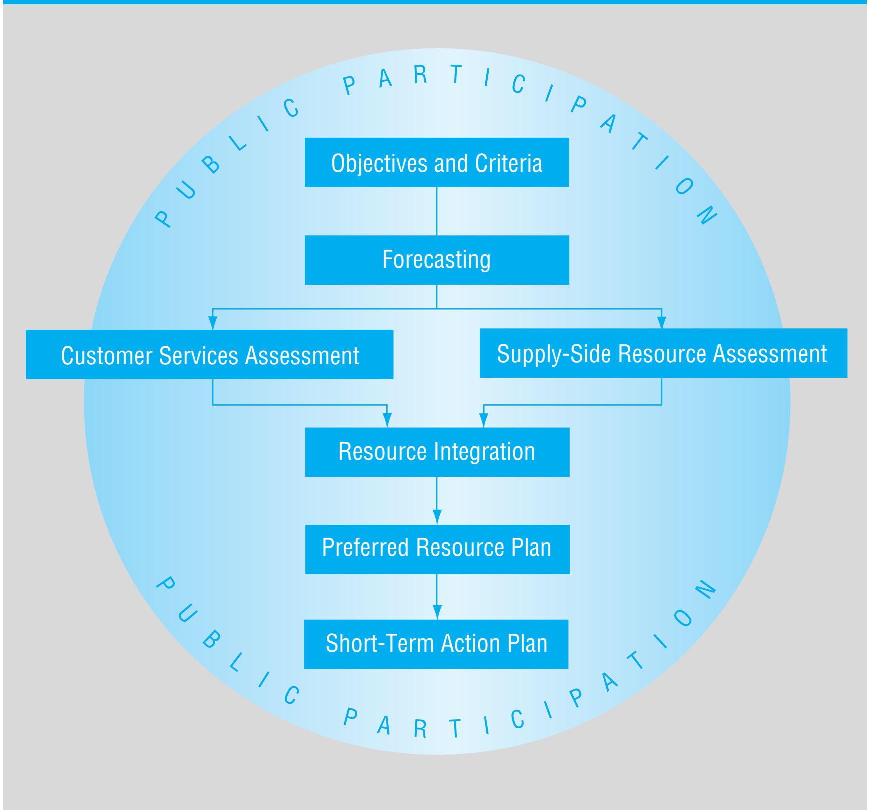
Least-cost planning, with its emphasis on end-use efficiency, was introduced in the mid-1980s to help address these issues. Least-cost planning has evolved into the concept of integrated resource planning defined in the National Energy Policy Act of 1992. Integrated resource planning is continuing to change to meet the increasingly competitive environment in the electric utility industry.

Integrated resource planning is continuing to change to meet the increasingly competitive environment in the electric utility industry.

Integrated Resource Planning Process Overview

An effective integrated resource planning process results in a plan that broadly identifies the long- and short-term actions a utility anticipates undertaking to meet future demands for energy services and to achieve its objectives. The integrated resource planning process evaluates both supply-side options

FIGURE 2-1. **A View of a Typical Integrated Resource Planning Process**



and customer service options. Supply-side options refer to various methods for generating or acquiring additional electrical energy. Customer service options encompass a wide range of technologies, programs, pricing strategies, and other activities that change the way consumers use electricity. Consumer actions improve the value of energy services. They can also provide resource benefits for the power system by avoiding the need to build or otherwise acquire supply-side resources.

A typical integrated resource planning process is illustrated in *Figure 2-1*. A utility must first look at its objectives and the issues affecting its operations, then develop evaluation criteria consistent with its objectives. These criteria are used as a guide in evaluating its energy resource options. The utility next looks at its projected need for power, which includes the utility's load forecasts and an assessment of its existing power system to meet the projected loads. If a need for new resources is identified, the utility evaluates potential supply-side and customer service resource options to meet these needs.

Integration is an interactive process that evaluates specific combinations of existing and new resource options called strategies. These strategies are evaluated based on the utility's evaluation criteria and future uncertainties that may affect resource choices. After the utility evaluates all its resource options and strategies against its criteria, it chooses a long-term resource strategy or plan that adequately and reliably meets its projected need for power and other customer services. A preferred plan is one that will score well on as many of the evaluation criteria as possible and will provide the utility with the necessary flexibility to deal with future uncertainties.

A good integrated resource planning process also yields the utility's short-term action plan. This plan lists the specific steps the utility will take in the next three to five years to support its long-term plan. For example, if the preferred long-term plan calls for an additional power plant in the future, the short-term action plan would include acquiring a site for the plant.

Some of the best practices used by leading electric utilities in preparing integrated resource plans include:

- Identifying a broad range of supply-side and customer service options and their unique operating characteristics.
- Using multiple evaluation criteria that include total cost and rate impacts, environmental impacts, and risk management to compare specific resource plans or strategies. To these standard evaluation criteria, TVA added a measure of economic value, which broadens the range of options considered in the planning process.
- Integrating multiple perspectives through a variety of public participation techniques designed to receive and consider the comments of the general public and "stakeholders."
- Incorporating uncertainties into the planning process, such as the uncertainty associated with the future demand for electricity, fuel prices, and the enactment of future environmental regulations. These uncertainties have the potential for dramatically changing a utility's future course of action. Several analytical techniques allow utilities to consider such uncertainties and build flexibility into their plans.

TVA's Approach to Integrated Resource Planning

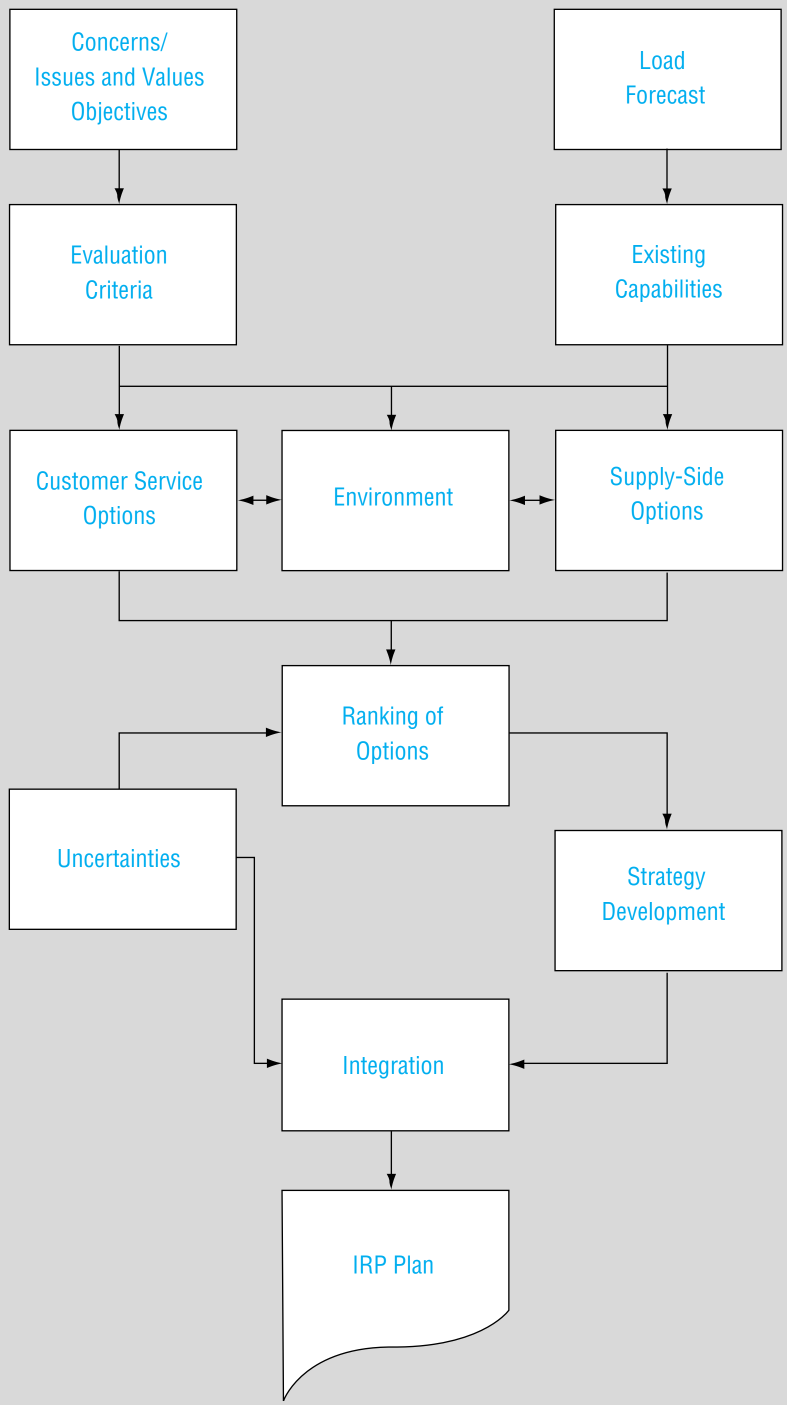
TVA's Energy Vision 2020 has incorporated the best industry practices and added several improvements to meet its unique situation and the changing utility environment.

First, TVA developed a highly interactive planning process to build Energy Vision 2020. This included a great deal of interaction between TVA and its stakeholders, and among stakeholders themselves. Also, there was extensive involvement from a broad cross-section of TVA staff, who have technical expertise and program responsibilities for the areas covered by integrated resource planning. They worked in different building block teams for each step of the process identified in *Figure 2-2*. Each team had members that not only represented the primary staff responsible for a technical area, but other members who could help the team understand issues or concerns from other perspectives (e.g., customers, environmental).

This process of increasing involvement by TVA stakeholders and employees has expanded the general awareness of the highly complex issues associated with utility decision-making. It will also help in building an understanding of the decisions the TVA Board of Directors will make concerning TVA's long- and short-term resource plans.

Second, most utility integrated resource plans to date have focused on meeting their business objectives in a regulated environment and on meeting regulatory commission standards and expectations. To go beyond best industry practices, Energy Vision 2020 focused on meeting customer expectations, while recognizing the potential challenges of a less regulated electric utility environment.

FIGURE 2-2. **Energy Vision 2020 Building Blocks**



This figure illustrates only the primary flow of information in developing Energy Vision 2020 and not the full process of building block interactions and feedbacks on common issues.

INTERACTIVE PLANNING

Interactive planning moves from the identification of issues and concerns to the development of preferred strategies. An interactive approach requires:

1. Identifying public issues and relevant concerns
2. Translating public issues and concerns into evaluation criteria, resource options, and uncertainties
3. Crafting resource options into strategies
4. Identifying possible future conditions (uncertainties)
5. Constructing scenarios
6. Using trade-off analysis to find the best strategies for the future

Value judgments about the importance of potential impacts from various resource options (e.g., on cost, rates, the environment, TVA's debt) are intentionally deferred until later in the process, when extensive discussions take place about making trade-offs among issues people value. Although TVA has had discussions with its stakeholders about the possible trade-offs among different values, the decision-making authority ultimately resides with TVA's Board of Directors. The Board is responsible for deciding which short-term and long-term energy strategy TVA will adopt to best serve its customers and meet the agency's other goals.

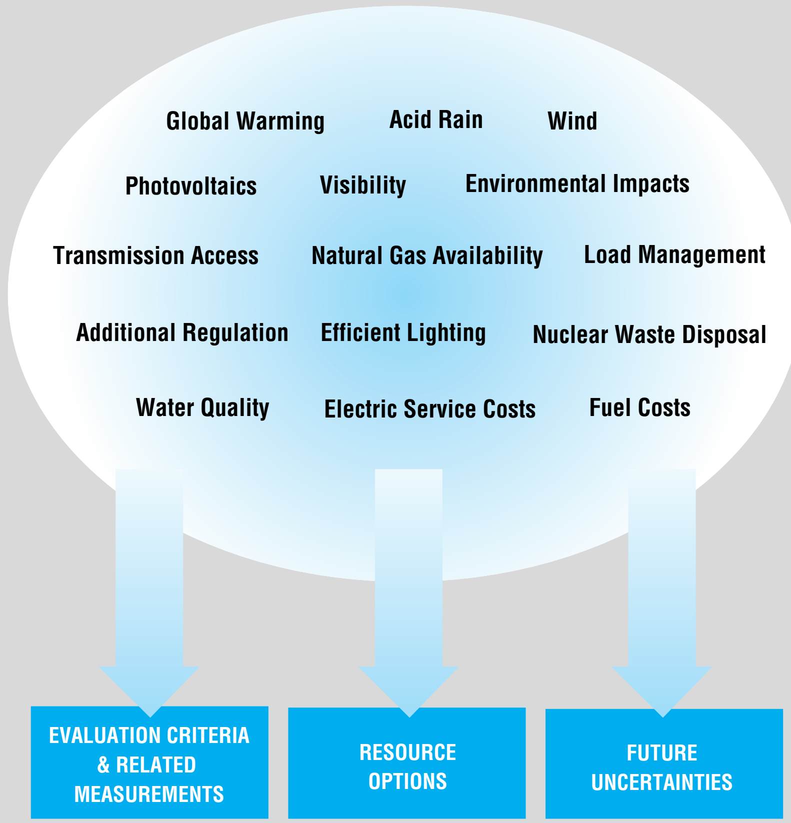
TVA'S IMPLEMENTATION OF THE INTERACTIVE PLANNING PROCESS

Below is an outline of TVA's movement through each step to the development of preferred strategies.

Step 1: Identifying Public Issues and Relevant Concerns

The objective in the early stages of the planning process was to accumulate as many relevant issues and concerns as possible from customers, TVA employees, environmental groups, and other key stakeholders. Some of these concerns are illustrated in *Figure 2-3*.

FIGURE 2-3. **Translating Public Concerns**



Issues and concerns from the public were translated into evaluation criteria, resource options, and future uncertainties used in Energy Vision 2020.

Step 2: Translating Public Issues and Concerns into Evaluation Criteria, Resource Options, and Uncertainties

TVA then categorized each issue or concern so that it could be systematically discussed and evaluated. This meant stating issues or concerns in a way that would allow as much quantitative evaluation as possible in the planning process. Quantitative evaluation provides a fact-based or numerical value system upon which to base decisions, and it reduces the subjective debate that can surround various issues or concerns.

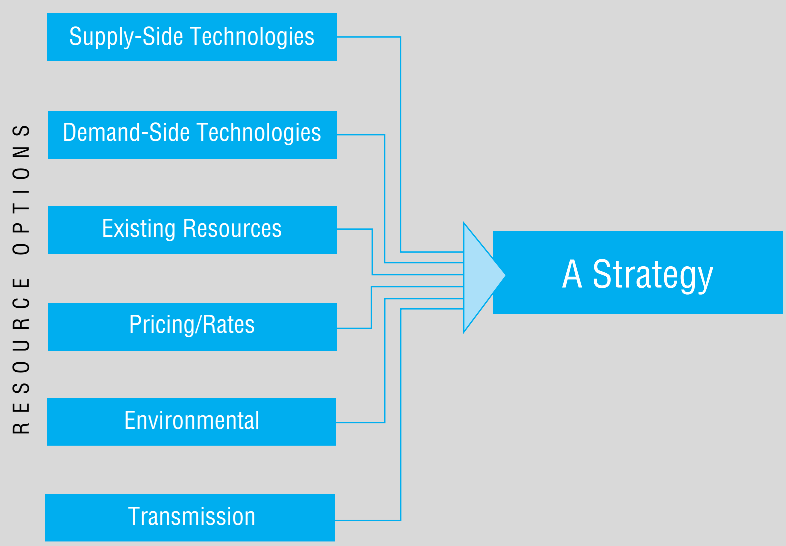
TVA translated concerns about the Valley's energy future into the following categories:

Evaluation Criteria and Measurements

Statements that reflected TVA and stakeholder values were translated into evaluation criteria. For example, impacts on rates and the environment are important considerations that TVA needs to consider in evaluating various future resource strategies. TVA then identified attributes that could be used to measure various impacts. For example, if there is a concern that development of a resource will cause rates to increase too much, the attribute could be the projected level of TVA's rates by a certain year. If an environmental concern is greenhouse gases, the attribute could be the amount of carbon dioxide emitted by that resource option over the planning period.

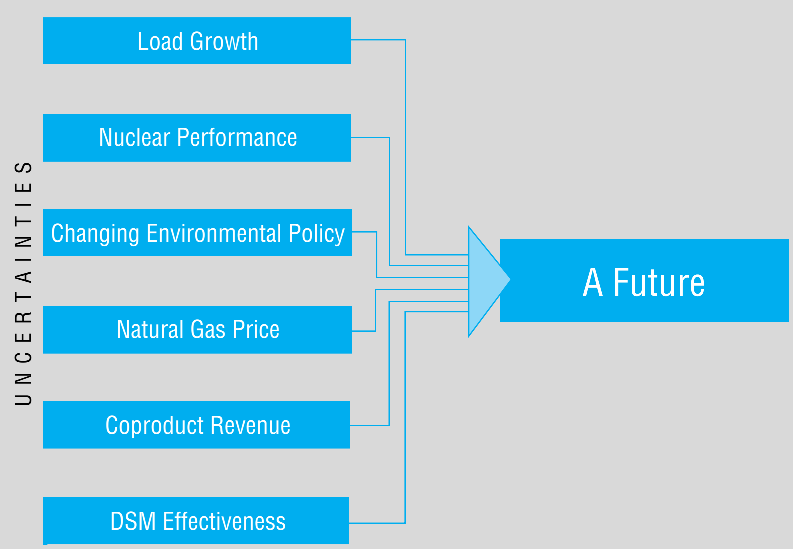
For some of the criteria, TVA established constraints as minimum and/or maximum bounds of acceptable performance. For example, if the concern is

FIGURE 2-4. **Creating Strategies**



Strategies were developed by combining resource options.

FIGURE 2-5. **Creating Futures**



Futures were developed by combining uncertainties of greatest concern.

the reliability of electricity, a constraint may be given in terms of minimum expectations for power quality or duration of power outages. For an environmental concern, such as greenhouse gases, a constraint may set a limit on the amount of carbon dioxide emissions a generating option may produce in a given time period.

See Chapter 5 for a detailed discussion of evaluation criteria, measurements, and constraints used in Energy Vision 2020.

Resource Options

Resource options grew out of suggested actions that stakeholders and others consider to be within TVA control and should be taken by TVA to meet its objectives, satisfy customer needs, and/or resolve issues. For example, if the issue is a shortfall in power supply in the year 2007, a suggested action or option for TVA could be to build a power plant to meet the demand. Another might suggest TVA pursue demand-side management programs to reduce consumer demand. More information about the supply-side and customer service options TVA considered in Energy Vision 2020 can be found in Chapters 7 and 8.

Uncertainties

Issues or concerns that may affect energy resources in the future but are beyond TVA's control are termed uncertainties. An example would be the future level of natural gas prices. This uncertainty is significant because natural gas is a source of fuel for power plants, as well as an alternative to electricity for some consumer needs. Critical uncertainties considered in TVA's integrated resource planning process can be found in Volume 2, Technical Document 8, Resource Integration.

Step 3: Crafting Resource Options into Strategies

After categorizing public concerns, TVA began identifying and characterizing resource options, ranking them based on costs, rates, debt, and environmental emissions, and screening out those that were clearly not feasible. *Figure 2-4* shows how the selected options were combined into a strategy to meet projected load and other criteria, as well as to address key uncertainties. More information on the development of specific strategies can be found in Chapter 9, Resource Integration/Alternative Strategy Comparisons.

Step 4: Identifying Possible Future Conditions (Uncertainties)

From the list of concerns that were translated into uncertainties, possible futures were defined. A future is a combination of one or more uncertain events. For example, a future could include high growth in electricity sales, high cost of natural gas, and increasing air emission controls in response to a global warming problem. Another future could be defined to include high electricity sales growth, low cost of natural gas, and no legislation requiring increased air emission controls. TVA created futures based on those uncertainties that could have the greatest impact on the resource strategies TVA might choose to implement. *Figure 2-5* illustrates how possible futures are created.

Step 5: Constructing Scenarios

A scenario is created by combining a single strategy for a single future. Each scenario can be discussed in terms of its relevant attributes and objectives. Scenarios are then evaluated using modeling and simulation techniques to measure their performance against the evaluation criteria.

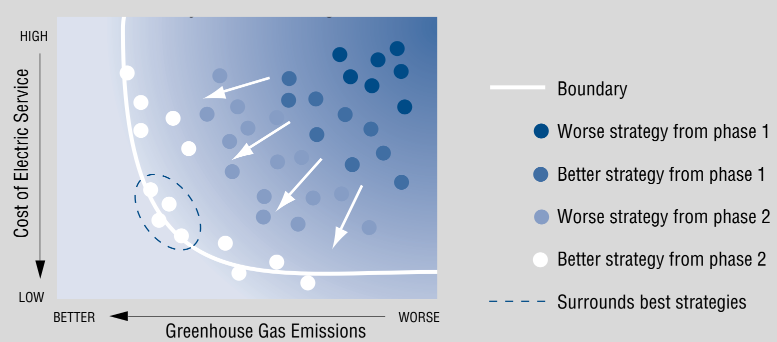
Step 6: Using Trade-Off Analysis to Find the Best Strategies for the Future

Once a set of feasible scenarios was developed, trade-offs among them were considered under the different futures. This trade-off analysis of scenarios was necessary because more than one evaluation criterion or measurement was relevant to evaluating the scenarios.

Discussions on trade-offs within TVA and with outside stakeholder representatives focused on how well various strategies might be able to meet selected evaluation criteria measurements. These discussions also considered what impacts the strategies might have on TVA's entire power system.

The purpose and nature of trade-off analysis are shown graphically in *Figure 2-6*. For illustration purposes, strategies were plotted in the trade-off graphs

FIGURE 2-6. **Using Trade-Off Analysis to Create Improved Strategies**



Better strategies were developed by analyzing trade-offs among various measures such as cost of electric service and greenhouse gas emissions. The strategies within the dotted line would be those with both the lowest electricity costs and the lowest greenhouse gas emissions.

for a given future. The axes of the graph identify two measures or attributes. In this example, the cost of electricity ($/kilowatt-hour) is on the vertical axis and greenhouse gas emissions (tons) are on the horizontal axis. The results for each strategy are plotted on the graph for given futures.

If there were only two evaluation criteria that TVA had to consider, the ideal strategy would be located closest to where the two axes meet (in the lower left hand corner). In this example, strategies within the dotted line would be those with the lowest electricity costs and the lowest greenhouse gas emissions.

Once trade-offs are initially analyzed (phase 1), strategies are modified and improved where possible (phase 2, etc.) to move them closer to the corner. In cases where an unavoidable trade-off exists, the decision-maker must choose between strategies. As an example, if there is no strategy with both the lowest costs and the lowest greenhouse gas emissions, the decision-maker may have to choose one over the other. After extensive reviews of different trade-offs among many pairs of evaluation criteria, those strategies that, in the opinion of the decision-maker, best meet the criteria and provide flexible choices are developed into the long-term resource plan. More information on the development of strategies and trade-offs can be found in Chapter 9.

Chapter Three

Affected Environment

Chapter Three: Affected Environment

This chapter contains an assessment of those natural and socioeconomic resources in the region that may be influenced by Energy Vision 2020 decisions about future energy resources. The assessment is made at a macro, or regional, scale rather than at a micro, site-specific scale.

The primary study area covers the TVA power service area and the Tennessee River watershed, comprising 201 counties within a 58-million acre area.

Appropriate elements of the Cumberland River in Tennessee, and the Mississippi River in Tennessee, both in the primary study area, and a portion of the Green and Ohio Rivers in Kentucky outside the study area, are included in this report, since TVA power plants are located in these river basins and, in the case of the Cumberland River, one hydroelectric plant. The assessment region for air quality is not limited to the TVA service area. There are pollutant emissions originating outside the region, pollutants leaving the area, and pollutant effects such as haze, ozone, and acidic precipitation that are recognized as regional issues.

Natural resources include regional air, water, and land resources. Overall, air and water quality are generally good and have been steadily improving. Land resources are adequate for siting energy supply facilities.

Understanding the conditions of these resources, trends in the region's environmental quality, and the relationship to TVA's activities is important. This provides the necessary reference or baseline for assessing the potential environmental consequences of implementing alternative energy strategies developed in Energy Vision 2020.

This Chapter Includes:

Affected Environment

Overview

Energy Vision 2020 evaluates the affected environment to help provide a baseline for assessing the environmental consequences of alternative energy strategies. Because Energy Vision 2020 includes an environmental impact statement, special emphasis is being given to the environment. A regional perspective takes in both natural conditions and those resulting from human development. It considers socioeconomic, air, water, and land resources. All topics in this chapter are considered in more detail in Volume 2, Technical Document 1, Comprehensive Affected Environment.

Because Energy Vision 2020 includes an environmental impact statement, special emphasis is being given to the environment in this report.

The primary study area for Energy Vision 2020, shown in *Figure 3-1*, includes the TVA power service area and the Tennessee River watershed, comprising 201 counties within a 58-million acre area. Within this study area, appropriate elements of the Cumberland River in Tennessee, and the Mississippi River in Tennessee are considered because TVA coal-fired plants are located on these rivers and, in the case of the Cumberland River, one hydroelectric plant. Outside the study area, a portion of the Green and Ohio Rivers in Kentucky are considered because TVA coal-fired plants are located on these rivers.

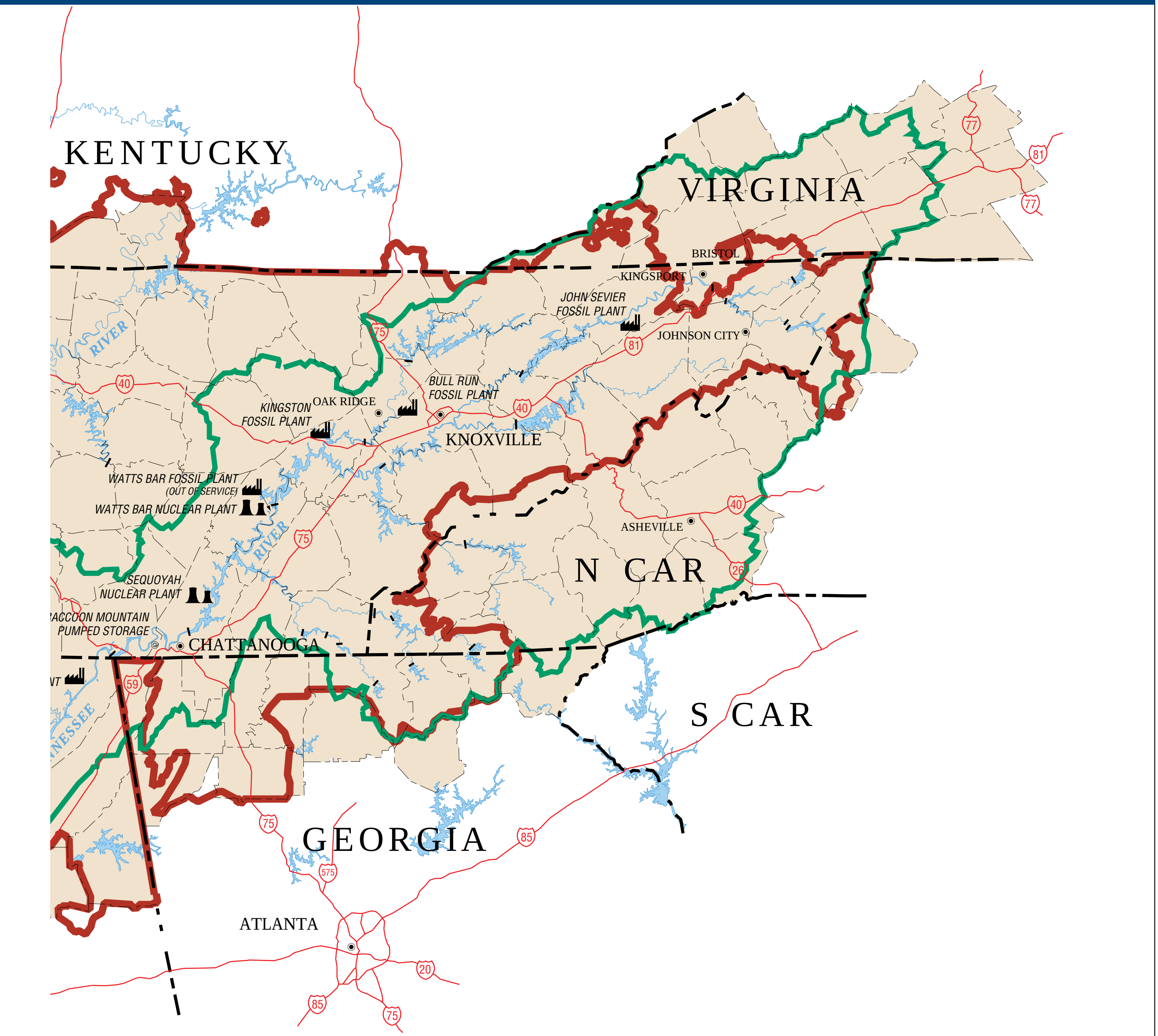
The Socioeconomic Environment

In 1994, the TVA power service region had an economy of $146 billion in total personal income, 3.6 million in total non-farm employment, and $175 billion in gross product. The population was 7.7 million in 1994. Per capita income in the region was about $19 thousand the same year, or about 86 percent of the national average.

Close to half of the region's population lives in non-metropolitan counties, compared to less than one-fourth in the nation. In 1994, about 26 percent of total non-farm employment in the region was in manufacturing, as compared to 16 percent for the United States. Manufacturing's predominance in the region is due to several advantages that have helped it in the past and should continue in the future. They include:

- A location in the South, with good access to the markets of the Northeast, the Midwest, the Southwest, and Florida
- Good transportation for shipping commodities to these markets
- A low wage (for the U.S.) workforce with good work habits
- Abundant, relatively low-cost resources including water, electricity, and land.

FIGURE 3-1. **The Energy Vision 2020 Study Area Includes the TVA Service Area and the Tennessee River Watershed**



LEGEND

Tennessee Watershed Boundary....................

Power Service Boundary ....

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

ECONOMY

A large manufacturing base has helped this area outperform the United States economy and is expected to continue to do so. Strong manufacturing gains since 1985 have stimulated the region's growth. Three critical factors hampered manufacturing in the early to mid-1980s: exceptionally high oil and energy prices, high interest rates, and high foreign exchange rates. These have returned to relatively lower levels and are expected to remain there, creating favorable conditions for growth in the region's manufacturing capabilities.

A strong manufacturing base has helped this area outperform the United States economy and is expected to continue to do so.

Although manufacturing is the core of the region's economic base, nonmanufacturing industries accounted for two-thirds of total gross regional product in 1994. The service sector, which makes up the bulk of the non-manufacturing side of the economy, has provided, and is expected to continue to provide, the great majority of all new jobs created in the region.

For the balance of the decade, the region's performance is expected to continue the trend of the 1985-1994 period. Relatively favorable national conditions and TVA's electric rates for regional manufacturing are both expected to continue. TVA expects the region's newer manufacturing industries to continue further expansion. After the year 2000, TVA expects the region's growth will slow considerably as the area's newer manufacturing industries reach maturity. Nevertheless, manufacturing's intensity is expected to continue to provide enough impetus for the region to expand somewhat faster than the national rate.

POPULATION

In 1994, about 7.7 million people lived in the TVA power service area, with almost half residing in the major metropolitan areas of Nashville, Memphis, Knoxville, Chattanooga, and Tri-Cities, Tennessee, and Huntsville, Alabama. These metropolitan areas are all mid-sized, without any one large dominating area in the region and are distributed fairly evenly throughout the region. Surrounding these metropolitan areas are a few smaller metropolitan areas and numerous satellite cities, along with the surrounding rural communities connected by both economic and transportation links. Thus, the region, while largely rural, is generally well served by centers of commerce and government, and the workforce is evenly distributed across the region rather than focused in any particular central area.

Regional Air Resources

Natural resources such as soils, forests, crops and other vegetation, surface waters, aquatic ecosystems and aquatic life are sensitive to air quality impacts of acidic deposition (including acid rain), ozone exposure, and deposits of heavy metals. TVA affects air quality through emissions from power plants. Air quality in the TVA region is generally good.

CRITERIA AIR POLLUTANTS

Air quality is important to protect human health and natural resources. Regional compliance with the Federal National Ambient Air Quality Standards serves as a key indicator of how well human health and the environment are protected.

The Environmental Protection Agency has established standards for six "criteria" pollutants. Pollutant concentration levels were established for two classes of effects: primary and secondary. Primary standards protect public health, and secondary standards protect public welfare (e.g., visibility, aquatic ecosystems, crops and forests, soils, materials). Current national ambient air quality standards are shown in *Figure 3-2*.

Locales where concentrations do not exceed the level of the standards are considered to be in compliance with the National Ambient Air Quality Standards and are thus designated as attainment areas. Areas where standards are not achieved are designated as non-attainment. (See *Figure 3-3 through 3-5.)*

SULFUR DIOXIDE (SO_2)

Health and Welfare Concerns

Sulfur dioxide can impact human health at sufficient concentrations. Concentrations of sulfur dioxide in the Tennessee Valley have been reduced by more than 40 percent since 1979 *(Figure 3-6)*. Current ambient levels of sulfur dioxide are generally below thresholds that pose risk of damage to vegetation and materials. Sulfur dioxide also combines with other elements to form sulfate, a secondary pollutant that contributes to acidic deposits and fine particles that can have an impact on human health and impair visibility.

FIGURE 3-2. **The National Ambient Air Quality Standards Set Limits for Six Pollutants to Protect Human Health and the Environment**

Pollutant	Averaging Time	STANDARD Primary	STANDARD Secondary
Carbon Monoxide	8-hour 1-hour	9.0 35.0	none none
Lead	Quarter Year	1.5	1.5
Nitrogen Dioxide	Annual	0.053	0.053
Ozone	1-hour	0.12	0.12
Particulate matter less than 10 microns in size (PM10)	24-hour Annual	150 µg/m^3 50 µg/m^3	150 µg/m^3 50 µg/m^3
Sulfur Dioxide	3-hour 24-hour Annual	none 0.14 0.03	0.50 none none

National standards, other than annual standards, are not to be exceeded more than once per year (except where noted in the figure). Units are parts per million by volume of air except for particulate matter with diameters less than or equal to 10 microns which is expressed in micrograms per cubic meter. The ozone standard is attained when the expected number of days per calendar year in which the maximum hourly average concentration is above the standard is equal to or less than one day.

FIGURE 3-6. **Concentrations of Sulfur Dioxide in the Energy Vision 2020 Study Area Are 40 Percent Below 1979 Levels**

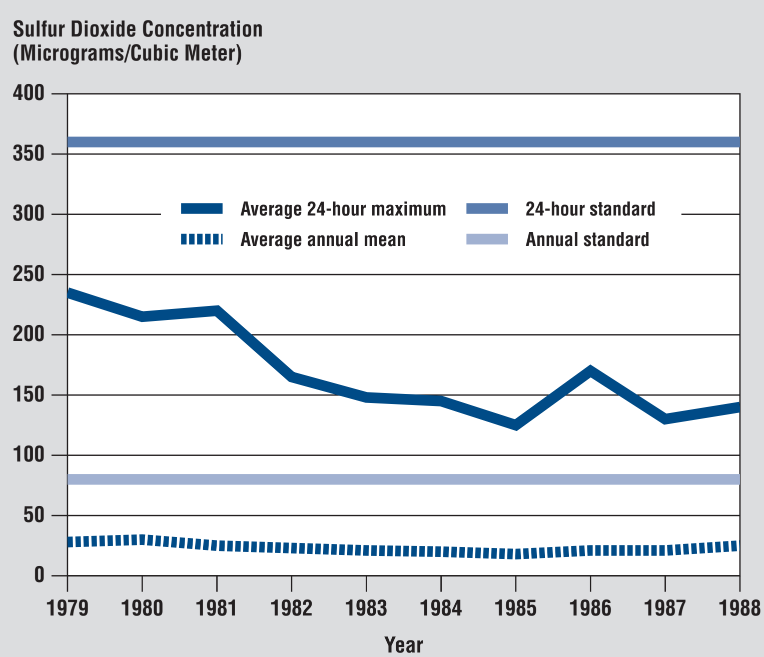
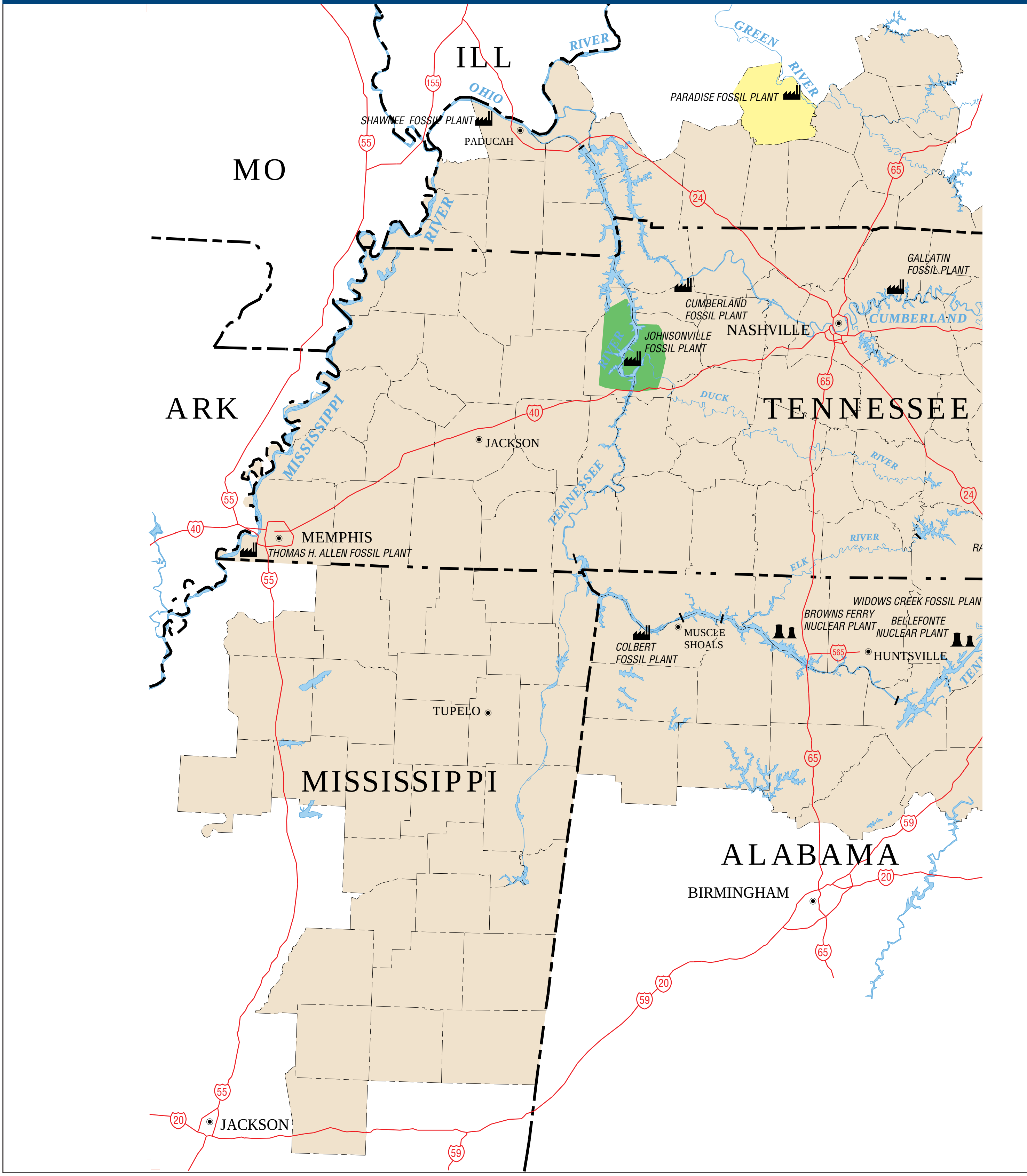


FIGURE 3-3. **Areas in Nonattainment for Sulfur Dioxide Under the National Ambient Air Quality Standards**



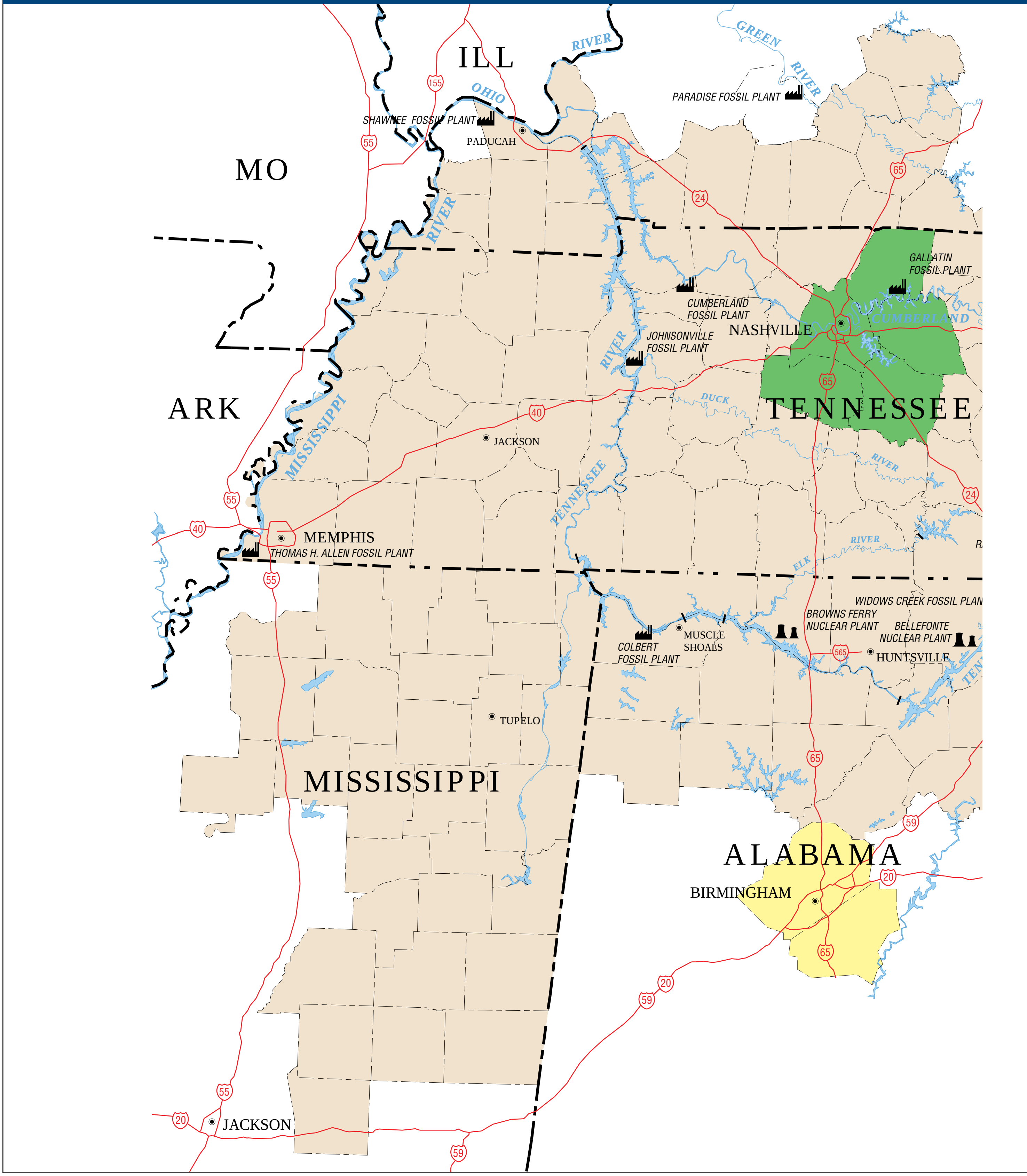
LEGEND

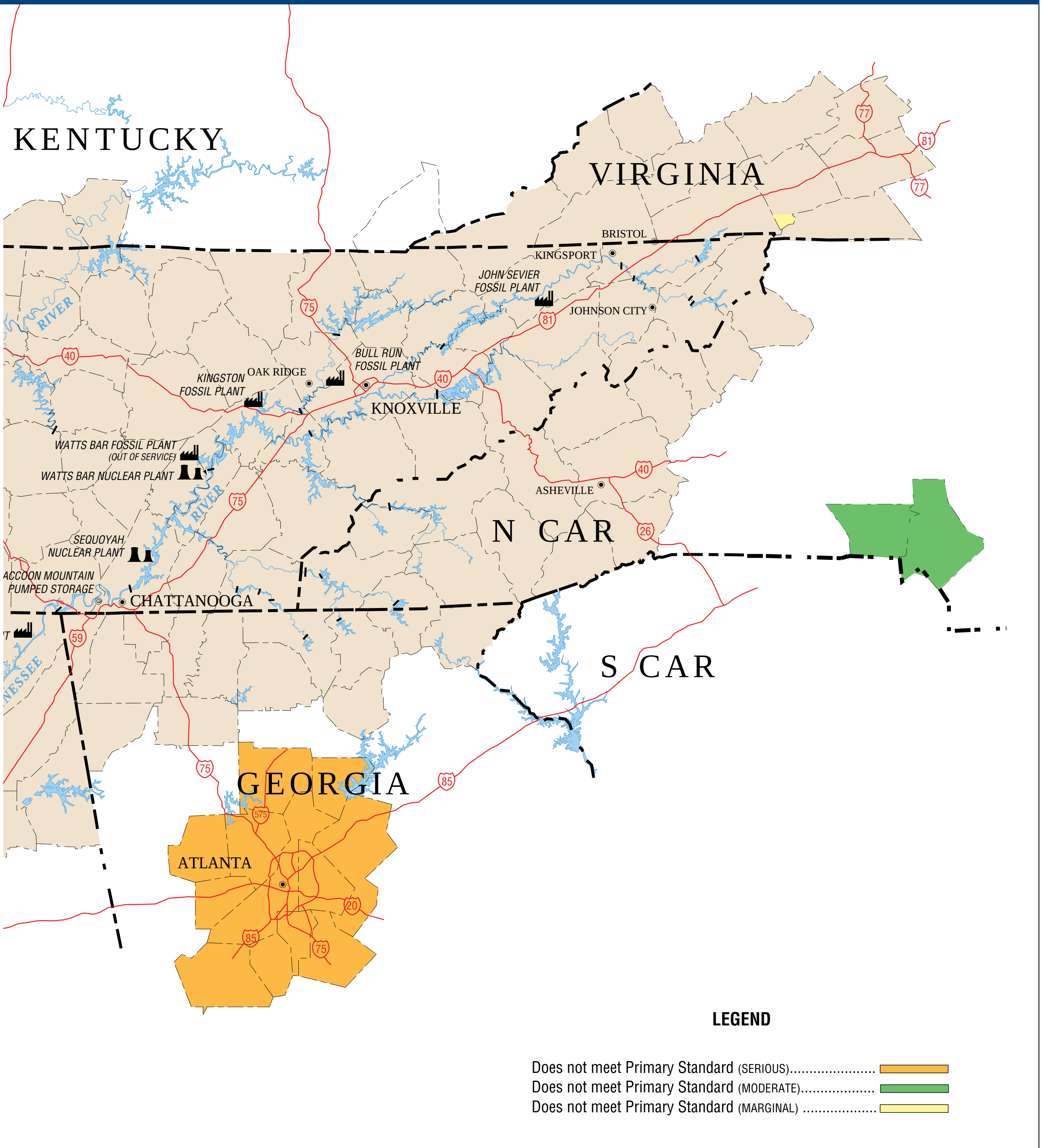
Does not meet Secondary Standard ....

Does not meet Primary or Secondary Standard ....

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

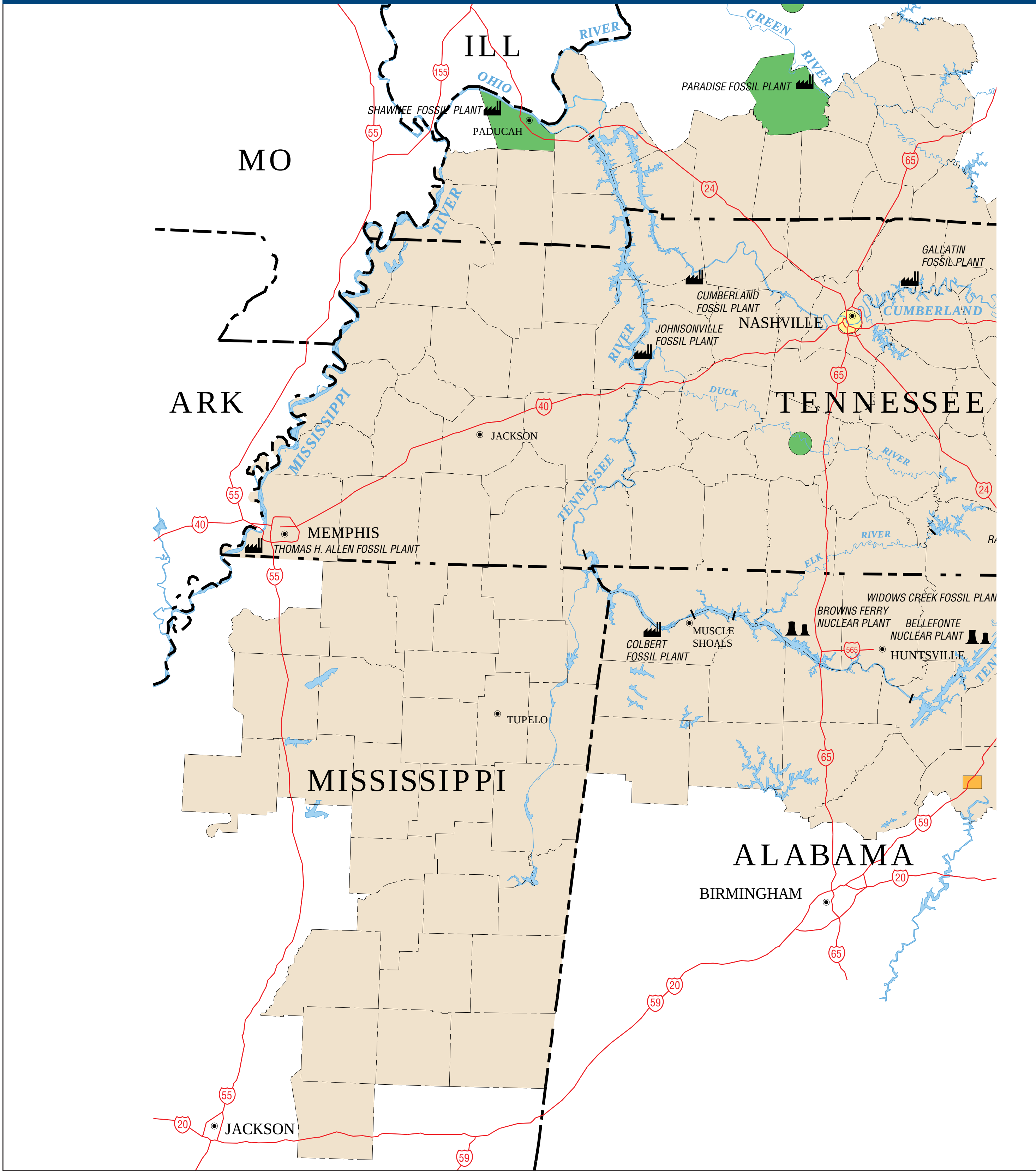
FIGURE 3-4. **Areas in Nonattainment for Ozone Under the National Ambient Air Quality Standards**

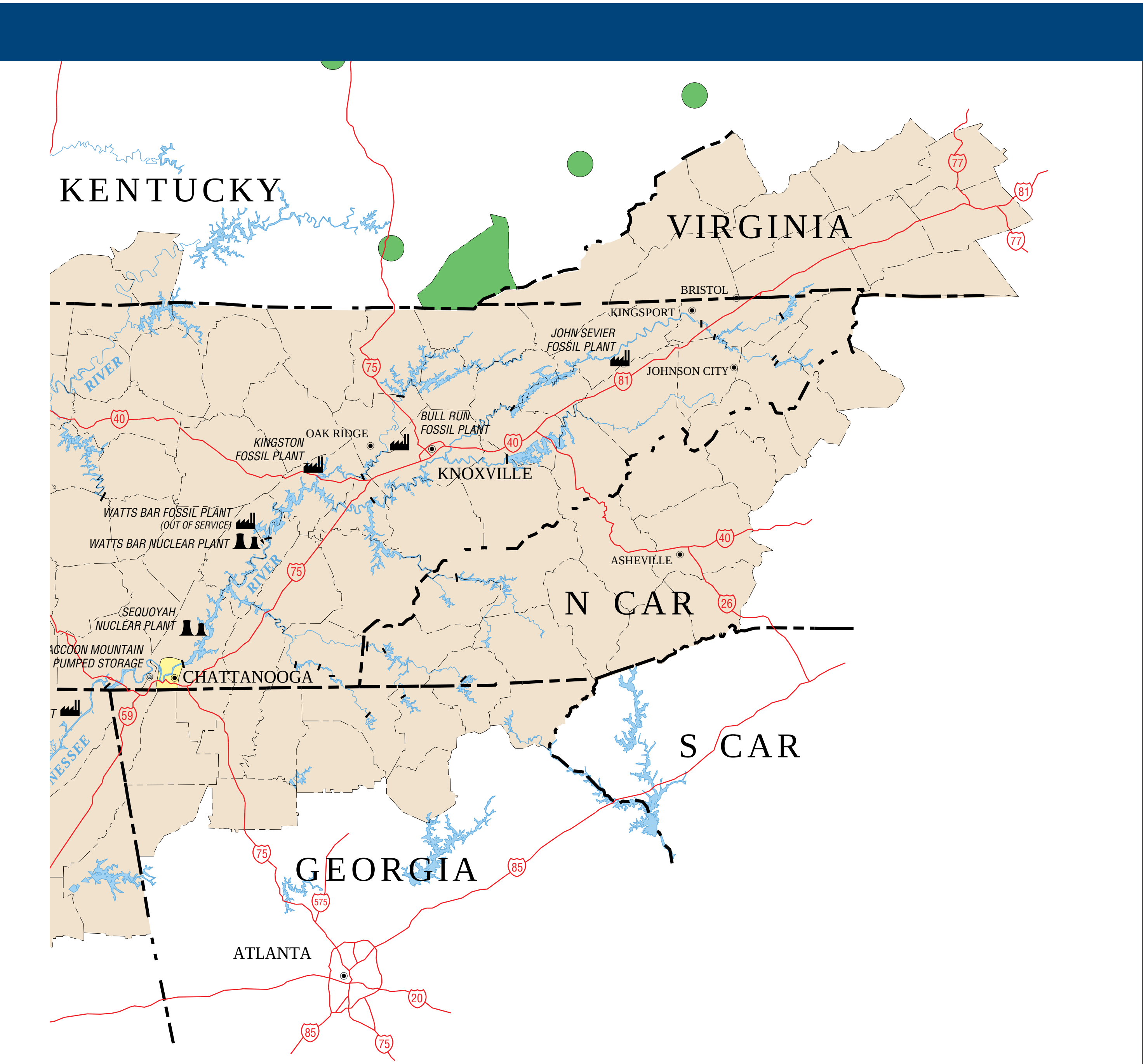




MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 3-5. **Areas in Nonattainment for Total Suspended Particulate Matter Under the National Ambient Air Quality Standards**





LEGEND

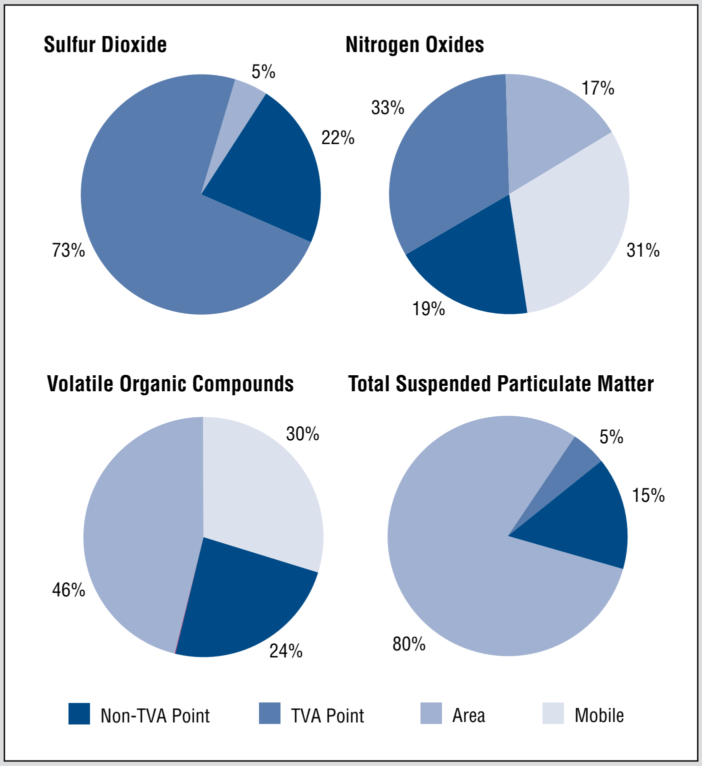
Does not meet Primary Standard ....

Does not meet Secondary Standard ....

Cannot be Classified ....

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 3-7. **Total Emissions of Human-Produced Sulfur Dioxide, Nitrogen Oxides, Volatile Organic Compounds, and Total Suspended Particulate Matter from the 201-County TVA Service Area**



Total emissions of sulfur dioxide, nitrogen oxides, volatile organic compounds, and total suspended particulate matter. Emissions from point, area, and mobile sources from the 201-county TVA service area are derived from Environmental Protection Agency 1990 Interim Inventory. Total suspended particulate matter emissions are derived from the 1985 Interim Inventory.

Sources of Contributions

Coal-fired power plants, industrial boilers, ore smelters, and petroleum refineries are major human-produced sources (point or stationary sources). In the TVA region, TVA accounts for three-fourths of the total sulfur dioxide emissions produced by human activity *(Figure 3-7)*. In the greater source area that contributes to sulfur dioxide loadings in the Tennessee Valley, TVA's emissions are roughly one-fourth of total emissions. Installation of emission controls, coal washing, and switching to coals with lower sulfur content have reduced TVA's sulfur dioxide emissions by 60 percent over the past two decades *(Figure 3-8)*. Following full implementation of the 1990 Clean Air Act Amendments (i.e., following Phase II), TVA sulfur dioxide emissions are expected to remain below 500 thousand tons per year.

NITROGEN OXIDES (NO_X)

Health and Welfare Concerns

Nitrogen oxides can be a respiratory irritant but at typical outdoor concentrations, health impacts are negligible. Nitrogen oxides emissions, however, contribute to acid rain, ozone, and visibility impairment.

Sources of Contributions

Natural sources of nitrogen oxides include microbial activity, lightning, and forest fires. Major sources produced by humans include motor vehicles, fossil-fuel power plants, industrial boilers, nitrogen fertilizers, and agricultural burning. Within the TVA region, nitrogen oxides emissions from TVA power plants accounted for 33 percent of total human-produced nitrogen oxides emissions, with mobile sources a close second at 31 percent. *(See Figure 3-7.)* TVA emissions of nitrogen oxides annually have been 500,000 tons. These emissions will be reduced to roughly 300,000 tons annually as TVA installs control equipment in response to the 1990 Clean Air Act Amendments. (See *Figure 3-9.)*

The variations in nitrogen oxides emissions from 1984 to 1993 are a result of changes in coal-fired plant generation to meet varying load requirements

and also reflect the availability of both coal-fired and nuclear plants during this period. Reductions during 1993 to 1995 are partially a result of environmental control measures. The large reductions in 2000 are the results of the implementation of more significant environmental control measures in response to the Clean Air Act Amendments.

TOTAL SUSPENDED PARTICULATE MATTER (TSP)

Health and Welfare Concerns

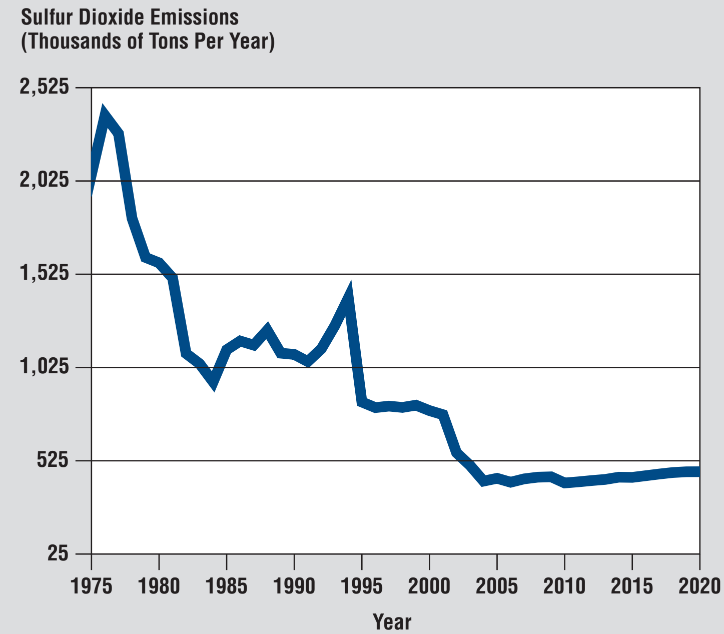
Particulate matter consists of small aerosol particles in the atmosphere that can impact the health of sensitive individuals and impair regional visibility. The particles of major concern for human health are less than 10 microns in size.

Particles emitted directly from a source are called primary particulate matter, whereas those formed in the atmosphere from emitted gases are called secondary particulate matter. Formation of secondary particulate matter of sulfates and nitrates from sulfur dioxide and nitrogen oxides and other elements occurs in the atmosphere as the pollutants are transported several hundred kilometers downwind from the points of origin. As with ozone, summertime conditions favor sulfate and nitrate particle formation. Because sulfate particles are the major contributor to regional haze in the eastern United States, visibility is usually poorest in the summer months.

Sources of Contributions

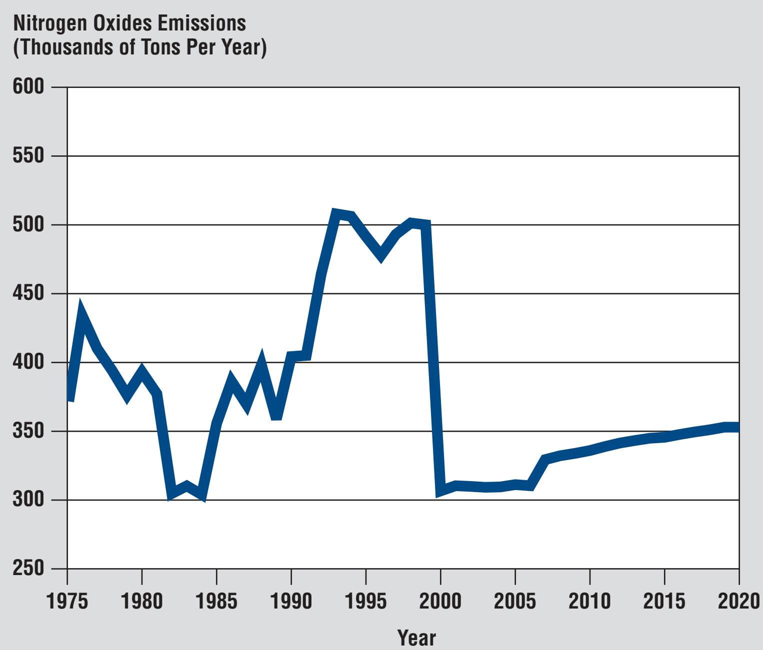
Particles in the air have many natural and human-produced sources. Human-produced sources include agriculture, waste incineration, industrial processing, fossil-fuel combustion,

FIGURE 3-8. **Historic and Projected TVA Emissions of Sulfur Dioxide**



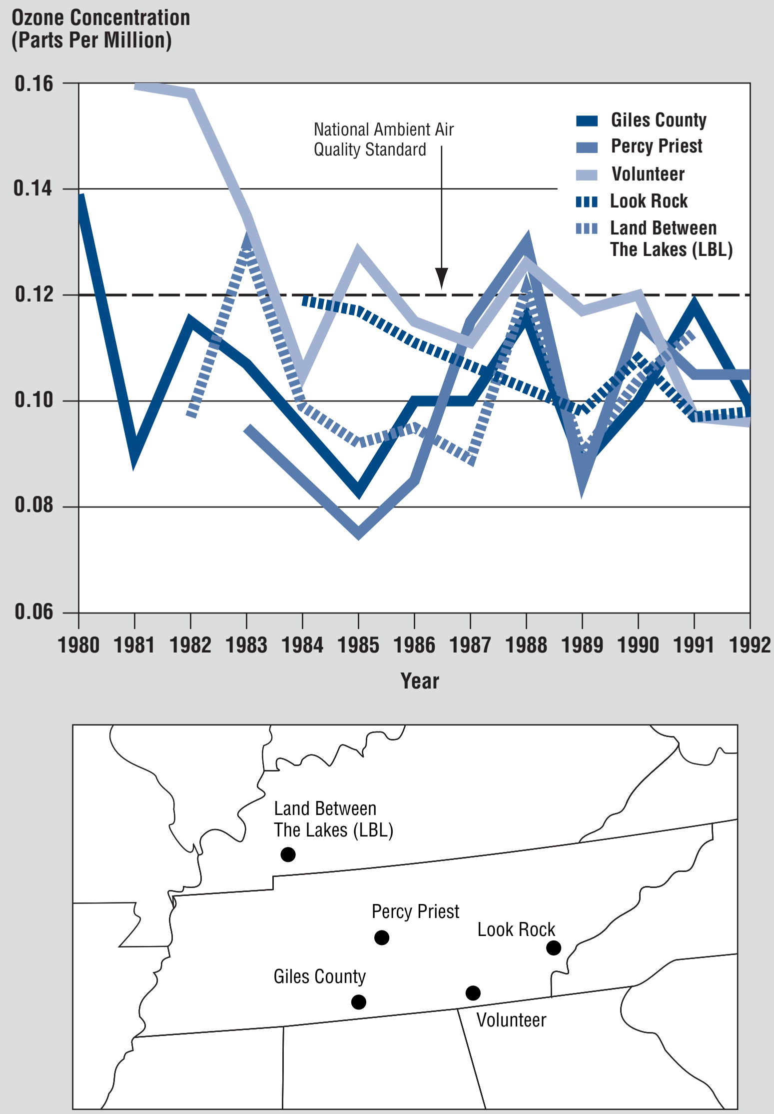
TVA emissions of sulfur dioxide have been reduced 60% since the 1970s and will be further reduced in compliance with the 1990 Clean Air Act Amendments.

FIGURE 3-9. **Historic and Projected TVA Emissions of Nitrogen Oxides**



TVA nitrogen oxides emissions increased during the 1990s as coal-fired generation increased. Emissions will decrease as TVA complies with the 1990 Clean Air Act Amendments.

FIGURE 3-10. **Maximum Hourly Ozone Concentrations at Five Monitoring Sites in the Energy Vision 2020 Study Area Have Shown Little Improvement**



construction, and mining. Human-produced emissions predominate in urban and industrial areas. Based on the 1985 emissions inventory by the National Acid Precipitation Assessment Program, TVA was found to contribute 5 percent of the human-produced total suspended particulate matter emitted in the 201 counties of the Tennessee Valley *(Figure 3-7)*. TVA emissions are primarily from coal-fired plants.

OZONE (INCLUDING NITROGEN OXIDES AND VOLATILE ORGANIC COMPOUNDS)

Health and Welfare Concerns

Ozone is a secondary air pollutant produced in the presence of sunlight from nitrogen oxides and volatile organic compounds in the lower atmosphere (troposphere). Ozone can irritate the eyes, nose, and throat, but typically the effects are temporary and pose no long-term health risks. Ozone at sufficient concentrations can harm vegetation and some materials.

In the Tennessee Valley, the cities of Chattanooga, Knoxville, Memphis, and Huntsville have recently attained the ozone standard. However, Nashville remains in non-attainment status. Other measures of ozone exposure across the Tennessee Valley have not shown any improvement that is discernable above the annual variability in trends due to meteorology *(Figure 3-10)*.

Sources of Contributions

Human-produced sources of nitrogen oxides, one of the contributors to ozone formation, were discussed earlier in this section. Human-produced sources of volatile organic compounds include motor vehicles, petrochemical storage and transport, chemical and industrial processing, and smaller sources. Vegetation, biological decay, and forest fires are natural sources of volatile organic compounds. In many areas of the southeastern United States, natural sources can contribute up to 90 percent of total volatile organic compounds. As shown in *Figure 3-7*, TVA emissions of volatile organic compounds are insignificant compared to the total amount emitted.

PREVENTION OF SIGNIFICANT DETERIORATION

The section of the 1977 Clean Air Act Amendments entitled "Prevention of Significant Deterioration" provides special protection for air quality and air quality-related values in national parks and wilderness areas, designated in the legislation as Class I areas. The Class I areas in the TVA region are designated on the map in *Figure 3-11*.

OTHER AIR QUALITY CONCERNS

Several air quality concerns have emerged in the past two decades. Acid deposition, regional visibility impairment, hazardous air pollutants, and greenhouse gases are now either regulated or being considered for regulation.

ACID DEPOSITION (INCLUDING SULFUR DIOXIDE AND NITROGEN OXIDES)

Health and Welfare Concerns

Acid deposition, or acid rain, is the acidification of rainfall below "natural" pH levels. Acid deposition can affect sensitive forests where ability to buffer incoming acids is depleted. High elevation spruce-fir forests, where loadings from wet, dry, and cloud deposition are greatest, are the most sensitive to acidification.

Data for the region around Tennessee indicate the most acidic (lowest pH) precipitation region to be Kentucky and portions of east Tennessee, with slightly lower acidity to the west and south. The lowest annual pH values for six sites across the TVA region are near 4.2 versus 5.2 to 5.6 for natural rainfall.

Sources of Contributions

TVA sulfur dioxide and nitrogen oxides emissions contribute to acid deposition. *(Figures 3-8 and 3-9)* The potential source area contributing to acid deposition in the Tennessee Valley is greater than that for ozone because the production rate of sulfate is slower than that for ozone. The rate of nitric acid formation is comparable to that of ozone. Conversion of sulfur dioxide to sulfate occurs within roughly 48 hours or an 800 to 1,000 kilometer distance from emissions sources. Thus, distant sources could be impacting sensitive areas such as the southern Appalachians, and TVA emissions could contribute to deposition outside the Tennessee Valley. However, the rate of sulfate formation can be very rapid in clouds, so depending on meteorological conditions, nearby sources may have greater contribution to deposition. TVA's contribution to acid deposition or acid rain is expected to decrease as its emissions of sulfur dioxide and nitrogen oxides are reduced in response to the 1990 Amendments to the Clean Air Act.

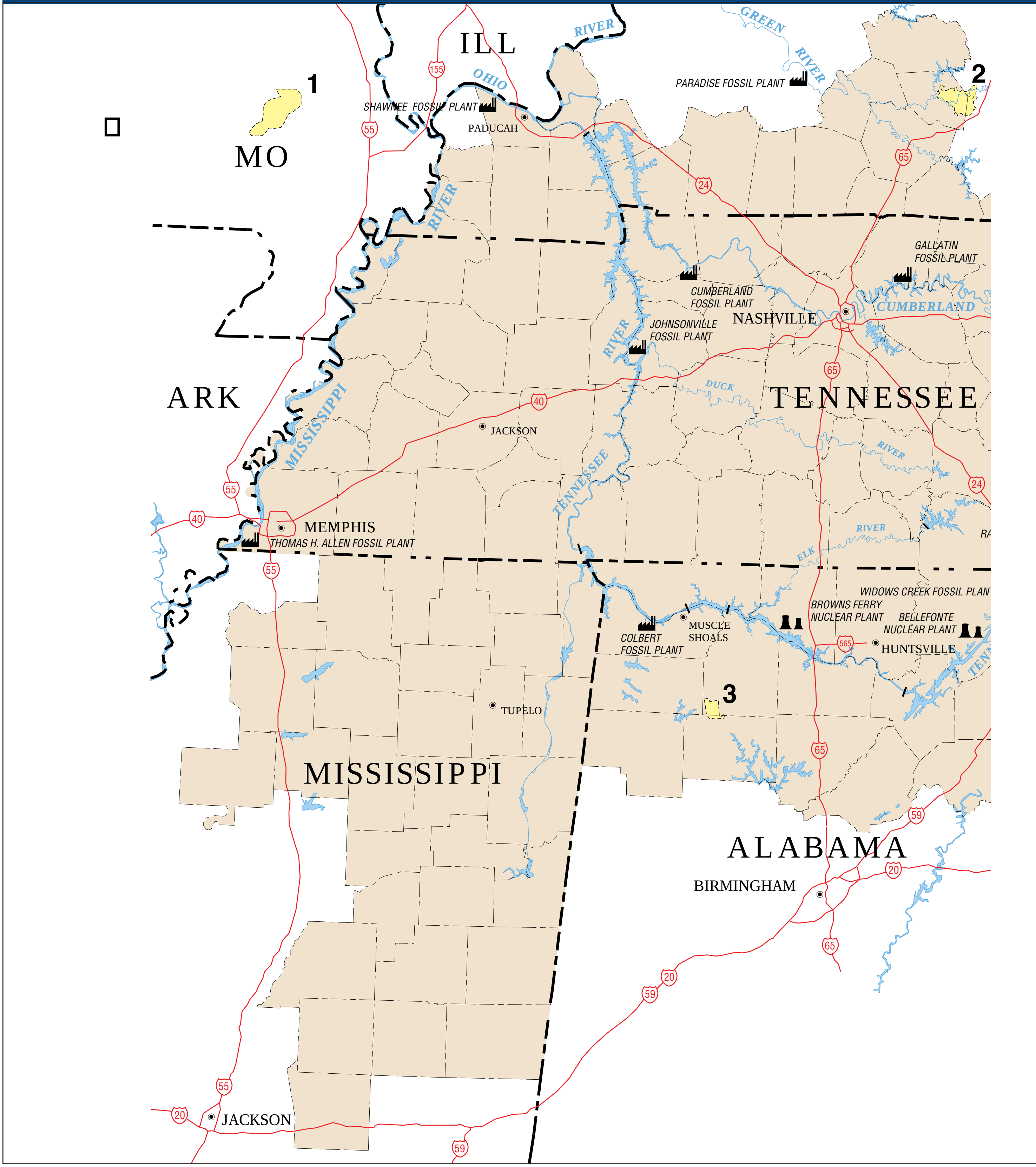
VISIBILITY IMPAIRMENT

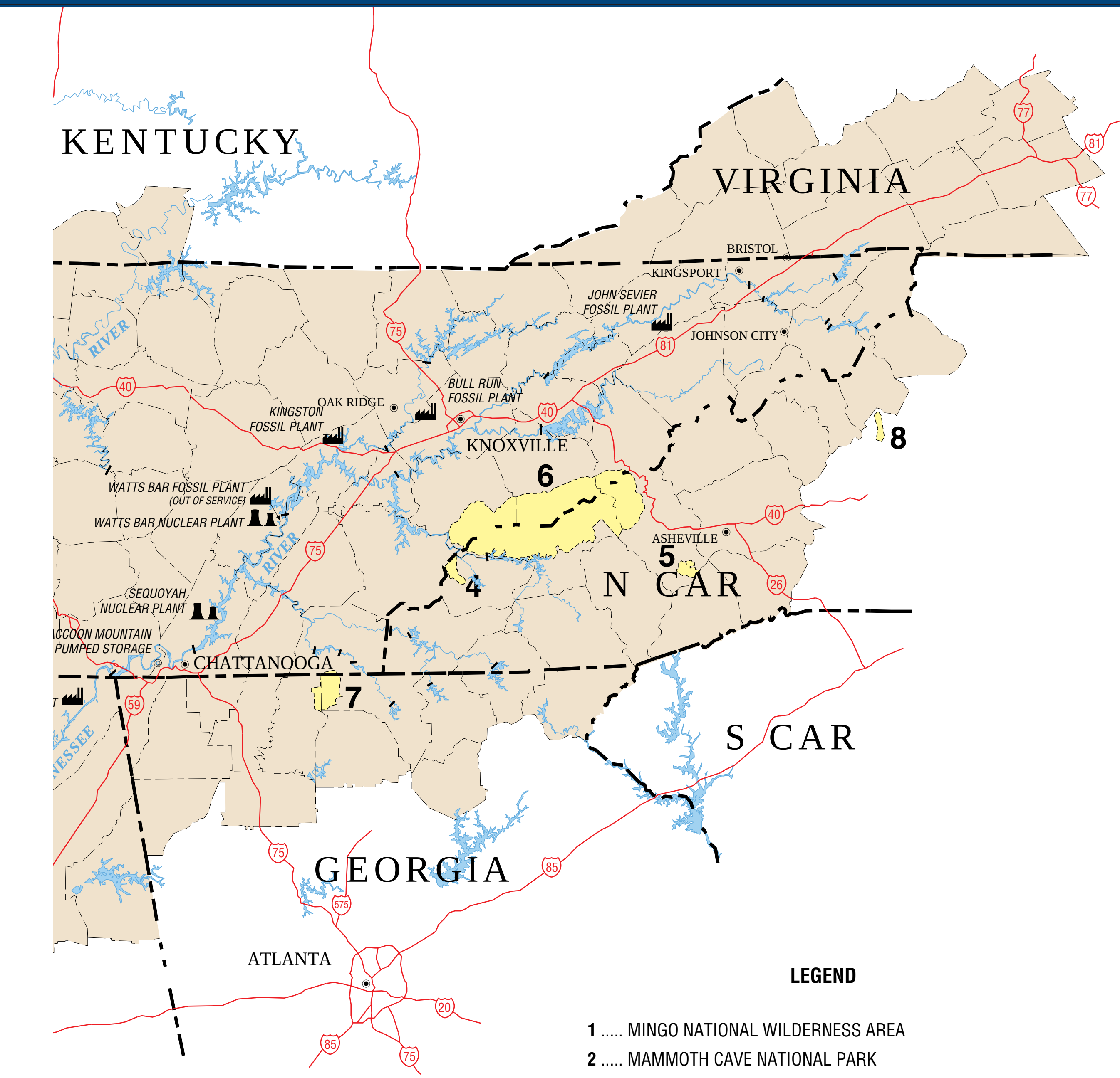
Health and Welfare Concerns

Visibility impairment refers to atmospheric conditions where the ability of an observer to discern form, color, or texture of a vista is reduced and therefore the scenic value of that vista is diminished.

Despite improvement in levels of sulfur dioxide *(Figure 3-6)* and particulate matter of less than 10 microns over the past decades, visibility has not

FIGURE 3-11. **National Park and National Wilderness Areas in the Energy Vision 2020 Study Area Designated as Air Quality Class I Areas for the Prevention of Significant Deterioration**





LEGEND

1 ..... MINGO NATIONAL WILDERNESS AREA
2 ..... MAMMOTH CAVE NATIONAL PARK
3 ..... SIPSEY NATIONAL WILDERNESS AREA
4 ..... JOYCE KILMER/SLICKROCK NATIONAL WILDERNESS AREA
5 ..... SHINING ROCK NATIONAL WILDERNESS AREA
6 ..... GREAT SMOKY MOUNTAINS NATIONAL PARK
7 ..... COHUTTA NATIONAL WILDERNESS AREA
8 ..... LINVILLE GORGE NATIONAL WILDERNESS AREA

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

improved in the TVA region. According to the U.S. Environmental Protection Agency's visibility studies, sulfates dominate visibility impairment in the eastern United States.

Sources of Contributions

The size of particles emitted directly from TVA facilities is generally larger than the size that impairs visibility. However, TVA sulfur dioxide and nitrogen oxides emissions contribute to levels of secondary sulfate and nitrate particles. The potential source area contributing to visibility impairment at areas of concern such as Class I areas in the southern Appalachians is roughly the same as that for acid deposition.

HAZARDOUS AIR POLLUTANTS

Health and Welfare Concerns

In the 1990 Clean Air Act Amendments, Congress identified 189 chemicals as air toxics. Depending on concentration, hazardous air pollutants can cause adverse health effects. From this list, the air toxics of greatest concern emitted by coal-fired power plants are arsenic, beryllium, cadmium, chromium, copper, and mercury. However, these pollutants are emitted in relatively small amounts.

Mercury is of special concern because levels observed in some sensitive watersheds in the upper midwestern United States, Canada, and Florida are sufficient to cause toxic effects to aquatic wildlife and to humans that consume contaminated fish. However, mercury levels in the Tennessee River and its tributaries are generally below thresholds set by the United States Environmental Protection Agency to protect human health. Atmospheric deposition in the Tennessee Valley is considered a minor contributor.

Radionuclides are one of the hazardous air pollutants being evaluated by the Environmental Protection Agency in its study of utility industry hazardous air pollutant emissions. Coal-fired boilers emit trace amounts of radioactive elements (uranium, radium, thorium, and their decay products) found in the fuel. These radionuclides become incorporated into fly ash and are released to the air in the particulate matter emitted from the boilers. Particulate air pollution control equipment, such as electrostatic precipitators, limit radionuclide emissions.

Sources of Contributions

The Electric Power Research Institute, the Environmental Protection Agency, and the Department of Energy have characterized toxic emissions for nearly 100 United States utility boilers representing a range of fuels, boiler configurations, and control technologies. On the basis of this data, the Electric Power Research Institute has estimated emissions and risk to human health from emissions at more than 600 utility plants. The Electric Power Research Institute's assessment indicated that none of the TVA plants and only 3 of the 600 plants in the study posed cancer risks greater than the 1-in-1-million criteria used by the Environmental Protection Agency as a level of possible health concerns.

GLOBAL CLIMATE CHANGE

The balance of solar energy received and heat radiated from the earth to space controls the earth's climate. Greenhouse gases absorb infrared (long wave) or thermal radiation emitted by the earth. This helps seal in some of the heat the earth would otherwise have lost from solar energy it received. The greenhouse effect is a natural phenomenon that makes the earth habitable. Greenhouse gases produced by human activities include water vapor, carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons.

Globally, atmospheric concentrations of greenhouse gases are believed to have increased from pre-industrial levels. The current rate of increase of carbon dioxide is 1.8 parts per million per year or 0.5 percent per year. Fossil fuel combustion and global deforestation are the primary contributors to carbon dioxide buildup. There is little doubt that carbon dioxide concentrations are increasing, but scientific debate continues about its consequences. Should changes in temperature and rainfall occur within a region such as the Tennessee Valley, there could be far-reaching impacts in areas such as energy, transportation, agriculture, forestry, and socioeconomic factors.

Despite the scientific uncertainties, TVA has agreed, along with some 75 other utilities, to participate in the United States Department of Energy's Climate Challenge initiative and to voluntarily limit equivalent TVA carbon dioxide emissions by the year 2000.

AIR QUALITY INDICES

TVA's existing energy resources and many of the resource options considered for Energy Vision 2020 can affect air quality in different ways. Air indices were developed to help characterize how TVA power system operations and alternative energy strategies might affect air quality impact areas.

A separate measure was also developed to sum the net greenhouse gas emissions for alternative future energy supply strategies. The measure is expressed in equivalent tons of carbon dioxide, the most common greenhouse gas.

A full explanation of the process used to develop measures for environmental evaluation criteria can be found in Volume 2, Technical Document 4, Evaluation Criteria.

Regional Water Resources

INTRODUCTION TO WATER RESOURCES AND POLLUTANTS

The quality of the region's water (surface water and groundwater) is critical to protection of human health and aquatic life. These water resources provide habitat for aquatic life, recreation opportunities, domestic and industrial water supplies, and other benefits.

Water quality can be affected through air emissions and deposition and wastewater from power plants, construction of facilities, and extraction of fuels to be used in power plants.

The scope of Energy Vision 2020 covers the TVA operating area, which includes the entire Tennessee and Cumberland River basins and portions of the lower Ohio, lower Mississippi, and Green and Ohio River basins *(Figure 3-12)*. Fresh water abounds in this area and generally supports most beneficial uses, including fish and aquatic life, public and industrial water supply, waste assimilation, agriculture, and water-contact recreation such as swimming. Water quality in the TVA region is generally good.

THE TENNESSEE RIVER

The Tennessee River basin contains all except one of TVA's dams and covers most of the TVA region. A series of nine locks and dams built mostly in the 1930s and 1940s regulates the entire length of the Tennessee River and allows nav-

FIGURE 3-13. **Principal Water Quality Concerns in TVA Reservoirs**

Navigation & West Tributary Reservoirs	USES AFFECTED: Aquatic Life	Fish Consumption	Recreation	Water Supply	SOURCE: Point	Non-Point
Kentucky			Aquatic Plants			
Normandy	Low Dissolved Oxygen			Taste, Odor, Iron, Manganese	X	
Pickwick				Algae		X
Wilson	Low Dissolved Oxygen			Taste, Odor		X
Wheeler	Low Dissolved Oxygen	DDT			X	X
Tims Ford	Low Dissolved Oxygen					X
Guntersville			Aquatic Plants			X
Nickajack		PCBs, Chlordane			X	X
Chickamauga	Low Dissolved Oxygen				X	X
Watts Bar	Low Dissolved Oxygen	PCBs			X	X
Melton Hill		PCBs				X
Ft. Loudoun		PCBs	Bacteria		X	X
Tellico	Low Dissolved Oxygen	PCBs				X
East Tributary Reservoirs						
Norris	Low Dissolved Oxygen					X
Cherokee	Low Dissolved Oxygen				X	X
Ft. Patrick Henry						
Boone	Low Dissolved Oxygen	Metals, Toxics			X	X
South Holston	Low Dissolved Oxygen					X
Wilbur						
Watauga						
Douglas	Low Dissolved Oxygen			Color	X	X
Nolichucky	Siltation		Siltation	Siltation		X
Fontana	Low Dissolved Oxygen					X
Ocoee 1-3	Metals, Siltation	PCBs	Siltation		X	X
Blue Ridge						
Appalachia						
Hiwassee	Low Dissolved Oxygen					X
Nottely	Low Dissolved Oxygen				X	X
Chatuge	Low Dissolved Oxygen					X

igation to Knoxville. Virtually all the major tributaries have at least one dam, creating 14 multi-purpose storage reservoirs and seven single-purpose power reservoirs. *Figure 3-12* is a map of the basin, showing dams and reservoirs. This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries.

Surface Water

Major water quality concerns within the Tennessee River drainage basin include point and non-point sources of pollution that degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs. The principal water quality concerns in TVA reservoirs are summarized in *Figures 3-13* and *3-14* . This informataion was derived primarily using data and analysis generated through TVA's comprehensive ecological health and use suitability monitoring program as well as other TVA aquatic monitoring and assessment activities. The criteria used in making the determinations were state water quality standards and fish consumption advisories.

Point and Non-Point Sources of Pollution

Point and non-point sources of pollution include:

- **Heat-release**—Utility plants and industry may release into streams or lakes water that has been heated above the temperature of the body of water.
- **Wastewater**—Sewage treatment systems, industry, and others dispose of waste into streams and lakes.
- **Runoff**—from agriculture, urban uses, and mined land are non-point sources that result in stream or lake pollution.
- **Air pollution**—Pollutant concentrations in the air can affect surface waters through rainout and deposition.

TVA Heat Releases

TVA conducts extensive aquatic monitoring programs to ensure that thermal and other discharges do not cause adverse impacts even at permitted levels. Recent programs have focused primarily on potential effects on spawning and development of cool-water fish species such as sauger, but have also included attraction of fish to thermal plumes from power plants and possible increases in undesirable aquatic micro-organisms, such as blue-green algae. In general, these monitoring programs have detected no significant negative effects resulting from release of heated water from TVA facilities. That is, there

FIGURE 3-14. **Principal Water Quality Concerns in Tennessee Valley Watersheds [1]**

	USES AFFECTED [2]			SOURCE	
Watershed	Aquatic Life	Fish Consumption	Recreation	Point	Non-Point
Chickamauga-Nickajack		PCBs	Bacteria		X
Pickwick-Wilson	Toxics				X
Watts Bar-Melton Hill	Siltation	PCBs	Bacteria		X
Duck River	Siltation		Bacteria		X
Guntersville-Sequatchie	Siltation		Bacteria		X
Clinch-Powell	Siltation				X
Wheeler-Elk		DDT, PCBs	Bacteria		X
Holston	Toxics	Mercury	Bacteria	X	X
French Broad	Siltation	Dioxin	Bacteria	X	X
Little Tennessee	Siltation	PCBs		X	X
Hiwassee	Metals, Siltation			X	X

[1] As designated by TVA's Clean Water Initiative

[2] Uses are affected by the problem noted on at least one stream in the watershed.

Figure 3-12. **Water Resources Considered in Energy Vision 2020 Include the Entire Tennessee River Basin and Portions of the Cumberland, Ohio, Mississippi, and Green River Basins**

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has been no demonstrable damage to established water uses or aquatic ecological integrity.

TVA Wastewater

Nuclear Plant Wastewater. Nuclear power plants have noncomplex wastewaters that are subjected to various levels of treatment and usually discharged to surface waters. These releases are controlled through state-issued National Pollutant Discharge Elimination System permits, which are part of Federal Clean Water Act statutes. Periodic toxicity testing is performed on this discharge as part of the National Pollutant Discharge Elimination System permit to ensure that plant wastes do not contain chemicals at deleterious levels that could affect aquatic life.

Coal-Fired Plant Wastewater. Coal-fired plants have several liquid waste streams that are treated and released to surface waters. These releases are permitted by each state under the National Pollutant Discharge Elimination System. Periodic toxicity testing of coal-fired wastewater ensures that there are no acute or chronic toxic effects to aquatic life.

Runoff and Air Pollution. Many non-point sources of pollution have not been subjected to government regulations or control and can contribute as much as five times more dissolved oxygen-consuming wastes than point sources. Principal causes of non-point source pollution are agriculture, including runoff from fertilizer, and pesticide and herbicide applications, erosion, and animal wastes; mining, including erosion and acid drainage; and urban runoff. Atmospheric deposition is another potential source of water pollution, particularly in relation to acid rain and fallout of toxic metals.

Low Dissolved Oxygen Levels

Another major water quality concern in the Tennessee River is low dissolved oxygen levels in stream reaches downstream of TVA dams. Long stretches of river can be affected, especially in areas where non-point source pollution uses up the dissolved oxygen restored through natural reaeration. TVA addressed this issue in its 1990 environmental impact statement, "Tennessee River and Reservoir System Operation and Planning Review." TVA has initiated a program to improve dissolved oxygen levels in water discharged from its dams based on this study.

Groundwater

Groundwater refers to water located beneath the surface in rock formations known as aquifers. Approximately half of the region has limited groundwater availability because of natural geohydrological conditions.

More than 64 percent of the region's residents rely totally, or in part, on groundwater for drinking water. More than 1.7 million residents (22 percent) in the region maintain individual household groundwater systems, usually a well. All areas in the Tennessee Valley region can generally supply enough

water at least for domestic needs. For the most part, the groundwater quality is adequate to support existing water supply uses even though some minimal treatment, such as filtration and chlorination, might be required.

Aquatic Life

The construction of the TVA dam and reservoir system fundamentally changed the character of the Tennessee River and its tributaries. While dams promote navigation, flood control, power benefits, and river-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal, and annual flow patterns that are characteristic of a river.

Tributary Reservoirs and Tailwaters

Reservoirs on the tributaries to the Tennessee River are typically of the deep storage type that retain water for long periods of time. Little flow and regular periods of thermal stratification result in oxygen depletion in the deeper water. These aquatic habitats are simplified relative to undammed streams, and fewer species are found. Lack of minimum flows and low dissolved oxygen in the first few miles below tributary dams may severely limit the habitat needed by native fish. This may restrict their movement, migration, reproduction, and available food supply.

Dams on tributary rivers affected the habitat of benthic invertebrates (benthos), which are a vital part of the food chain of aquatic ecosystems. Benthic life includes worms, snails and crayfish, which spend all of their lives in or on the stream beds, and aquatic insects, mussels and clams, which live there during all or part of their life cycle. Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters below dams. Further downstream from dams, the number of benthic species increases as natural reaeration occurs and dissolved oxygen and temperatures rise.

Mainstream Reservoirs

The nine mainstream reservoirs on the Tennessee River differ from tributary reservoirs primarily in that they are shallower, have greater flows, and thus retain the water in the reservoir for a shorter period of time. They generally do not become as strongly stratified as tributary reservoirs. Although dissolved oxygen in the lower lake levels is often reduced, it is seldom depleted. Winter drawdowns on mainstream reservoirs are much less severe than tributaries, so bottom habitats generally remain wetted all year. This benefits benthic organisms, but promotes the growth of aquatic plants in the extensive shallow overbank areas of some reservoirs.

Tennessee River mainstream reservoirs generally support healthy fish communities, ranging from about 50 to 90 species per reservoir. Good to excellent sport fisheries exist, primarily for black bass, crappie, sauger, white and striped bass, sunfish, and catfish. The primary commercial species are channel and blue catfish and buffalo.

OTHER RIVERS IN THE STUDY

The Tennessee River basin contains most of TVA's dams and power plants. In addition to these facilities, the Ohio, Green, and Mississippi Rivers each host a TVA coal-fired plant; and the Cumberland River basin, two coal-fired plants and a hydroelectric plant.

Any surface water, groundwater, and aquatic life characteristics in these rivers that differ from those described under the Tennessee River can be found in Volume 2, Technical Document 1, Comprehensive Affected Environment, as can a more detailed discussion of the affected environment of the Tennessee River.

WATER QUALITY INDICES

Water indices were developed to help characterize how TVA power system operations might contribute to each of the environmental impact areas selected. The indices provide measures to evaluate environmental impacts of alternative future energy supply strategies. Measures in the indices are weighted by the relative contribution of TVA power system operations to water quality impacts and issues. A full explanation of the process used to develop measures for environmental evaluation criteria can be found in Volume 2, Technical Document 4, Evaluation Criteria.

Regional Land Resources

INTRODUCTION TO LAND RESOURCES

The TVA region encompasses some 58 million acres. Of this area, non-federal rural land occupies about 50 million acres. As in all areas inhabited by humans, resource problems do exist. Humans have influenced the entire Tennessee Valley and its adjacent region through agriculture, timber harvesting, and other land uses.

A broad range of land uses takes in management of the natural ecosystem, agriculture, forestry, urban and industrial use, and recreational use. Factors such as soils, groundwater, wildlife, sensitive or threatened ecosystems, threatened and endangered species, cultural resources, and terrestrial environments, such as wetlands and forests, are critically important in supporting and preserving these uses.

TVA affects land resources through site selection for power plants, reservoirs, and transmission lines; fuel procurement; air emissions; radioactive waste management; and solid waste management.

AGRICULTURAL LANDS AND CROP PRODUCTION

The TVA region is a predominantly rural area with 40 percent of the land area in crop production or pasture and 55 percent in forest. Small farms that grow and market a wide diversity of agricultural products characterize agriculture in the Tennessee Valley. Corn, cotton, soybeans, tobacco, wheat, and vegetables account for the major crops produced in the region. Livestock production is

another major agricultural activity and land use. About 14 million acres of prime farmland occupy the Tennessee Valley region, distributed as 55 percent cropland, 23 percent pasture, 20 percent forest, and 2 percent nonagricultural.

FOREST RESOURCES

Fifty-five percent of the TVA region is forested. Reserved forest land, consisting of parks, wilderness areas, and other forested lands specifically withdrawn from commercial timber cutting by legislation or administrative designation, totals 944,976 acres. The remainder of the forested area, 31 million acres, or 97 percent of the forest, is classified as timberland.

Forest stressors include past land use practices that resulted in erosion and site degradation, extreme climactic conditions (freezing injury, ice damage, drought, flooding), air pollutants, and exotic, as well as native, forest insects and diseases.

CULTURAL RESOURCES

The Tennessee Valley region features many archaeological sites. The National Historic Preservation Act requires federal agencies to appropriately identify, protect, and manage significant cultural resources on their land or those affected by their undertakings whether on federal or nonfederal property.

OTHER LAND USE CONDITIONS

Electric and Magnetic Fields

Electric and magnetic fields (EMF) are both natural and man-made. For example, every device that generates, transmits, or uses electricity produces these two types of energy fields. These include electric power lines, electric appliances, motor vehicles, and electric wiring.

A 1979 epidemiological study suggested that there might be a potential link between magnetic fields associated with electric distribution lines and childhood leukemia. After 15 years of further research, results have been mixed. If EMF does indeed pose a risk, most researchers believe that it is low.

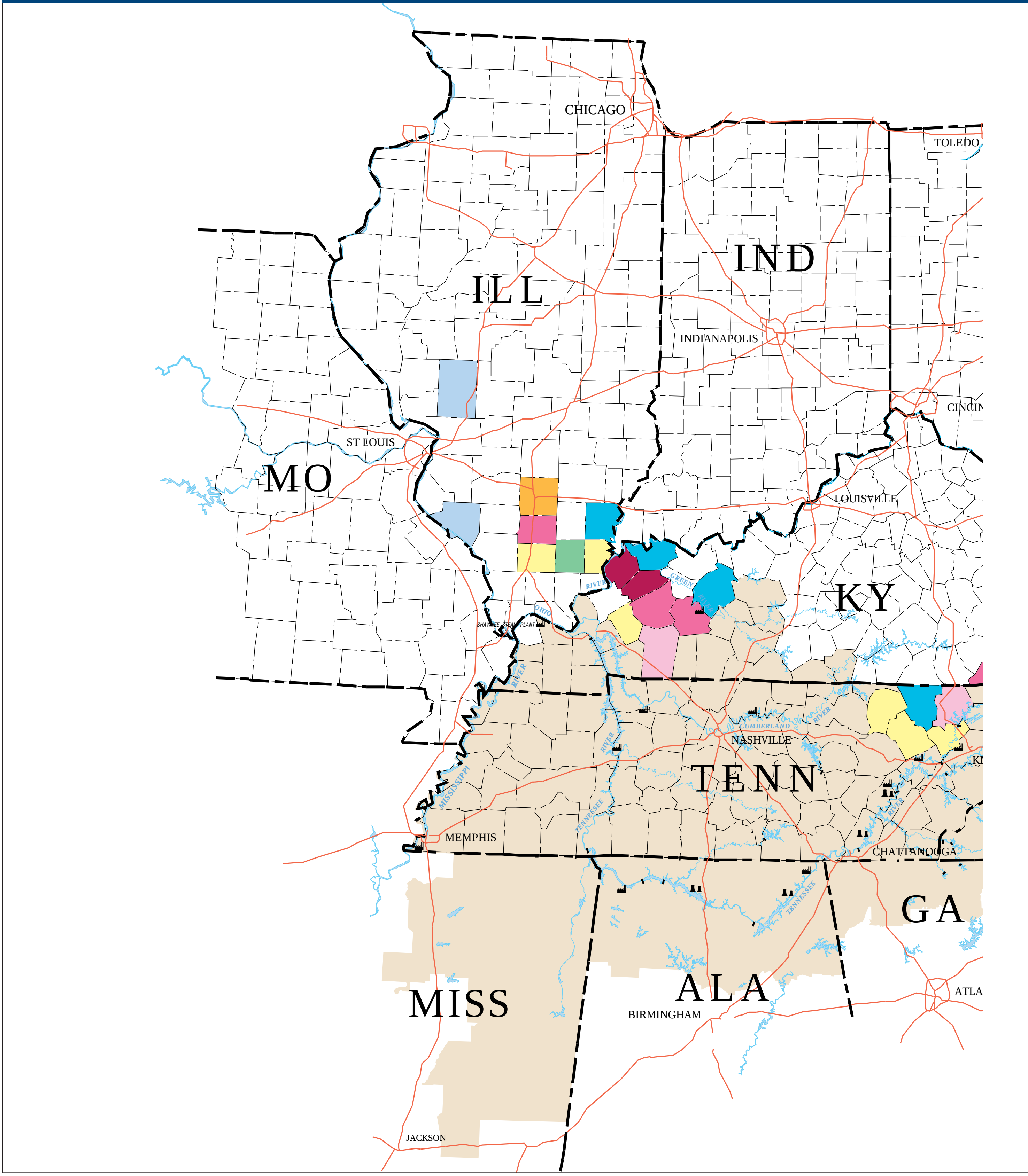
No federal regulations govern EMF exposure levels. TVA adopted interim guidelines in 1993 that address EMF exposures. Under these guidelines, TVA will take into account EMF exposure when planning new transmission lines. In addition, TVA will design upgrades of existing lines to reduce EMF levels when practicable.

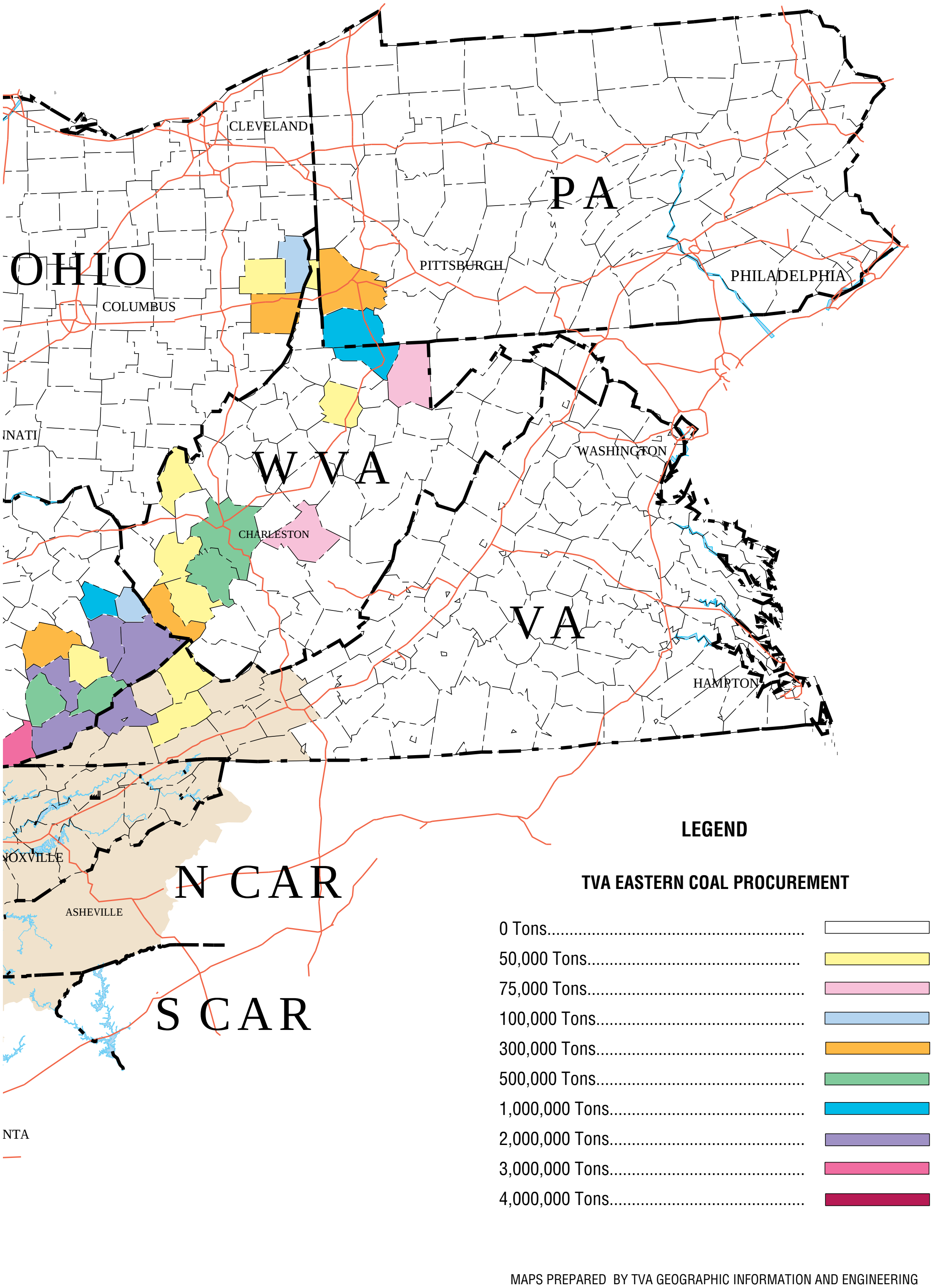
Fuel Procurement

TVA's eastern coal procurements are about 7.1 percent of the eastern United States production (east of the Mississippi River) and about 0.36 percent of the western United States production. The map in *Figure 3-15* shows the location and intensity of TVA coal procurement in the eastern United States by county for fiscal year 1994.

Land-related environmental impacts of mining are primarily the direct and indirect effects of changes in land use. These impacts may include acid drainage from exposed sulfur-bearing rock, erosion from disturbed mining areas

FIGURE 3-15. **TVA Procured Coal From Seven Eastern States in Fiscal Year 1994**




CLEVELAND
PA
PITTSBURGH
PHILADELPHIA
OHIO
COLUMBUS
W VA
WASHINGTON
CHARLESTON
VA
HAMPTON
N CAR
ASHEVILLE
S CAR
LEGEND
TVA EASTERN COAL PROCUREMENT
0 Tons
50,000 Tons
75,000 Tons
100,000 Tons
300,000 Tons
500,000 Tons
1,000,000 Tons
2,000,000 Tons
3,000,000 Tons
4,000,000 Tons
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

and coal transport roads, loss of wildlife habitat, stream siltation, unstable land situations, and fugitive dust. Various regulations, including those implementing the Surface Mining Control and Reclamation Act of 1977, have reduced the potential risk of significant impacts.

The natural uranium for TVA's nuclear plants comes from uranium producing areas all over the world. TVA's five nuclear units use a total of about 2.5 million pounds of U308 per year. TVA currently has sufficient inventory to last until 1999. TVA and a number of other United States utilities are expected to soon be using commercial grade slightly enriched uranium derived from nuclear warheads. The highly enriched uranium obtained from both United States and Russian nuclear warheads will be diluted to low levels, which allows its use in commercial nuclear plants.

Coal Combustion Solid Wastes

The combustion of pulverized coal in power plant boilers produces solid wastes such as fly ash and bottom ash (or boiler slag in some boiler designs). Any of these wastes may be marketed as byproducts, depending on their quality and on market conditions.

TVA production of these byproducts during fiscal year 1994 was nearly 6 million tons, with almost half being fly ash. Of the 6 million tons, 1.177 million tons, or 20 percent, were utilized or marketed. The remainder of the byproducts is either disposed of or stored on the plant site in ash ponds or in dry-stacked landfills.

Nuclear Waste

The nuclear fuel used for power plants produces radioactive solid wastes requiring storage and disposal. These wastes are placed in two categories: high-level radioactive waste and low-level radioactive waste. These indicate the type of radioactive material, the intensity of its radiation, and the time required for decay of the radiation intensity to natural levels.

High-Level Nuclear Waste

Background. Operation of TVA's 5 nuclear units will produce about 115 metric tons of used fuel each year. After it is removed from the reactor, used or spent fuel is stored at nuclear plant sites either in pools or in dry casks. The Nuclear Waste Policy Act of 1982 established a program to build the nation's first underground high-level waste repository early in the next century. In 1987, amendments to the Nuclear Waste Policy Act designated the remote area of Yucca Mountain, Nevada, northwest of Las Vegas, for study as a permanent repository site. The Department of Energy has begun site characterization and the comprehensive scientific investigation of Yucca Mountain's suitability.

TVA Spent Fuel Storage. TVA plans to continue to store spent nuclear fuel on-site at plant locations until the Department of Energy accepts physical custody by shipment off-site to a monitored retrievable storage facility or to an underground repository for ultimate disposal by burial. Current spent fuel storage capacity is sufficient at Sequoyah Nuclear Plant until 2004, and Browns

Ferry Nuclear Plant until 2007. Based on a one-unit operation of Watts Bar Nuclear Plant, spent fuel storage capacity will be sufficient until 2018.

TVA has sufficient outside site area at each of its nuclear facilities to store any high-level waste associated with decommissioning activities and life-of-plant quantities of used fuel. As the pools approach the current storage limits, TVA will initiate studies to increase on-site storage capacity.

Low-Level Nuclear Waste

In a nuclear energy plant, the low-level radioactive waste comes from items such as filters, cloth and paper wipes, plastic shoe covers, tools and materials, water purification media (resins), and other residues.

Until July 1995, the low-level waste generators located in the eight Southeastern states were required to dispose of their waste at the Barnwell, South Carolina disposal facility. In July, South Carolina withdrew from the Southeast Compact Commission in order to open the Barnwell facility to all states except North Carolina. The states participating in the Southeast Compact Commission have selected North Carolina as the host state to select, license, and construct a new disposal site. TVA plans to continue to use the Barnwell facility for low-level radioactive waste disposal until the North Carolina facility is opened. Should either or both of the disposal facilities close unexpectedly, low-level radioactive waste will be stored in on-site facilities at the TVA nuclear plants. These facilities are sized to handle any anticipated storage needs for the foreseeable life of the plants.

BIOLOGICAL RESOURCES

The biological resources of the Valley are summarized in this section.

Terrestrial Ecology

Wetlands

Wetlands are typically lands that are covered by shallow water or have a water table near the surface, or support plants typically found in wet habitats. Although wetlands occur throughout the TVA region, they are most extensive in the south and west.

Wildlife

The TVA region contains portions of seven physiographic regions and a great variety of plant and animal communities. About 70 species of mammals, 300 species of birds (including 175 which nest within the region), 65 species of reptiles, and 77 species of amphibians can be found regularly in the region. Several salamander species are only found in the TVA region (endemic). Few other terrestial vertebrate species are restricted to the TVA region

Vegetation

TVA's 201-county region contains approximately 4,300 species of herbs, shrubs, and trees in numerous habitats and plant communities. Much of the region is heavily forested. Based on an analysis of mature forests, Braun recognized

five major forest regions in the TVA area. Local vegetation types vary greatly within Braun's regions because of variation in elevation, relief, soil fertility, moisture, and the degree of human disturbance. These forest regions are described in more detail in Volume 2, Technical Document 1, Comprehensive Affected Environment.

Sensitive or Threatened Ecosystems

The TVA region includes several terrestrial communities that are either restricted to the TVA region, are best represented there, or include a large proportion of their total area in the region. These include the Southern Appalachian spruce-fir, cedar glade, and limestone cave systems. Several endangered plant and/or animal species, as well as species not found outside the TVA region, occur in each of these communities.

Threatened and Endangered Species

Thirty-eight species of plants and 100 species of animals in the TVA region are either listed as endangered or threatened species or formally proposed for such listing by the United States Fish and Wildlife Service. These species, their distribution by river basin, and their habitats are listed in Volume 2, Technical Document 1, Comprehensive Affected Environment. An additional 380 species in the TVA region have been identified by the United States Fish and Wildlife Service as candidates for listing.

Chapter Four

Existing Power System

Chapter Four: Existing Power System

TVA's existing power system provides 25,600 megawatts of dependable generating capacity in the summer—57 percent from coal-fired plants, 16 percent from hydro facilities, 13 percent from nuclear, 8 percent from combustion turbines, and 6 percent from pumped-storage hydro.

TVA will add two nuclear units in 1996 (Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3), which will bring the total capacity to 28,000 megawatts.

TVA's existing coal-fired plants will continue to provide the largest part of TVA's generating supply during the Energy Vision 2020 planning period. Although the 1990 Clean Air Act Amendments imposed significant requirements on utilities to reduce sulfur dioxide emissions, as well as other air pollutants, TVA is taking actions that will meet or exceed these requirements.

TVA operates approximately 16,000 miles of transmission lines to carry power from 42 generating sites to 750 wholesale delivery points. TVA also connects with 13 neighboring utilities at 57 different locations.

In 1994, TVA generated 134 billion kilowatt-hours of electricity—84 percent was wholesaled to distributors, with the balance to directly served industrial and federal customers. The total revenue from these sales was $5.4 billion.

In 1988, TVA changed its wholesale rate design to meet several objectives, including equity, efficient operations, and competitiveness. Looking to the future, TVA recognizes that rates for electric services will have to be more flexible to meet customer and consumer needs and expectations.

This Chapter Includes:

- TVA Customers and Sales
- Generating Resources
- How Power Supply Decisions Are Made
- 1990 Clean Air Act Amendments' Impact on Generating Facilities
- Customer Service Programs/Demand-Side Management
- TVA's Transmission System
- TVA's Financial Condition and Results of Operation
- TVA's Electric Rate Structure

Existing Power System

TVA Customers and Sales

TVA is the nation's largest public power utility, generating more than 134 billion kilowatt-hours of electricity annually, enough power to supply three cities the size of New York City. Through 160 municipal and cooperative power distributors, TVA serves 7.7 million people in parts of 7 states.

Revenues from power sales totaled $5.4 billion for fiscal year 1994. In addition, Congress provides appropriated funds (tax money) to TVA for regional resource and economic development and stewardship of the federal investment. Appropriations for fiscal year 1994 were $140 million, or 2.6 percent of TVA's total budget. TVA's power program is self-financing, and Congress provides no funds for it.

TVA is the nation's largest public power utility, generating more than 134 billion kilowatt-hours of electricity annually, enough power to supply three cities the size of New York City.

TVA IS A POWER WHOLESALER

TVA is primarily a wholesaler of power. Wholesale power is delivered to 160 power distributors that, in turn, distribute electricity to homes and businesses within their service areas. These distributors are a diverse group. The largest distributor of TVA power, Memphis Light, Gas & Water Division, serves 360,000 customers with annual electric sales of almost 12 billion kilowatt-hours. Some of the smaller municipal systems serve 1,500 customers or fewer. Electric cooperatives range in size from 3,500 customers to 95,000 customers.

TVA also sells power directly to 54 industries that have large or unusual loads and to 10 federal installations. Together, these directly served customers account for about 16 percent of TVA's energy sales. The directly served industries include chemical, metal, paper, textile, and automotive manufacturers.

TVA also has arrangements for exchanging power with 13 neighboring electric systems with which it buys and sells power on an almost daily basis.

Figure 4-1 provides a breakdown of TVA customers and sales for fiscal year 1994.

TVA POWER EXCHANGES

TVA exchanges, or buys and sells power, with neighboring electric systems through 57 interconnections. The sale of power by TVA provides a way to earn revenue. The purchase of power is sometimes necessary to meet heavy demand; at other times, it may be more economical for TVA to purchase excess power from a neighboring utility than to generate it. TVA also "wheels" power

FIGURE 4-1. **TVA Customers and Sales for Fiscal Year 1994**

	Customers	Annual Energy (Millions of kWh)	Estimated Impact on Annual Peak (MW)
DISTRIBUTOR SERVED SALES			
Residential	3,068,076	46,330	11,900
Commercial	501,198	33,408	5,400
Manufacturing	3,036	23,101	2,900
Outdoor Lighting	14,216	1,235	0
Direct-Served Industrial Sales	54	16,706	1,700
Direct-Served Federal Sales	10	2,309	700
Other Sales and Losses		11,077	1,800
Total Requirements		134,166	24,400

TVA wholesales electricity to power distributors and sells electricity directly to some large industrial customers and federal agencies. In addition, TVA at times sells power to neighboring utilities who are connected to the TVA power transmission system. Figure 4-1 shows the number of customers served by distributors and TVA and the electricity sales to each group.

at a fee for other utilities. Wheeling is transporting power from one utility to another through TVA's transmission system.

For fiscal year 1994, power exchanges with other utilities were as follows:

- **Sales to other utilities** – 8.6 billion kilowatt-hours (6 percent of TVA's total sales)
- **Purchases from other utilities** – 8.2 billion kilowatt-hours
- **Wheeling transactions** – 0.9 billion kilowatt-hours

It is interesting to note that in 1988, TVA was a net purchaser of power at a cost of $330 million. In 1992, TVA became a net seller, producing off-system sales revenue of almost $95 million. By 1994, revenue from net sales climbed to $193 million. This increase in sales can be attributed to improvements in TVA's generating system, increasing both efficiency and production capacity.

Generating Resources

TVA currently has 25,600 megawatts of generating capacity. Electricity is produced through a combination of coal-fired, hydroelectric, nuclear, combustion turbine, and pumped-storage hydro plants. *Figure 4-2* shows the capacity mix and the percentage of capacity supplied by each type of generation.

TVA plans to begin operating Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 in 1996, which will add 2,235 megawatts of generating capacity to the power system. Other adjustments to generating capacity will include improvements to the hydro and coal-fired plants and the sale of steam, bringing total capacity to 28,000 megawatts in 1996.

FIGURE 4-2. **TVA's 1994 Capacity Mix**

Type of Capacity	Megawatts	Percent
Conventional Hydro	4,044	16
Pumped-Storage Hydro	1,532	6
Coal	14,743	57
Combustion Turbines	1,952	8
Nuclear	3,282	13
TOTAL	25,553	100

TVA produces power from a number of different types of generating sources. This chart shows the generating capacity for various types of resources and the percentage of TVA's overall generating capacity provided by each.

In addition to conventional power generation, TVA has more than 2,500 megawatts of interruptible power contracts that allow TVA to interrupt power to industrial customers during peak load periods. This interruptible power is used as part of TVA's available capacity; however, due to variations in industrial plant operations, not all of the contracted power is available for interruption at the same time. Typically, about 1,700 megawatts of industrial load reduction are available at peak times.

TVA's generating sources are a diverse mix that offers TVA a distinct advantage over many other utilities. The varied mix provides a buffering effect that helps TVA absorb the impacts of changes that affect only one particular

type of generation, such as more stringent nuclear regulations or coal-fired air emission reduction requirements. By "averaging" the impacts across the system, the effects are greatly reduced compared to a utility that is chiefly dependent on a single type of generating source.

A description of TVA's various generating resources—hydro (conventional and pumped-storage), coal-fired, combustion turbine, and nuclear plants—follows. Generating capacity for fiscal year 1994 is included for each source of production.

TVA'S HYDRO SYSTEM

The TVA hydro system includes 109 conventional hydroelectric generating units and four pumped-storage units at Raccoon Mountain Pumped-Storage Facility. These conventional hydro units are located at 29 sites along the Tennessee River and its tributaries.

Hydro capacity is 4,044 megawatts, which includes 405 megawatts available from the U.S. Corps of Engineers' hydro generating plants along the Cumberland River and 321 megawatts from Aluminum Company of America plants. Aluminum Company of America owns hydro plants located on tributaries of the Tennessee River, and TVA operates these plants as part of its power supply system.

Hydro generating capacity will be increased as the result of ongoing modernization projects. Upgrades and improvements at TVA's plants will add approximately 360 megawatts of capacity by 2005, while improving the efficiency of these plants by 3 percent.

COAL-BURNING POWER PLANTS

TVA has 59 active coal-fired units located at 11 plant sites throughout the Valley. The coal-fired units range in size from 107 megawatts for each of the Johnsonville units 1-4 to 1,224 megawatts for each of the two units at Cumberland. The oldest active coal unit was placed in service in 1951, and the newest unit is Cumberland 2, which began operation in 1973. A recent review identified no technical problems that would prevent the continued operation of these generating units through the study period covered by Energy Vision 2020.

TVA's coal-fired units have a combined capacity of 14,743 megawatts. TVA anticipates some minor reductions in coal system capacity as the result of the installation of pollution control equipment and the sale of steam, rather than electricity, to a DuPont facility adjacent to TVA's Johnsonville Fossil Plant.

COMBUSTION TURBINES

TVA has 48 combustion turbine units that are located at four coal-fired plant sites. Of this total, 28 are capable of burning natural gas or oil. The other 20 units have the capability to burn oil only. The combined capacity of these combustion turbines is 1,952 megawatts. The average age of TVA's combustion turbine units is approximately 23 years, and all units are anticipated to be available throughout the study period of Energy Vision 2020.

TVA recently upgraded the reliability of its combustion turbines, which has reduced the forced outage rate, a measurement of reliability.

NUCLEAR GENERATION

Five nuclear units, located at three sites, are included in TVA's existing inventory of supply resources: Browns Ferry Nuclear Plant Units 2 and 3, Sequoyah Nuclear Plant Units 1 and 2, and Watts Bar Nuclear Plant Unit 1. Total generating capacity of the three operating nuclear units is 3,282 megawatts. Watts Bar Nuclear Plant Unit 1 was granted a license to load fuel and perform low power testing in November 1995. Fuel loading was completed in November, and Watts Bar Nuclear Plant Unit 1 is expected to begin commercial operation in spring 1996. Browns Ferry Nuclear Plant Unit 3 fuel load was completed in October and it is scheduled to return to service in early 1996. These units are considered part of TVA's existing power system for the purposes of Energy Vision 2020.

The two units coming on line in 1996 will provide an additional 2,235 megawatts of generating capacity. Operating Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 will help meet projected future loads on the TVA power system at a very economically competitive cost. As of March 31, 1995, TVA's undepreciated investment in these two units was approximately $6.8 billion and $1.8 billion, respectively. Both Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 will be revenue-producing assets when they go into operation. The construction expenditures on these units will be depreciated, and the depreciation costs will be recovered in revenues. Revenues will exceed the depreciation, fuel, and operations and maintenance expense at the plants. Operating the plants will allow TVA to begin earning a return on the agency's investment in the form of generation from Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3.

Compared to purchasing power or meeting demand with coal-fired generation or combustion turbine units, operation of these two nuclear units will be among TVA's lowest cost generating sources. Operating costs for Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 are projected to be approximately 1.7 cents per kilowatt-hour. In contrast, the operating costs of alternative generating sources would range from 2.0 to 6.0 cents per kilowatt-hour.

TVA's nuclear performance has improved considerably during the past several years. The performance of Browns Ferry Nuclear Plant Unit 2 has been excellent since the plant was restarted in 1990. Performance at Sequoyah, while not reaching the same levels of excellence, has also had significant high points, including being ranked as one of the top nuclear plants in the country for net generation and setting the TVA record for longest continuous run by a large generating station in 1991. The combined capacity factor for TVA's three operating units for fiscal year 1995 was 80 percent.

While TVA has scaled back its nuclear construction program, nuclear generation will continue to play a vital role in helping provide economical power generation.

Detailed information on all of TVA's generating resources, such as plant locations, capacity, and performance and cost characteristics (including decommissioning cost for nuclear) can be found in Volume 2, Technical Document 3, Existing Power System.

How Power Supply Decisions Are Made

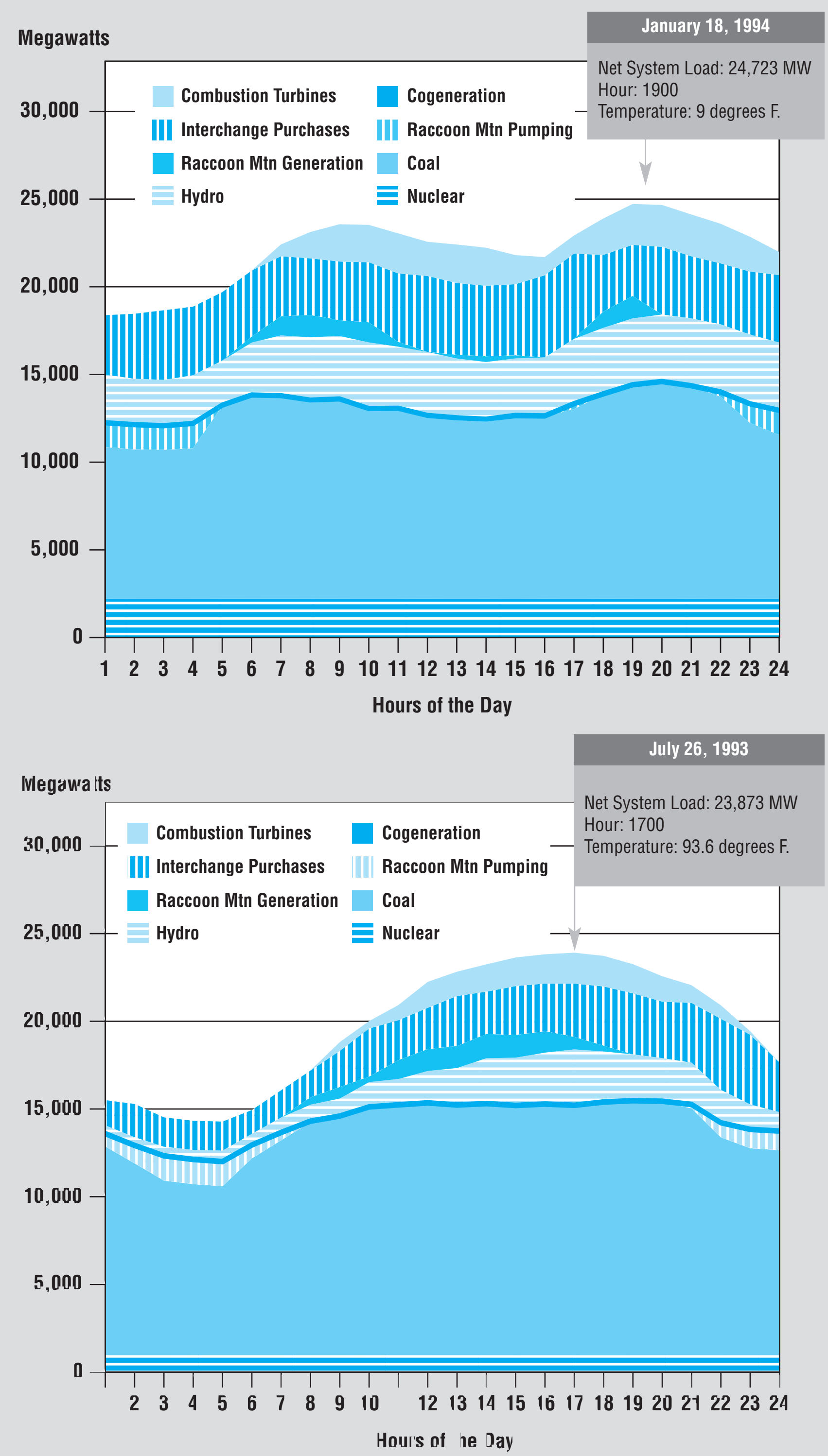
Though TVA has the capacity described in the previous section, the actual use of these energy sources varies depending on costs, weather, customers' needs, and other factors such as operating constraints of a particular power generation source.

Power from TVA's various generation sources is dispatched, or distributed, to meet the demand for electricity at the lowest cost. The primary factor in determining generating mix at any particular time is fuel costs. However, variable operation and maintenance costs (costs that vary with the power output of the various generating units) are added to the fuel costs in dispatching generating units. In addition, beginning in 1995, the economic value of the allowances required to emit sulfur dioxide from some TVA sources is included in making dispatching decisions.

Figures 4-3 and *4-4* show the dispatch of the system for the 24-hour periods of January 18, 1994, and July 26, 1993. These dates represent the all-time winter and summer peak demand on the TVA power system and illustrate how various power production sources are brought on line to meet energy demands.

The hydro resources are the least expensive to operate because they have no fuel costs. Hydro resources provide an economical way to reduce the amount of generation required from other, more expensive generating sources during periods of high demand. Hydro resources are not used continuously because they are limited by the amount of rainfall and runoff into the storage reservoirs or

FIGURE 4-3 & 4-4. **TVA Load and Supply**



Generating resources are brought on line as needed to meet customer demand for electricity. Since power production costs vary, depending on the generating source, plants are brought on line in the most economical sequence. These figures illustrate how the need for power was met during days of winter and summer peak demand.

lakes in the Tennessee Valley. There is significant variation in the amount of hydro output available from week to week and year to year based on the amount of rainfall. Hydro resources also must be operated under constraints to meet the needs of flood control and navigation, and take into account recreation and tourism effects.

Pumped-hydro capacity at the Raccoon Mountain Plant is used to meet peak requirements, as well as to satisfy other system needs such as operating reserve. The operating characteristics of a pumped-storage facility, however, make it a limited resource. The amount of generation is limited by the amount of water in the storage pond at the top of the mountain. This storage pond supports only a set number of hours of operation at full output. In addition, TVA's ability to pump water back into the storage pond may be affected at times by reduced availability of low-cost power to operate the pumps.

Energy production from hydro plants was 20.2 billion kilowatt-hours for fiscal year 1994, accounting for 15.4 percent of TVA's generation. This includes the net pumped-hydro generation from Raccoon Mountain and hydro generation received from the Corps of Engineers and Aluminum Company of America.

Nuclear generation is operated as much as possible, since its fuel costs are relatively low. Another consideration is the physical operating constraints of nuclear plants. Nuclear units are not easily cycled—meaning they cannot be brought on line quickly and the output of energy cannot be adjusted quickly compared to other sources. Hydro is, in contrast, a resource that can respond almost immediately to changes in demands for power. Therefore, nuclear generation is principally used as part of TVA's "base load." Base load is the minimal amount of power that must be available around the clock to meet demand.

Energy produced by TVA's nuclear plants during fiscal year 1994 totaled 18.4 billion kilowatt-hours, or 14 percent of all energy produced by TVA.

Coal-fired generation provides the bulk of TVA's power supply, representing more than 50 percent of the available generating capacity. Coal-fired units do vary in operating costs, depending on the technology at the various plants and the type of coal used by the generating units (high-sulfur coal or low-sulfur coal). In addition, some coal-fired plants, like nuclear units, are not designed to be brought on or off line quickly, and the output of energy is not readily adjustable.

TVA's coal-fired plants supplied 92.1 billion kilowatt-hours during fiscal year 1994, which was 70.4 percent of the total energy supply.

Combustion turbines are relatively high in cost to operate. Combustion turbine units operate on natural gas or fuel oil, both high-cost fuel sources. In addition, TVA's combustion turbines have lower efficiency compared to other types of generating resources. They are used sparingly to meet peak demands.

Energy production from combustion turbines during fiscal year 1994 was 0.2 billion kilowatt-hours, or 0.2 percent of all electricity generated.

1990 Clean Air Act Amendments' Impact on Generating Facilities

The 1990 Clean Air Act Amendments imposed new requirements on the utility industry. The most significant of these requirements derive from the "acid rain" provisions of the amendments, which require the United States electric utility industry to reduce its emissions of sulfur dioxide and nitrogen oxides. Utilities, such as TVA, that burn significant amounts of coal to generate electricity have substantial emission reduction obligations.

SULFUR DIOXIDE CONTROLS

The sulfur dioxide portion of the "acid rain" provisions also introduced on a national scale a new approach to environmental regulation. This approach is intended to reduce the overall cost of achieving the environmental objective by setting a national cap for utility sulfur dioxide emissions and establishing a mechanism to allow emissions reductions to come from the sources that can achieve these reductions at least cost.

The Environmental Protection Agency annually issues to each regulated source a number of sulfur dioxide "allowances" based on the sulfur dioxide annual average emission rate for each fossil unit in 1985 and the amount of coal burned during the baseline period of 1985 through 1987. (One "allowance" gives the source permission to emit one ton of sulfur dioxide.) A source's reduction obligation, the difference between baseline sulfur dioxide emissions and the number of allowances issued by the Environmental Protection Agency, can then be met by either reducing emissions from that source or by ensuring, through allowance transfers, that equivalent reductions are made at another source(s). A source is deemed to be in compliance if, at the end of the year, it holds enough allowances to cover its sulfur dioxide emissions.

Thus, utilities can choose to make "excess" reductions at one or more sources while either (a) making lesser or no reductions at other units on their system that are less economical to control, (b) selling the excess allowances to other utilities, or (c) banking the excess allowances for use in future years. Conversely, a utility could choose to take lesser or no reductions and achieve compliance by buying allowances from others.

Sulfur dioxide emissions are to be reduced in two phases according to the Clean Air Act Amendments. The larger and more polluting utility units are required to reduce sulfur dioxide emissions in Phase I. Phase I sources generally were to be in compliance by January 1, 1995. In Phase II, the remainder of utility sources become subject to sulfur dioxide reductions, and the allowances issued by the Environmental Protection Agency to the Phase I affected sources will be reduced. All sources must be in substantial compliance with Phase II requirements by January 1, 2000.

Twenty-six of TVA's 59 operating coal-fired units are Phase I units. Its remaining coal-fired units are Phase II sources. To date, TVA's approach has been

not to rely on the ability to buy allowances from other sources to achieve its reduction obligations. The TVA system is large enough that it can take advantage of the flexibility available under the allowance program to substantially reduce its cost of compliance.

TVA has already completed the actions necessary to achieve Phase I compliance. Sulfur dioxide emissions control equipment has been installed on TVA's largest Phase I generating units, units 1 and 2 at Cumberland Fossil Plant. This $535 million project included the installation of wet limestone flue gas desulfurization equipment (scrubbers). These scrubbers reduce Cumberland's sulfur dioxide emissions by approximately 95 percent. Other control measures have included the switch to lower sulfur coal at TVA's Allen Fossil Plant in Memphis. Through these actions, TVA will meet its reduction obligations for all 26 affected units through Phase I and have excess reductions banked for use during Phase II.

NITROGEN OXIDES REDUCTION

Utility sources subject to Phase I sulfur dioxide reductions must, in general, also achieve nitrogen oxides reductions during Phase I. There is no national cap and allowance system comparable to the sulfur dioxide reduction program for nitrogen oxides. Nitrogen oxides compliance is based on an allowable emission rate determined by the boiler type. However, flexibility is provided within a utility system to include multiple units within an "averaging plan" that would allow excess reductions at one or more units to offset lesser reductions at others.

Nitrogen oxides reductions are required at 19 of TVA's 26 Phase I units. (The remaining seven units, because of their boiler type, will be subject to reductions during Phase II.) These reductions have already been achieved by installing low-nitrogen oxides burners at 13 of the 19 units. On 4 of these 13 units, separated over-fire air, a supplemental nitrogen oxides control technology, has also been installed to achieve additional reductions. As with sulfur dioxide, TVA will achieve nitrogen oxides compliance on a system-wide basis by using an "averaging plan."

TVA is proceeding to install low-nitrogen oxides burners at many of its Phase II units in advance of the year 2000 regulatory deadline. Installation of burners is either accomplished or planned for the John Sevier, Kingston, and Widow's Creek Fossil Plants. (TVA has a total of 40 generating units that will be subject to Phase II nitrogen oxides reduction requirements.)

COSTS

Total estimated cost for the pollution control measures required for acid rain compliance will be approximately $2.3 billion dollars. By the end of fiscal year 1995, $770 million will have been spent. Operating cost increases associated with these actions will exceed $300 million per year.

OTHER CONSIDERATIONS

TVA has not incurred significant costs or liabilities from other provisions of the 1990 Clean Air Act Amendments. The Nashville/Davidson County area currently exceeds the allowable levels for ambient ozone concentration. The State of Tennessee must develop plans acceptable to the Environmental Protection Agency to reduce ambient ozone concentrations to acceptable levels. This could have required nitrogen oxides reductions from the Gallatin Fossil Plant. (Nitrogen oxides react with other chemicals in the air to form ozone. The Gallatin plant is within the Nashville/Davidson County area.) However, Tennessee has accepted the nitrogen oxides reduction installation at the Gallatin Fossil Plant as meeting the nitrogen oxides reductions required by their plan.

Other ways the 1990 Clean Air Amendments may affect TVA are discussed in Chapter 3, Affected Environment.

Customer Service Programs/Demand-Side Management

Customer service and demand-side management programs have been a part of TVA's energy supply resource mix since the late 1970s. These programs promote energy conservation and the efficient use of electricity. They were initiated in response to the rising cost of energy and the rising cost of building new electric generating units that began in the mid-1970s.

These programs provide benefit to both the end-use consumer through reduced energy costs and to TVA by avoiding the need for additional generating capacity. By 1988, these programs were credited with saving more than 2,300 million kilowatt-hours per year and cutting TVA's system demand by 1,200 megawatts. *Figure 4-5* shows the savings associated with each of these programs, the benefits of which continue today.

Through the years, the economics of TVA's conservation and energy management programs began to change. More than 631,000 Valley homes were weatherized during the 1980s under the Home Insulation Program; this was the backbone of TVA's conservation programs. Building standards for energy efficiency in new homes began to rise as consumers learned of the benefits of improved weatherization techniques. By the late 1980s, TVA was approaching market saturation for its home weatherization program. At the same time, the supply of available power increased, both within TVA and from other utilities, causing TVA to begin a review of its customer service and demand-side management

FIGURE 4-5. **Historical Customer Service Programs**

Program	Units	Millions of Kilowatt-Hours	Megawatts
Sunscreens	5,000	4	-
Heat Pump Water Heater	2,000	5	1
Solar Water Heater	7,000	26	10
Cycle and Save	111,000	0	79
Energy Saver Homes	36,000	116	36
Wood Heaters	16,000	79	55
Heat Pumps	135,000	228	74
Home Weatherization	631,000	1,883	959
TOTAL		**2,341**	**1,214**

TVA served thousands of customers in the decade of the 1980s through programs designed to save energy and increase comfort. For example, 631,000 customers saved a total of 1,883 million kilowatt-hours of energy during the decade through home weatherization and reduced TVA's need for new capacity by 959 megawatts.

FIGURE 4-6. **Impacts of Current Demand-Side Management Programs for 1995 – 1996**

Program	Units	Millions of Kilowatt-Hours	Megawatts
RESOURCE ACQUISITION (Savings)			
Heat Pump	19,330	51.5	16.5
New Homes	5,857	4.6	1.3
Manufactured Homes	1,230	5.0	1.6
Interruptible Rates		N/A	1,700.0
Direct Load Control	96,850	N/A	69.6
BENEFICIAL ELECTRIFICATION (Sales)			
Heat Pump	10,870	81.7	29.9
New Homes	3,143	21.1	1.4
Manufactured Homes	660	2.6	0

TVA's current programs include energy efficiency programs, a rate program, a direct load control program, and beneficial electrification programs. For example, the heat pump program includes both energy efficiency and beneficial electrification components, and results in a net increase in sales of 30.2 million kilowatt-hours. The interruptible rates and direct load control programs significantly reduce peak demand, but instead of reducing energy requirements, shift energy usage from peak periods to off-peak periods.

programs to make sure that they were still cost-effective for TVA's ratepayers.

As a result of this review, TVA began reshaping its customer service and demand-side management programs during the late 1980s and early 1990s. While the early programs continue to benefit the power system, current initiatives are geared to assist consumers in making electricity a better value through the use of new electric technologies and techniques. Customer service offerings now include an electric heat pump program, a new homes program, a manufactured housing program, and a direct load control program. (This load management program shifts energy use to off-peak hours or periods of low demand for electricity, e.g., the cycling of appliances such as water heaters.) These programs, which are offered through participating distributors of TVA power, are currently scheduled to continue through 1996.

TVA also has rate programs for interruptible power for industrial customers, as discussed earlier in this chapter. This includes Economy Surplus Power (ESP), which is a real-time pricing program for interruptible load. Approximately 1,700 megawatts of industrial load is available for interruption during peak periods. In addition, TVA and participating distributors of TVA power provide a broad range of technical assistance to commercial and industrial customers to help them get the most value for their energy dollar. Some of these services include recommendations on efficient heating and cooling equipment, outdoor lighting systems, power monitor metering, power quality analysis, and preparation of feasibility/application studies for new electrotechnologies that offer opportunities for lower production costs and increased output.

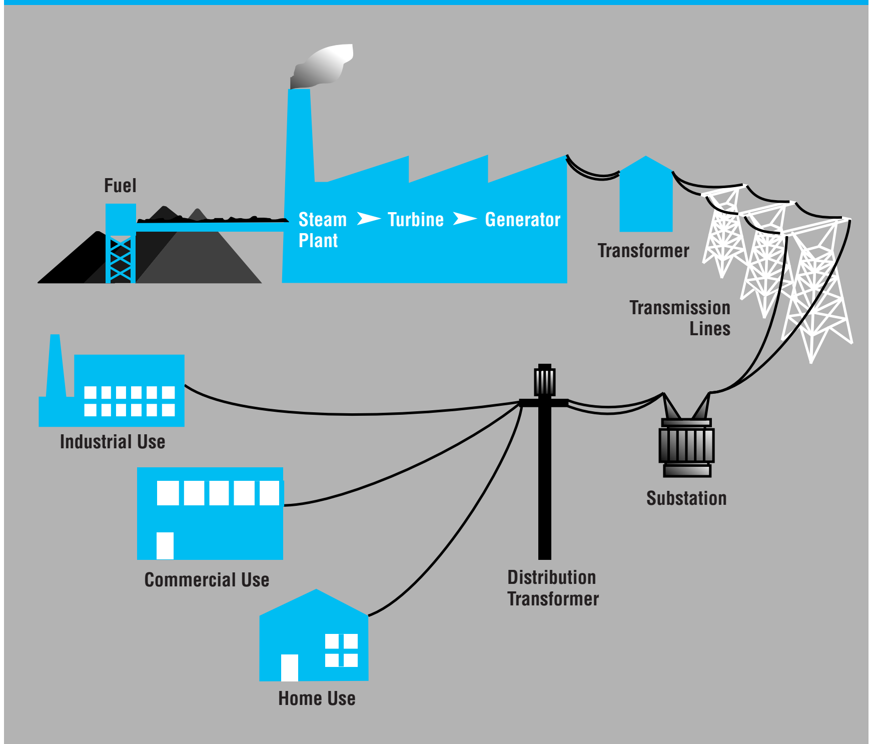
Figure 4-6 shows the impacts of these current demand-side management programs—energy efficiency programs, a rate program, a direct load control program, and beneficial electrification programs. The values in *Figure 4-6* are the impacts occurring only in the year 1996 for the cumulative participation in the program during 1995 and 1996.

TVA's Transmission System

TVA operates an interconnected transmission system capable of carrying power from its 42 generating sites to 750 wholesale delivery points and to 57 points of interconnection with neighboring power systems.

Figure 4-7 illustrates how power is delivered from generating plants to distributors to homes and businesses. Power from generating facilities is produced at low voltages, such as 24,000 volts, which are then generally boosted to 500,000 or 161,000 volts for delivery to wholesale and directly served customers through TVA's transmission system. At delivery points, this high voltage power is reduced at substations to voltages that can be sent through distribution lines to end users, where it is further reduced so that it can be used in homes and businesses.

FIGURE 4-7. **Generation, Transmission, and Distribution**



Electricity is produced at one of TVA's power generating plants and carried over TVA's high voltage transmission system to delivery points of distributors of TVA power. Through a series of substations and transformers, voltage is reduced to appropriate levels for use in homes and businesses.

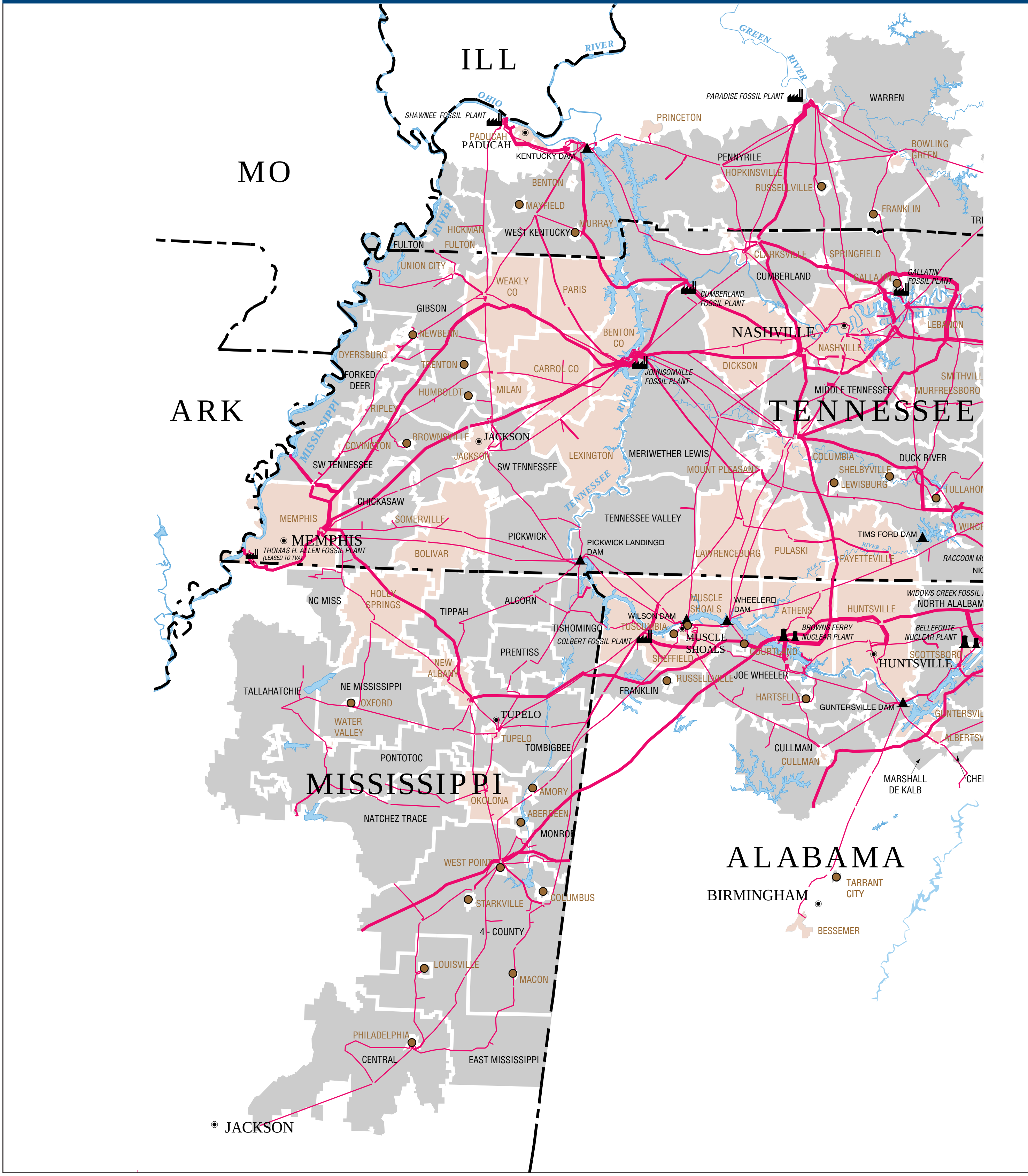
The transmission system includes 12,200 miles of 161,000 and 500,000 volt transmission lines. These two overlaid networks are tied together at 25 locations through 500,000 and 161,000 volt substations located throughout the TVA service area. In addition, 3,800 miles of 69,000 and 46,000 volt lines are operated radially to serve dispersed load centers. Distributors accept power from TVA at voltages ranging from 161,000 to 13,000 volts and, in turn, distribute power at voltages ranging from 161,000 to 120 volts to small industries, commercial customers, and homes.

TVA's transmission system is also directly connected to 13 neighboring utilities with interconnection voltages ranging from 500,000 to 69,000 volts. These interconnections allow TVA and its utility neighbors to buy and sell power from each other and to wheel power through their systems to other utilities.

TVA's generation and transmission facilities are self-funded through power revenues. Improvements to the transmission system are planned and implemented to ensure continued reliability and service. The fiscal year 1995 budget for transmission system capital projects is approximately $130 million. These include more than 150 active projects ranging from simple new delivery points ($100-$300 thousand) to major 500,000 and 161,000 volt substations ($30-$40 million) in Mississippi and Alabama.

Figure 4-8 provides an overview of the power system, including the 500,000 and 161,000 volt transmission lines, the generating plants (hydro, fossil fuel,

FIGURE 4-8. **The TVA Power System**



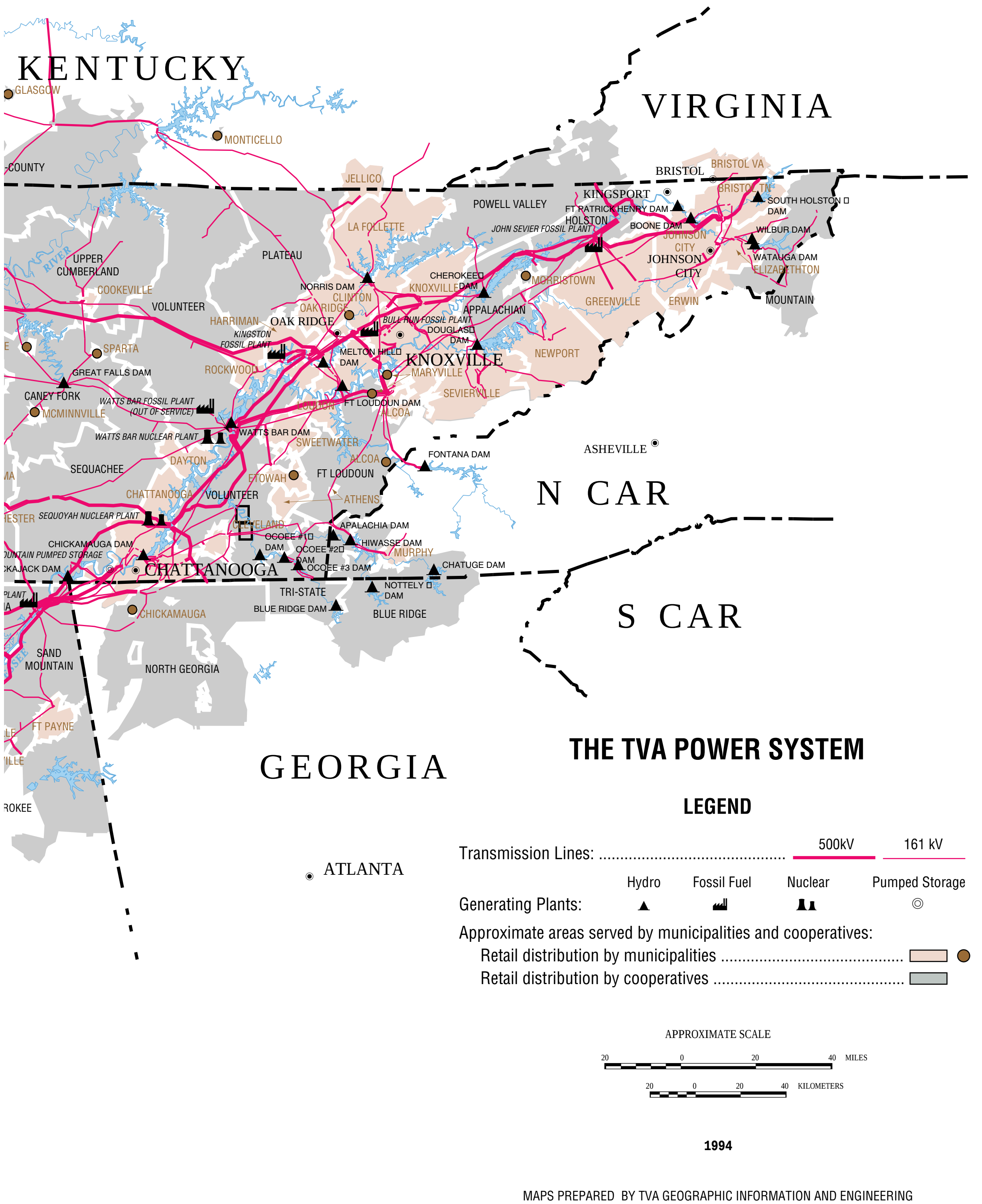

KENTUCKY
VIRGINIA
N CAR
S CAR
GEORGIA
GLASGOW
MONTICELLO
JELLICO
POWELL VALLEY
BRISTOL
BRISTOL VA
BRISTOL TN
KINGSPORT
SOUTH HOLSTON DAM
FT PATRICK HENRY DAM
HOLSTON
BOONE DAM
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
WILBUR DAM
WATAUGA DAM
ELIZABETHTON
LA FOLLETTE
PLATEAU
UPPER CUMBERLAND
COOKEVILLE
VOLUNTEER
NORRIS DAM
CLINTON
CHEROKEE DAM
KNOXVILLE
MORRISTOWN
GREENVILLE
ERWIN
MOUNTAIN
HARRIMAN
OAK RIDGE
APPALACHIAN
BULL RUN FOSSIL PLANT
KINGSTON FOSSIL PLANT
DOUGLAS DAM
SPARTA
MELTON HILL DAM
KNOXVILLE
MARYVILLE
NEWPORT
ROCKWOOD
GREAT FALLS DAM
CANEY FORK
MCMINNVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
FT LOUDOUN DAM
LOUDON
ALCOA
SEVIERVILLE
WATTS BAR NUCLEAR PLANT
WATTS BAR DAM
SWEETWATER
SEQUACHEE
DAYTON
ALCOA
FONTANA DAM
ASHEVILLE
ETOWAH
FT LOUDOUN
CHATTANOOGA
VOLUNTEER
ATHENS
SEQUOYAH NUCLEAR PLANT
CLEVELAND
APALACHIA DAM
CHICKAMAUGA DAM
OCOEE #1 DAM
HIWASSEE DAM
OCOEE #2 DAM
MURPHY
CHATTANOOGA
OCOEE #3 DAM
CHATUGE DAM
NOTTELY DAM
TRI-STATE
BLUE RIDGE DAM
BLUE RIDGE
CHICKAMAUGA
SAND MOUNTAIN
NORTH GEORGIA
FT PAYNE
ATLANTA
THE TVA POWER SYSTEM
LEGEND
Transmission Lines: ....
500kV
161 kV
Hydro
Fossil Fuel
Nuclear
Pumped Storage
Generating Plants:
Approximate areas served by municipalities and cooperatives:
Retail distribution by municipalities ....
Retail distribution by cooperatives ....
APPROXIMATE SCALE
20 0 20 40 MILES
20 0 20 40 KILOMETERS
1994
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE 4-9. **Interconnections with Other Utilities**

- Associated Electric Coop
- Appalachian Power
- Big Rivers EC
- Carolina P&L
- Central Illinois Public Service
- East Kentucky Power Coop
- Electric Energy Inc.
- Entergy Services
  - Arkansas P & L
  - Mississippi P & L
- Kentucky Utilities
- Louisville Gas & Electric
- Nantahala P&L (Duke)
- Southern Company
  - Alabama Power
  - Georgia Power
- Union Electric

TVA has interties with 13 neighboring electric systems, which allows these systems to buy, sell, and wheel power.

and nuclear), and the approximate areas served by the 160 power distributors (municipalities and cooperatives).

Figure 4-9 shows the 13 neighboring utilities that TVA has interconnections with to buy, sell, and wheel power.

TVA's Financial Condition and Results of Operation

Since 1988, actions taken by TVA to reduce its costs and interest expense have allowed it to keep electric rates at the level they were in 1987. The TVA Board approved an eighth year of stable electric rates for TVA customers on September 21, 1994. TVA has been able to do this by refinancing its debt, reducing its workforce, and improving the efficiency of its operations.

FINANCIAL RESULTS OF OPERATION

Revenue

Operating revenues were $5.4 billion for fiscal year 1994. Total energy generated was 134 billion kilowatt-hours for 1994, which was 3.4 percent higher than the previous year. This increase was due to growth in sales to

municipal and cooperative distributors, direct served industries, federal agencies and off-system sales.

Operating Expenses

Operating expenses for fiscal year 1994 were $3.5 billion; fuel expenses accounted for $1.5 billion of this total. Non-fuel operating expenses were $2 billion. Operating and maintenance expenses for 1994 were $1.1 billion, compared to $1.2 billion for 1993. The decrease in operating and maintenance expenses reflects continuing efforts to reduce costs.

Depreciation and amortization costs were $639 million in fiscal year 1994, an increase of $182 million compared to fiscal year 1993. The increase was attributable to the amortization of deferred charges, additions to completed plants, and an increase in the composite depreciation rate.

FIGURE 4-10. **Financial Statement**

	Millions of Dollars		
	1994	1993	1992
OPERATING REVENUES	$5,401	$5,276	$5,065
OPERATING EXPENSES			
Fuel and purchased power, net	1,493	1,401	1,354
Operating and maintenance	1,081	1,174	1,098
Depreciation and amortization of deferred nuclear costs	639	457	505
Tax equivalent payments	248	237	241
Total operating expenses	3,461	3,269	3,198
Operating income	1,940	2,007	1,867
OTHER INCOME AND DEDUCTIONS, net	(59)	23	(87)
Income before interest charges	1,881	2,030	1,780
INTEREST CHARGES			
Interest expense	1,853	1,777	1,695
Allowance for funds used during construction	(123)	(58)	(35)
Net interest charges	1,730	1,719	1,660
NET INCOME	151	311	120

This figure summarizes TVA's income and operating expenses for fiscal years 1992, 1993, and 1994. Net income for fiscal year 1994 was $151,000,000.

Interest Expense

Interest expense for fiscal year 1994 was $1.9 billion, an increase of $76 million compared with 1993. The increase was the result of additional borrowings related to financing TVA's power program. In 1994, TVA refinanced $5 billion of existing long-term debt to save $65 million in annual interest expense. Since refinancing efforts were begun in 1989, TVA has achieved $317 million in interest expense savings.

Earnings

TVA's power program consists primarily of the generation, transmission, and sale of electricity. Net income for fiscal year 1994 was $151 million.

Figure 4-10 summarizes TVA's statement of operations and retained earnings for 1994, 1993, and 1992.

CONTROLLING THE TVA DEBT

Concern about TVA's debt was one of three major issues identified by the public during scoping meetings held as part of Energy Vision 2020. Other major concerns were TVA's nuclear program and TVA's ability to remain competitive.

In the opinion of many TVA customers and members of the public, high debt is generally associated with a poor competitive position. Since the large capital expenditures necessary to complete TVA's nuclear units will increase

TVA's debt, completing these units contributes to a perception that TVA's competitiveness will suffer. With the rapid evolution of the utility industry into a competitive environment, many utilities are trying to improve their debt structure so that the pricing of electricity can be more flexible in response to future uncertainty. Clearly, with the increasing risk of TVA losing customers to other utilities, prudent business practices suggest that debt be carefully managed and controlled.

TVA's debt limit, as set by Congress in the TVA Act, is $30 billion. TVA's current debt is some $3 billion below this debt ceiling. The TVA Board has announced plans to establish a self-imposed debt limit $2-3 billion below the $30 billion allowed by Congress. This internal limit on debt will be formally reviewed periodically to ensure that the limitation meets TVA's continuing business needs. However, one of the major constraints utilized in Energy Vision 2020 was to keep the debt for any feasible resource plan within these limits.

TVA's Electric Rate Structure

The rates for TVA power must be adequate to meet power system needs and be as low as feasible. TVA's rate structure must also respond to customer needs. TVA develops wholesale rates for the distributors (who, in turn, serve most end users) and for large directly served industrial customers.

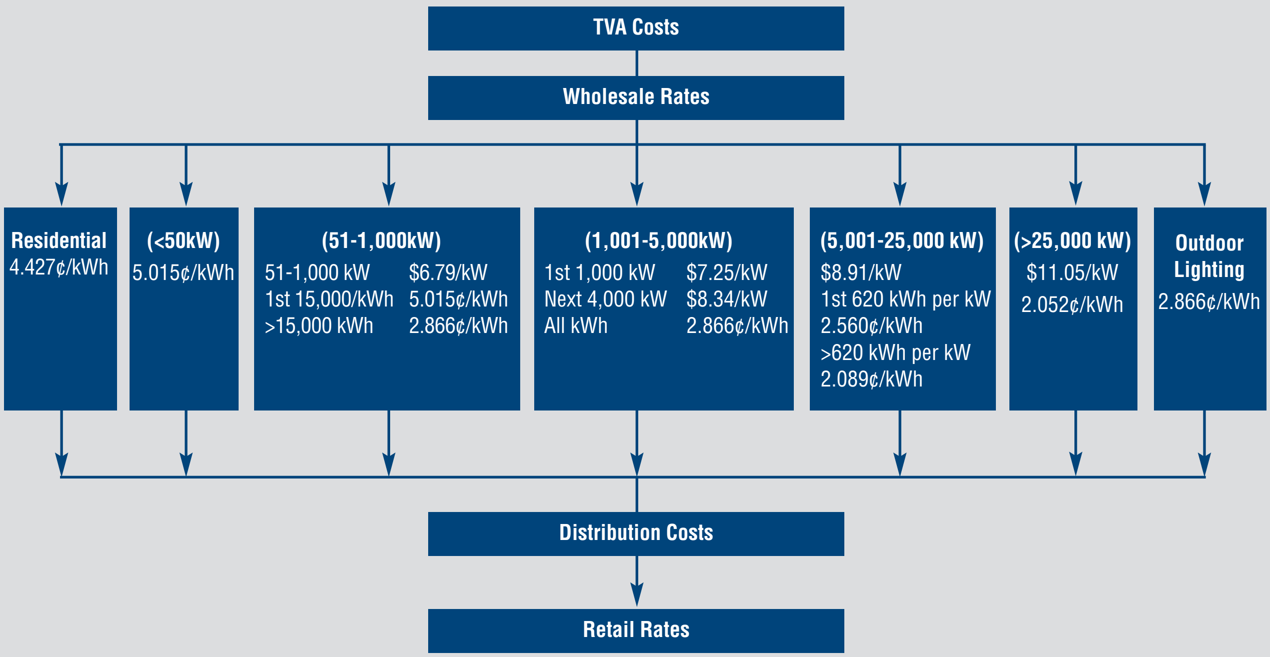
Working with the distributors of TVA power, a major restructuring of TVA's rate design was begun in 1988. This was done in an effort to simplify and improve the way TVA applied power rates.

Specific objectives of the rate restructuring were to:

- Encourage efficient operations
- Provide stable and predictable margins
- Support quality service
- Be competitive
- Be cost-of-service based to ensure equity and avoid discrimination
- Be as simple as possible
- Provide consistent price signals
- Encourage the efficient use of resources
- Encourage economic development of the TVA region as a whole
- Be responsive to changing customer needs

As a result of this restructuring, an "end-use wholesale rate" was developed. This wholesale rate has separate charges for residential and general service end-use groups. General service includes 6 classes of customers: those with demands less than 50 kilowatts, between 51 and 1,000 kilowatts, 1,001 to 5,000

FIGURE 4-11. **TVA Rate Structure**



Wholesale power rates are based on the cost of service for different classes of customers. Distribution cost is added to the wholesale rate by distributors of TVA power to determine the end-use retail price of electricity.

kilowatts, 5,001 to 15,000 kilowatts, 15,001 to 25,000 kilowatts, and demand greater than 25,000 kilowatts. Power rates for large industrial customers with demands greater than 25,000 kilowatts are the same whether they are served by a distributor or directly by TVA. *Figure 4-11* illustrates TVA's rate structure.

As part of the end-use wholesale rate implementation, distributors were provided the flexibility to design retail rates. Distributor retail rates include the end-use wholesale charge paid to TVA, along with the distribution costs for their individual systems.

Even though distributors design their own retail rates, TVA reviews and approves the rates before application. This review is to ensure that the rates are consistent with the requirements of the TVA Act.

Several optional rate arrangements are available for commercial and industrial consumers. These include Economy Surplus Power, an interruptible rate, and the Enhanced Growth Credit, a program that provides power bill credits for new and expanding industries.

Chapter Five

Evaluation Criteria

Chapter Five: Evaluation Criteria

Sound judgments about energy resource options require a way to evaluate cost, benefits, and effects on the environment for each of these options.

Through Energy Vision 2020, TVA developed a comprehensive evaluation system that reflects TVA's goals and objectives, as well as the concerns and values of the public. TVA's evaluation criteria include:

- Long-Run Cost/Value
- TVA Short- and Mid-Term Rates
- Reliability
- Environment
- Economic Development
- Financial Requirements
- Risk Management
- Equity Among Rate Classes

These criteria and associated measures became the quantitative basis for ranking supply-side and customer service options. They were later used in the multi-attribute trade-off analysis to evaluate and improve TVA's strategies.

This Chapter Includes:

- Using the Evaluation Criteria
- Evaluation Criteria and Measurement Descriptions

Evaluation Criteria

TVA's evaluation criteria (listed in *Figure 5-1*) were developed to reflect the values of the public and TVA's goals and objectives. The public's concerns were collected through the public participation process described in Chapter 1. The method by which TVA translated the public concerns and TVA's goals and objectives into measurable criteria for Energy Vision 2020 is described in Chapter 2. These quantifiable measures of public concern and TVA's goals provide the primary guidance for developing the strategies.

Through Energy Vision 2020, TVA developed a comprehensive evaluation system that reflects TVA's goals and objectives, as well as the concerns and values of the public.

Using the Evaluation Criteria

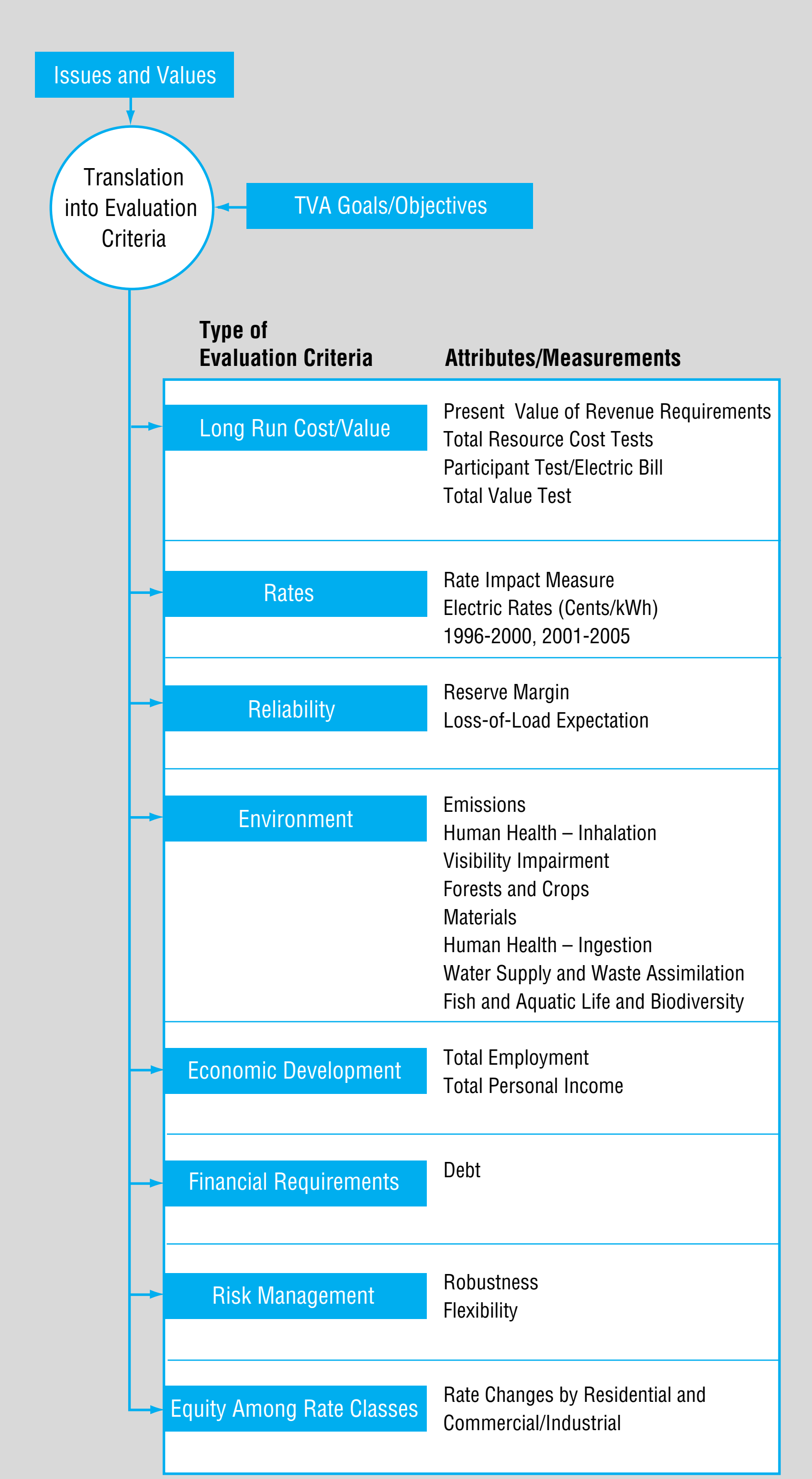
The evaluation criteria and their associated measurements are used at two different points in the integrated resource planning process. First, individual resource options are evaluated and ranked based on appropriate measurements. This ranking is used to prioritize and group individual resource options into possible resource strategies. The evaluation criteria measurements are then used in multi-attribute trade-off analysis to evaluate strategies (for example, short-term rates versus environmental quality measures). By looking at a series of key trade-off plots, the decision-maker is able to see the likely positive or negative consequences of using certain strategies. Additional information about the multi-attribute trade-off analysis used in Energy Vision 2020 is found in Chapter 9.

Evaluation Criteria and Measurement Descriptions

LONG RUN COST/VALUE

The long run cost/value criteria provide a measure of how various resource options and strategies will change TVA's overall cost of doing business and its requirements for revenues over the full 25-year planning period. This, in turn, provides a measure of whether certain options and strategies will add value for TVA's customers. TVA presently uses four different tests to measure long-run cost and benefits.

FIGURE 5-1. **Evaluation Criteria**



Multiple evaluation criteria are used in Energy Vision 2020.

- **Total Resource Cost (TRC) Test** – This test measures whether a resource option or strategy will be cost effective when the net costs and benefits for customers are included in the analysis. The costs include all utility and customer costs for implementing a resource option. The benefits result from the reduction in the cost of producing electricity by implementing the resource option instead of the next best alternative. Choosing options or strategies with the lowest total resource cost is a measure of the least economic cost or highest economic efficiency.
- **Participant Test** – This test is a benefit-cost measurement that evaluates demand-side management programs from the point of view of the customers participating in the programs. The benefits measured include reduction in the participants' utility bills, incentives paid by the utility, and any state, federal, or local tax benefits the participant may receive from participating in the programs. The costs include any additional customer out-of-pocket expenses incurred as a result of participating in the program.
- **Rate Impact Measure (RIM)** – This test measures what happens to electric rates due to changes in utility revenue and operating costs in the long term caused by resource options or strategies
- **Total Value Test** – This test measures not only the total cost of a resource option or strategy from the point of view of TVA and customers as a whole, but also the effects upon the benefits or "value" that participants and ratepayers receive. Value is measured by the

difference between what consumers are willing to pay for a service and what they actually pay. Traditional cost-effectiveness tests are insufficient to capture the full range of benefits that a customer might experience (such as productivity and quality improvements from selecting an option that results in increased electric consumption). The total resource cost test measures value only in terms of cost reductions in electric service. The value test measures value from cost reductions in electric service, other energy services such as natural gas, cost reductions in improvements to industrial processes, and quality improvements in the delivery of energy services. The value test provides an improved measure of economic efficiency.

TVA SHORT- AND MID-TERM RATES

The competitiveness of utilities will be largely based on their rates in the future marketplace. Therefore, all resource options and strategies are measured for their short- and mid-term effect on rates (as well as using the long-term rate impact measurement test described above). TVA has elected to show average short-term impacts for the years 1996-2000 and average mid-term impacts for the years 2001-2005. Electric rates are becoming an increasingly important criterion for resource planning as the industry becomes more competitive and the planning horizon is shortened.

RELIABILITY

To maintain its competitiveness, TVA must not only supply electricity at the lowest possible cost, it must also provide a reliable supply of electricity. For the purposes of Energy Vision 2020, reliability means TVA's ability to provide a continuous supply of electricity to meet its customers' peak demand (expressed in megawatts) and energy requirements (kilowatt-hours). TVA relies on all resources considered in Energy Vision 2020 to meet its reserve requirements, including purchases of power and options to purchase.

The reliability of the TVA power system depends on the performance of TVA's generation and transmission systems. An important consideration in analyzing system reliability is reserve margin and loss-of-load probability. The trigger for adding new generating capacity is generally based on an analysis of loss-of-load probability. Loss-of-load probability can be described as the expected number of hours over a one-year period where TVA's hourly loads are expected to exceed its available supply of power. This is then converted into a reserve margin, or the amount (percentage) of "extra" generation TVA should have in addition to the projected peak load forecast to provide coverage for unexpected outages, scheduled maintenance, etc.

As discussed in Chapter 6, Load Forecast and Need for Power, TVA uses a reserve margin of 15 percent for the years 1996 and 1997 and 13 percent for the years 1998-2010. Since these reliability requirements must be met by all strategies considered in Energy Vision 2020, system reliability is treated as a constraint on each strategy. Therefore, all strategies considered during this process had adequate and comparable levels of reliability.

ENVIRONMENT

Certain environmental costs can be readily identified and included in the total costs of a particular resource option. A good example is the cost for pollution control equipment to reduce sulfur dioxide emissions. It is not always possible, however, to quantify or value all environmental impacts associated with supply-side or electric power generation resources. Nevertheless, these impacts are real and need to be measured and accounted for in the decision-making process to the extent possible. Whenever possible, TVA has analyzed the environmental impacts on the same basis as other evaluation criteria by using the multi-attribute analysis process.

Most of the resource options and strategies being considered in Energy Vision 2020 are generic in nature, rather than being associated with specific projects or sites. For example, integrated coal gasification combined cycle plants are considered in various strategies, but no site is proposed. Without specific sites, TVA is unable to fully evaluate those impacts that are dependent on local conditions. However, TVA does identify differences in strategies, either quantitatively or qualitatively, that reflect air and water pollutant emissions and other indicators such as land use for existing and new resources and their potential for impact on the environment.

TVA's environmental analysis focused primarily on regional or broad-scale environmental impacts and the generic impacts associated with categories of energy options. Site-specific or local impacts of an individual energy resource project will be addressed in detail in future environmental reviews as specific energy projects are developed.

As discussed in Chapter 3, Affected Environment, measurements of individual pollutant emissions or other indicators of potential environmental impacts were combined to form the indices of impacts listed in *Figure 5-2*. More detailed rationales for the various weightings for the measures are in Volume 2, Technical Document 1, Comprehensive Affected Environment.

ECONOMIC DEVELOPMENT

Economic development is a primary mission of TVA and a recognized public concern in the TVA service area. Historically, the residents of the Tennessee Valley have had low levels of per capita personal income compared to national averages. For this reason, all of the states in the Valley place a high value on opportunities to broaden and enhance their economic base.

Alternative strategies for meeting future needs for electricity have different economic impacts. This criterion, like the others, does not override other considerations. Nevertheless, it is necessary and appropriate to evaluate the economic consequences of each proposed resource option and strategy.

Energy Vision 2020 uses two measurements of economic development: (1) total employment created by various resource strategies in the Valley and (2) the effect of these strategies on total personal income for Valley residents.

FIGURE 5-2. Environmental Indices and Weightings

Environmental indices have been developed by weighting environmental emissions. The environmental indices have been developed for air and water impacts. In addition, greenhouse gases are measured in terms of equivalent tons of carbon dioxide.

		IMPACT AREAS: Air — Environmental Evaluation Criteria				IMPACT AREAS: Water — Environmental Evaluation Criteria			
Environmental Measure	**Units**	**Health-Inhalation**	**Visibility Impairment**	**Forests and Crops**	**Materials**	**Health-Ingestion**	**Water Supply and Waste Assimilation**	**Fish and Aquatic Life and Biodiversity**	**Greenhouse Gases Total Equivalent Carbon Dioxide (Millions of Tons)**
Sulfur Dioxide (SO_2) Emissions	Annual Average Tons	0.40	0.70	0.25	0.60				
Nitrogen Oxides (NO_X) Emissions	Annual Average Tons	0.50	0.25	0.75	0.40				
Total Suspended Particulates (TSP) Emissions	Annual Average Tons	0.05	0.05						
Carbon Dioxide (CO_2)Emissions	Annual Average Thousands of Tons								1
Mercury (Hg) Emissions	Annual Average Tons	0.05							
Coalbed Methane Recovered	Annual Average Tons								-21
Natural Gas Methane Emissions	Annual Average Tons								21
Landfill Methane Recovered	Annual Average Tons								-21
Wood Waste Methane Avoided	Annual Average Tons								-21
Wood Waste Carbon Dioxide Avoided	Annual Average Thousands of Tons								-1
Short Rotation Woody Crops Carbon Dioxide Avoided	Annual Average Thousands of Tons								-1
Heat Release to Surface Water	Annual Average Quadrillion BTUs						0.10	0.05	
Water Consumption	Annual Average Trillions of Gallons						0.10		
Water Use	Annual Average Trillions of Gallons							0.03	
Coal Burned	Annual Average Millions of Tons							0.20	
Nuclear Power Production	MWh					0.05		0.02	
Coal Power Production	MWh					0.60		0.05	
Hydro Electric Peaking Production	MWh					0.35	0.80	0.60	
New Power Plants Constructed	Number							0.05	

FINANCIAL REQUIREMENTS

The TVA power program is self-supporting, and its customers ultimately bear all of the costs incurred by the program. The power program receives no federal tax dollars. The TVA Act prescribes certain financial requirements for TVA. For example, TVA is to provide electric power at rates that are as low as possible. Other financial requirements are contained in the covenants of lending documents executed when TVA borrows money for capital improvements.

To address the general public concern over TVA's existing debt, all resource options and strategies were evaluated in terms of impact on TVA's debt. The TVA Act sets a limit on the amount of debt TVA may have outstanding at any one time. An Act of Congress is required to change this limit, which is currently $30 billion. TVA's debt is currently some $3 billion below this debt ceiling. The TVA Board has announced that TVA will limit its debt to an amount about $2 to $3 billion below the Congressionally set limit.

RISK MANAGEMENT

Uncertainties in load growth, fuel prices, capital costs, and regulatory standards have long challenged utility planners. Added to this list of traditional uncertainties is the likelihood of increasing competition, which will make sound resource decisions even more difficult.

Risk management is now considered an essential part of the planning process at TVA. Planners are shifting from simply making resource investments, based on a fixed set of assumptions about the future, to a different mode of planning that accounts for certain levels of uncertainty in future events. Plans must be both robust and flexible to successfully deal with an uncertain future.

A robust strategy is one that performs well relative to the evaluation criteria across a variety of possible futures. A flexible strategy is one that is conducive to being modified as events unfold and near-term futures become more clearly known. More flexible options are likely to be based on smaller units or program sizes. Flexible options would also have short lead times to construct or start, lower capital costs, and low walk-away costs.

Energy Vision 2020 introduces new techniques for analyzing flexibility. These techniques are based on financial options valuation models and extensions of decision analysis models. Financial options valuation models, such as the Black Scholes model, have been adapted by TVA to look at the value of flexibility in the utility industry. Decision analysis models have been extended to incorporate multiple decision points with many possible uncertainties to analyze the value of flexibility.

EQUITY AMONG RATE CLASSES

As in most businesses, utilities establish different classes of customers to tailor their products and services to meet the particular needs of those customers and to assign appropriate costs. The rate structures used by TVA and the distributors of TVA power provide a primary distinction between residential and commercial and industrial customers. Issues of equity among different class-

es of customers arise when a utility offers services to a particular class of customers for its benefit or to achieve social objectives (e.g., energy conservation). Likewise, issues of equity within a rate class can exist between those who participate in a program and those who do not (non-participants).

Typically, customers who participate in special programs or services (e.g., demand-side management) receive most, if not all the benefits. These programs, however, can increase non-participants' electric rates without providing them with corresponding benefits (i.e., reduced electric bills).

Energy Vision 2020 addresses the issues of equity by looking at the rate impacts of each customer service option on the residential and the commercial and industrial rate classes. In addition, equity is evaluated through the Rate Impact Measure (RIM) test. Programs that pass the RIM test benefit all customers through lower power bills for participants and lower rates for non-participants. If a program does not pass the RIM test, implementing the program would cause non-participants' rates to increase—creating a subsidy for participants.

Chapter Six

Load Forecast and Need for Power

Chapter Six: Load Forecast and Need for Power

TVA's need for power is based on an analysis of the ability of existing power facilities to meet customers' projected electricity needs. The need varies from season to season, day to day, and even minute to minute. TVA develops two types of forecasts—one for annual system peak load and one for annual system energy requirements.

One of the basic lessons of the 1970s was that it is extremely risky to plan on the basis of a single forecast. To deal with uncertainty in forecasting, TVA develops a range of forecasts—high, medium, and low.

TVA has determined its need for power to meet the medium load forecast to be 800 megawatts by 1998 and 16,500 megawatts by 2020. Based on the high load forecast, additional capacity will be needed by 1997, and the need for new power supply resources increases from that point on. Under the low load forecast, TVA will not need additional capacity during the forecast period for Energy Vision 2020.

The estimates include a reserve margin, or additional generating capacity for reliability of 15 percent average through 1997, 13 percent average for the years 1998 to 2010, and 12 percent average for the years 2011 to 2020.

This Chapter Includes:

Load Forecasting

- What Is Load Forecasting?
- Why Do Load Forecasting?
- The Results of TVA's Load Forecast
- Historical Perspective – Forecast Accuracy
- Elements of TVA's Load Forecast

Need For Power

- Where We Are Today – Current and Planned Capacity Additions
- Future Needs – Comparing Where We Are Today to the Load Forecast

Load Forecast and Need for Power

A projection of future power needs is basic to the integrated resource planning process. Astute business planning requires estimating future requirements, in this case, the demand for electricity. Planning also includes inventorying existing supply capabilities and determining what improvements, additions, or changes will be needed to meet future customer demands.

This chapter explains the findings of the Energy Vision 2020 load forecast analysis and how TVA estimates the need for power.

Forecasts serve as a guide to TVA power planners to ensure that the need for power will be met reliably and economically no matter what the future holds.

Load Forecasting

WHAT IS LOAD FORECASTING?

Load forecasting is simply what the name implies—it is a forecast, an estimate, or a prediction of how much electricity will be needed by the Valley's residences, companies, and other institutions in the future.

WHY DO LOAD FORECASTING?

The need for power in the Tennessee Valley varies from season to season, day to day, and even minute to minute. To ensure that an adequate supply of power is available to meet the demand, TVA must plan far into the future. Load forecasting is one of the planning processes used by TVA.

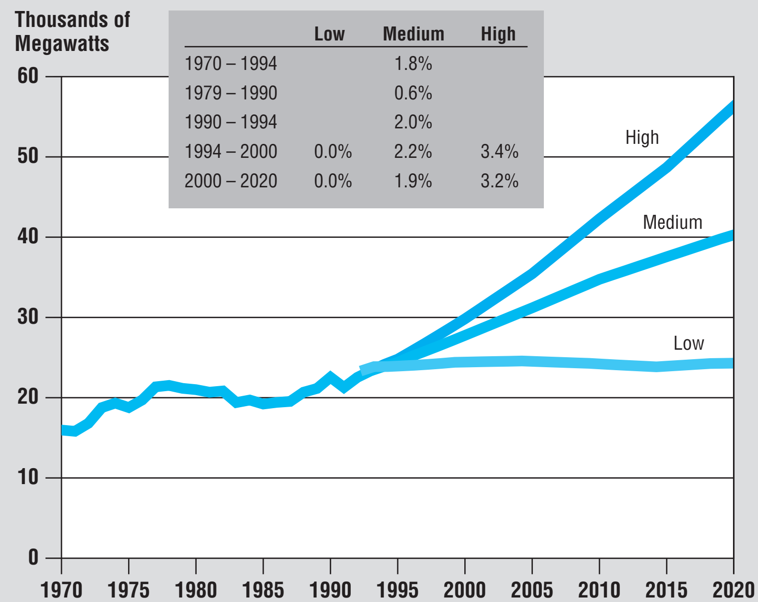
THE RESULTS OF TVA'S LOAD FORECAST

TVA develops two types of forecasts—one for annual system peak load and one for annual system energy requirements. The annual system peak load, measured in megawatts, is the highest load TVA needs to be prepared to serve each year. The annual system energy requirement, measured in kilowatt-hours, is the total electricity used during a year.

For each type of forecast—low, medium, and high—forecasts are developed to reflect the uncertain future. This range of forecasts serves as a guide to TVA power planners to ensure that the need for power will be met reliably and economically no matter what the future holds.

The range of long-term system peak load forecasts developed for Energy Vision 2020 is shown in *Figure 6-1*. For the medium forecast, peak loads are expected to increase 2.2 percent per year through 2000 and 1.9 percent per year from

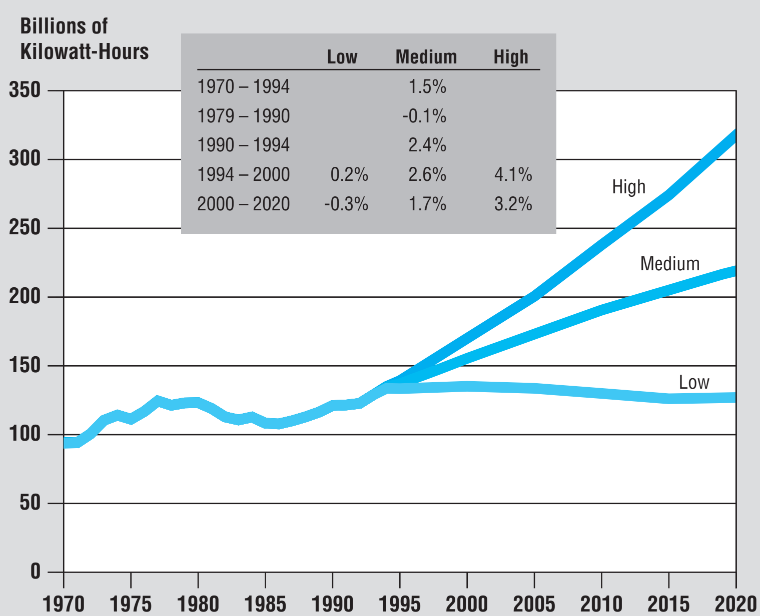
FIGURE 6-1. **Actual and Projected Growth of System Peak Needs**



	Low	Medium	High
1970 – 1994		1.8%	
1979 – 1990		0.6%	
1990 – 1994		2.0%	
1994 – 2000	0.0%	2.2%	3.4%
2000 – 2020	0.0%	1.9%	3.2%

A wide range of forecasts was developed to predict TVA's peak electricity needs each year.

FIGURE 6-2. **Actual and Projected Growth of Electricity Needs**



	Low	Medium	High
1970 – 1994		1.5%	
1979 – 1990		-0.1%	
1990 – 1994		2.4%	
1994 – 2000	0.2%	2.6%	4.1%
2000 – 2020	-0.3%	1.7%	3.2%

A wide range of forecasts was developed to predict the amount of electricity needed in each year.

2000 to 2020, with peak loads of 27,800 megawatts in 2000 and 40,300 megawatts in 2020. Recognizing the uncertainty in forecasting through the year 2020, TVA's high peak load forecast calls for an increase of approximately 3.3 percent per year with a peak load of 56,400 megawatts in 2020. The low peak load forecast calls for no increase in growth through 2020. The peak load for 1994 was 24,400 megawatts.

The system peak demand forecasts shown in *Figure 6-1* are derived from the energy requirement forecasts shown in *Figure 6-2*. These projections are based on state-of-the-art forecasting models that are accepted throughout the utility industry. These are explained later in this chapter.

The range of long-term forecasts for system energy requirements is shown in *Figure 6-2*. For the medium forecast, total system energy requirements are expected to increase 2.6 percent per year through the year 2000 and 1.7 percent per year from 2000-2020, with a demand for 155.5 billion kilowatt-hours of electricity in 2000 and 219.6 billion kilowatt-hours of electricity in 2020. In the high energy requirements forecast, demand for electricity grows at a rate of 4.1 percent a year through 2000 and 3.2 percent from 2000-2020, with a demand for 170 billion kilowatt-hours of electricity in 2000 and 317.5 billion kilowatt-hours of electricity in 2020. The annual growth rates for the low energy requirements forecast are 0.2 percent through 2000 and -0.3 percent from 2000-2020 with energy requirements of 135.1 billion kilowatt-hours of electricity for 2000 and 126.3 billion kilowatt-hours of electricity for 2020. The system energy requirements for 1994 were 133.4 billion kilowatt-hours.

HISTORICAL PERSPECTIVE – FORECAST ACCURACY

As stated earlier, forecasting future electricity needs is full of uncertainty. However, TVA's load forecast accuracy since 1985 has been within plus or minus 5 percent of actual loads over each five-year period. This is well within the industry standard of plus or minus 8 percent accuracy.

ELEMENTS OF TVA'S LOAD FORECAST

The load forecast is the basis for planning decisions, such as construction of power plants and implementation of demand-side management. Since the implementation of resource decisions can require many years and enormous financial obligation, state-of-the-art load forecasting is necessary. Key elements used to prepare a state-of-the-art forecast are:

- Best information about key variables
- Best methods that lead to best results

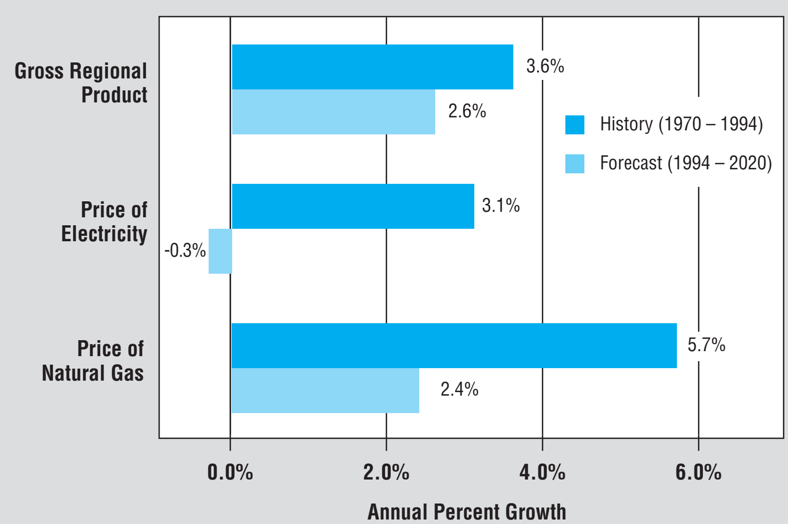
Best Information About Key Variables

TVA's forecast of electric energy requirements is driven by forecasts of four key variables that influence electricity use. These variables include (1) regional economic growth, (2) the price of electricity, (3) the price of alternative energy sources, and (4) TVA's competitive success. A summary of historical and forecast growth rates for the first three key variables is shown in *Figure 6-3*. In this figure, Gross Regional Product is shown as the measure of regional economic growth, and the price of natural gas is used to represent the price of alternative energy sources. The fourth variable, TVA's competitive success, is a new factor introduced into the forecast in response to rising competitiveness.

1. Regional Economic Growth

TVA produces its own forecasts of regional economic activity. These forecasts are derived from forecasts of the national economy. DRI/McGraw-Hill, an internationally recognized forecasting service, produced the forecast of the national economy. DRI/McGraw-Hill forecasts the national Gross Domestic Product to increase by 2 percent per year through 2020 compared to the historical average annual growth rate of 2.3 percent from 1979 to 1994. The TVA region is expected to continue to outperform the nation, primarily due to the continued strong performance of Valley manufacturing. (See Chapter 3, discussion

FIGURE 6-3. **Key Variables**



This chart compares historical and forecast rates of growth for these variables influencing electricity use, including regional economic growth as indicated here by Gross Regional Product, price of electricity, and price of alternative energy sources such as natural gas.

of socioeconomic environment.) Gross Regional Product for the Tennessee Valley is forecast to grow 2.6 percent annually through 2020 compared to the historical average annual growth rate of 3.2 percent from 1979 to 1994.

2. Price of Electricity

TVA has not increased electric rates since 1987 and is committed to no rate increases through 1997.

TVA has not increased electric rates since 1987 and is committed to no rate increases through 1997. This has been achieved through a combination of efforts including controlling costs, refinancing debt, and efficiency improvements. Holding rates constant is expected to continue to have a positive impact on electricity sales. Simply put, increases in the price of electricity reduce sales—lower electric rates increase sales. The TVA wholesale price of electricity in real terms (that is, without including inflation) is expected to decline 0.3 percent per year through 2020.

3. Price of Alternative Energy Sources

The potential for consumers to substitute fossil fuels, primarily oil and natural gas, for electricity will depend on relative prices for a particular end use, such as heating, and on technology factors, such as new types of equipment becoming available. For example, the development of new types of home heating and cooling systems could make it enticing for consumers to use one energy source over another.

Natural gas has emerged as electricity's most important competitor in the market. Because of this, the price of natural gas compared to the price of electricity is the major factor in determining how successfully electricity competes. This affects how much electricity will be used and therefore is a factor in determining the load forecasts. Natural gas prices, without including inflation, are forecast to increase 2.4 percent per year through 2020.

4. TVA's Competitive Success

Competition is growing in the electric utility industry (See Chapter 1, discussion of competitive environment). Regulators are opening markets and allowing some customers to change energy providers. This increases the amount of uncertainty in the load forecast. In the medium forecast, the net effect of competition is that TVA will retain its current customers.

Market and regulatory changes impact TVA's high and low forecasts. If TVA operates at lower costs than the competition and legal requirements permit, TVA may have opportunities to gain customers from outside the existing service territory. This is termed "high competitive success." Likewise, if TVA is a higher cost producer than its competitors, it is likely to lose customers to competing electric utilities—described as "low competitive success." Both cases assume that deregulation of the electric industry continues.

In evaluating TVA's competitive success in the future, TVA analyzed competitive impacts for all sales. In other words, TVA looked at the total electric market rather than at specific customers. Results of surveys of distributors of TVA power and TVA's direct-served industries were used to identify the amount

of load that appeared to be at high risk. TVA used this information in forecasting its performance in a low competitive success environment.

To estimate the potential for gain in wholesale markets, loads of municipal and cooperative distributors in neighboring regions were used to project TVA's performance in a high competitive success environment. Under high competitive success, approximately 5 percent of these loads are captured by TVA by the year 2015.

A more thorough discussion of the four key variables and the methods used to prepare the load forecast can be found in Volume 2, Technical Document 5, Load Forecast.

Best Methods That Lead to Best Results

TVA stays abreast of developments in load forecasting and continually incorporates new information into its forecasting process. State-of-the-art forecasting requires using the best methods available that lead to best results. The best methods include (1) using several advanced models, (2) building energy forecasts by class of customer and end use, and (3) producing a range of forecasts to deal with uncertainty.

1. Using Several Advanced Models

Advanced forecasting models and techniques are key tools used by TVA in developing its load forecast. These models allow for computer simulation of projected power needs based on a variety of considerations. These model and forecasting techniques have been incorporated to form a complete forecasting system from data collection to evaluation of forecast uncertainties.

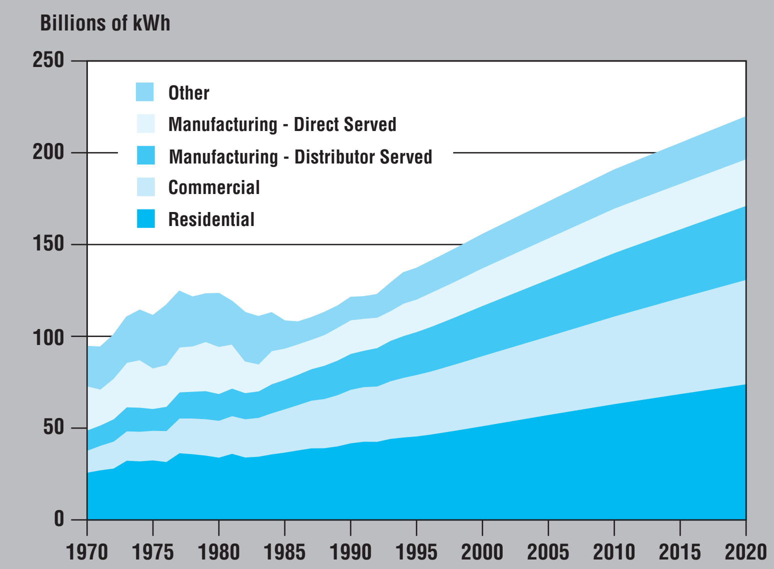
Three types of models are used:

- Econometric modeling is used extensively. An econometric model summarizes in equations estimated relationships between economic trends over a period of time.
- End-use models are used to measure how much energy will be consumed by given end uses such as residential air conditioners, office lighting, and industrial motors.
- Conditional demand and qualitative choice analysis is a combination of econometric and end-use modeling.

Best methods available include the following models that are used in the Energy Vision 2020 forecast:

- Residential Conditional Demand Model
- Residential Energy End-Use Planning System
- Electricity Forecasting Model
- Commercial Energy End-Use Model
- Industrial Energy End-Use Model
- Regional Economic Simulation Model
- Financial Model
- Hourly Electric Load Model

FIGURE 6-4. **Sales by Customer Class**



Annual Increase In Sales (%)

			Manufacturing		
	Residential	Commercial	Distributor Served	Direct Served	Other
1970 - 94	2.4%	4.3%	3.1%	-1.5%	-1.7%
1979 - 90	1.6	3.6	2.2	-3.4	-6.7
1990 - 94	2.4	3.0	4.3	-2.3	4.6
1994 - 00	1.7	2.5	2.8	3.5	4.0
2000 - 20	1.9	2.0	2.0	1.1	1.2

Electricity sales are shown for the customer classes of residential, commercial, and manufacturing. Electricity sales for the manufacturing customer class are divided into sales to industrial customers served by distributors and sales to industries served directly by TVA. The other category includes outdoor lighting sales and power sales to other federal agencies.

More detailed information about the models and techniques used by TVA in preparing the load forecasts can be found in Volume 2, Technical Document 5, Load Forecast.

2. Building Energy Forecasts by Class of Customer and End Use

System energy requirements forecasts include several types of sales and also energy lost in transmission. TVA, through the 160 distributors of TVA power, serves three major groups or classes of electric customers: residential customers, commercial customers, and industrial or manufacturing customers. *Figure 6-4* shows the sales for these classes of customers. The energy forecast is developed by adding electricity sales to these groups, certain miscellaneous sales such as outdoor lighting, and sales to other federal agencies. The forecast also includes electric energy that is lost in transmitting and distributing power. These losses, which amount to approximately 7 percent of the electricity generated, occur because there is some natural resistance to electricity flow in power lines.

Residential. The residential forecasts are influenced by variations in six key factors: per capita income, population size, residential electric prices, residential natural gas prices, household types, and appliance efficiencies. In 1994, TVA's residential sales were 46.3 billion kilowatt-hours. In the medium forecast, residential sales are forecast to be 51.4 billion kilowatt-hours in 2000, and 74.3 billion kilowatt-hours in 2020. Growth rates are expected to be 1.8 percent per year through 2000 and 1.9 percent per year from 2000-2020.

Commercial. Electricity sales to commercial customers are driven by economic activity, the price of electricity, the price of natural gas, technology, and efficiency improvements. The 1994 commercial sales were 33.4 billion kilowatt-hours. In the medium forecast, commercial sales are expected to be 38.2 billion kilowatt-hours in 2000 and 56.9 billion kilowatt-hours in 2020. Growth rates are projected to be 2.3 percent per year through 2000 and 2 percent per year from 2000-2020.

Manufacturing. Manufacturing sales are influenced by economic activity, price of electricity, the price of natural gas, efficiency improvements, and the availability of new technologies. The manufacturing sector is especially important to TVA because the Valley economy is more dependent on manufacturing than is the economy of the United States as a whole. The TVA region has experienced faster growth in manufacturing than the United States. From 1979 to 1994, TVA region manufacturing output grew by an average of 4.2 percent per year, compared with an average of 1.8 percent per year for the nation as a whole.

The forecast of manufacturing sales is divided into two groups: sales to industrial customers served by distributors of TVA power and those industries served directly by TVA. (TVA directly serves 54 large industries due to their extremely high demand for power or unique operating characteristics that would make service by a power distributor difficult.)

Industrial sales by power distributors have increased steadily in the past and are expected to continue to increase. In the medium forecast, total electricity sales to industries served by power distributors are expected to increase from 23.1 billion kilowatt-hours in 1994 to 27.3 billion kilowatt-hours by 2000 and to 40.3 billion kilowatt-hours by 2020. Growth rates are expected to average 2.8 percent per year through 2000 and 2 percent per year from 2000-2020.

The forecast for industries served directly by TVA is developed on a company-by-company basis. In other words, direct-served customers are analyzed individually to develop a forecast for each company. These individual company forecasts are then added to determine the overall forecast for this group of customers. In the medium forecast, total electricity sales to directly served industries are expected to increase from 16.7 billion kilowatt-hours in 1994 to 20.5 billion kilowatt-hours by 2000 and to 25.4 billion kilowatt-hours by 2020. Growth rates are expected to be 3.5 percent per year through 2000 and 1.1 percent per year from 2000 to 2020.

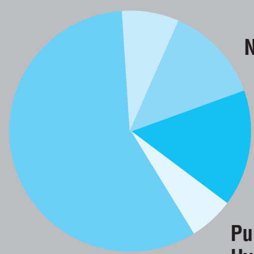
3. Producing a Range of Forecasts to Deal with Uncertainty

Growth in economic activity, population, and electricity sales in the future are all uncertain. TVA prepares the best medium forecast possible with the information available at the time of preparation. However, TVA's forecasters do not expect that the future will turn out to be exactly as forecast. High and low forecasts are prepared to show the degree of uncertainty that exists. TVA uses the range of forecasts to evaluate integrated resource planning options to determine how well they perform under different futures.

In the Energy Vision 2020 load forecast, TVA deals with uncertainty in two ways. First, as explained earlier, several models are used to generate the forecast. This provides the power planners with more than one forecast to analyze the relationship between electricity sales and the key variables.

Second, once the medium forecast is determined, the high and low levels of each key variable are quantified and models are used to determine the high and low sales levels. For the high load forecast, there are 9 out of 10 chances of the actual load being less than the forecast. For the low load forecast, there

FIGURE 6-5. **TVA's 1994 Generating Capacity Mix**



TVA's generating capacity mix and the percentage of power supplied by each source is shown.

is 1 out of 10 chances of the actual load being less than the forecast. This means that the high and low load forecasts are reasonable limits, or bounds, on the expected load in the future.

Additional information on TVA's load forecast can be found in Volume 2, Technical Document 5, Load Forecast.

Need For Power

WHERE WE ARE TODAY—CURRENT AND PLANNED CAPACITY ADDITIONS

TVA currently has 25,600 megawatts of generating capacity. Generating sources include coal-fired, hydroelectric, nuclear, and pumped-storage hydro plants, along with combustion turbines. (See Chapter 4 for a more detailed description of TVA's existing power system.)

Figure 6-5 shows TVA's generating capacity mix and the percentage of power supplied by each source.

Hydro and nuclear plants have the lowest operating costs and are used to the fullest extent possible by TVA. Coal-fired generating plants, the third lowest in cost, are used according to power system demand. Pumped-storage units are used to meet peak demand since energy output is limited by the size of the water reservoir. Combustion turbines or gas-fired plants are the most costly to operate and are typically used to meet peak demand only.

When assessing current generating resources, it is necessary to include not only those in operation, but also any planned additions or changes to the system. TVA already has under development additional supply-side resources of 2,400 megawatts as shown in *Figure 6-6*. These capacity additions consist largely of Watts Bar Nuclear Plant Unit 1 with 1,170 megawatts and Browns Ferry Nuclear Plant Unit 3 with 1,065 megawatts. Both plants are expected to be in operation in 1996. Other ongoing or expected power system capacity changes include improvements to hydroelectric facilities. However, reductions in generating capacity at some of TVA's coal-fired plants due to steam sales and the installation of pollution control equipment are also expected to occur during this period.

FIGURE 6-6. **Current and Planned Capacity**

	Current Capacity in 1994	Planned Capacity Additions from 1994 – 2005	Total Capacity in 2005
Conventional Hydro	4,044	360	4,404
Pumped-Storage Hydro	1,532		1,532
Coal	14,743	(153)	14,590
Combustion Turbines	1,952		1,952
Nuclear	3,282	2,235	5,517
Total	25,553	2,442	27,995

TVA's current capacity measured in megawatts is shown for each generating power source. TVA already has underway additional supply-side resources as shown by the planned capacity additions.

On the demand side, TVA has in excess of 2,500 megawatts of interruptible power contracts with industrial customers. These contracts allow TVA to interrupt power to these industrial customers during periods of peak loads or high demands on the power system. In other words, TVA has the right to turn off or turn down power to some industries so that others can use the power when power supplies are not adequate to serve everyone.

This interruptible power is used as part of TVA's available capacity; however, not all of

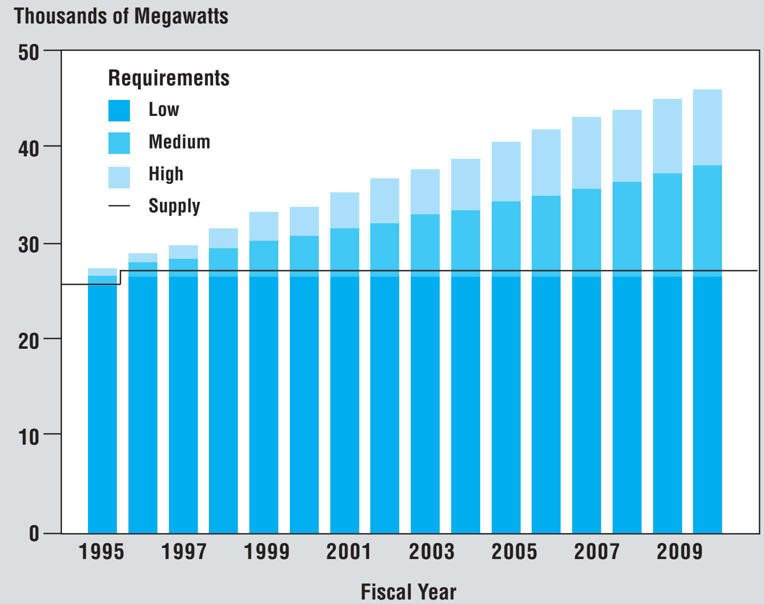
the contracted power is available for interruption due to variations in contracts. Approximately 1,700 megawatts of the 2,500 megawatts of industrial load is available for interruption during peak periods through 2002. After 2002, the availability of interruptible power is expected to drop to 1,500 megawatts through 2020.

FUTURE NEEDS—COMPARING WHERE WE ARE TODAY TO THE LOAD FORECAST

The low, medium, and high load forecasts developed for Energy Vision 2020 are compared to current generating capacity to provide a picture of future power needs. Comparing existing capability to the load forecasts predicts when and how much additional resources will be needed at any given time.

The future need for power is illustrated graphically in *Figure 6-7*, which shows the expected capacity surplus or deficit for low, medium, and high load projections through 2010. Supply, indicated by the solid line, is defined by TVA's current system capacity and planned additions to capacity. Capacity requirements represent the annual peak load forecasts plus reserve margins.

FIGURE 6-7. **Long-Term Capacity Requirements and Supply**



The expected capacity surplus or deficit for low, medium, and high projections are shown through the year 2010. The low, medium, and high capacity requirements are shown by the different colors on the vertical bars. These capacity requirements include both TVA's annual peak load forecasts plus reserve margins. Supply, which includes both TVA's current system capacity and planned additions to capacity, is indicated by the solid line. The difference between the solid line and the requirements shows the deficit or surplus which defines the need for power.

System Demand and Supply Requirements

The medium load forecast developed for Energy Vision 2020 indicates that TVA will need about 800 megawatts of additional generating capacity by 1998. The need for power is based on projections of peak demand—the maximum amount of electricity used at any given time.

This need for power is in addition to the completion or return to service of Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3, available interruptible power, and improvements to TVA's existing generating system.

In the longer term, TVA estimates the need for additional generating capacity will increase to 6,250 megawatts by 2005 and up to 16,500 megawatts in 2020. Resource options identified during Energy Vision 2020 will be used to meet these future needs for power.

Additional information about these resource options can be found in Chapter 7, Supply-Side Options; Chapter 8, Customer Service Options; and Chapter 9, Resource Integration/Alternative Strategy Comparisons.

Based on the high load forecast, additional capacity will be needed by 1997, and the need for new power supply resources increases from that point forward. Under the low load forecast, TVA will not need additional capacity during the forecast period for Energy Vision 2020.

Reserve Requirements

As explained earlier, electric utilities plan and operate their systems to be able to meet the maximum need for energy or the peak load forecast. However, emergencies can occur that prevent certain energy resources from operating—generating units could break down—or maintenance of a resource may require that a unit be off-line when unexpected demands arise. Therefore, capacity is also needed to provide a reserve margin sufficient to ensure power system reliability.

Reserve margin is simply additional power supply that can be called upon in an emergency. The amount of reserve power that may be needed is determined by studying the costs of providing an "acceptable" level of system reliability (the higher the reliability, the higher the cost), the performance of the TVA power system, and the performance of other power systems that TVA may rely upon for power purchases when necessary.

System reliability is determined by the ability of the system to withstand sudden equipment failures on generation or transmission facilities and by changes in load caused by temperature variations or customer equipment failures. Poor reliability can result in interruptions of electric service—people lose their electricity.

Practically speaking, it is not possible to have a power system that is 100 percent reliable. There is always some possibility that an equipment failure or an unforeseen event will cause a power interruption or outage to a customer. Reliability can be improved by adding extra capacity, but this increases the cost to the customer. However, power interruptions also cost the customer, in terms of lost production from manufacturing plants or as a discomfort from the loss of air conditioning on a hot summer day.

Optimum reliability balances the cost of adding new capacity with the cost of outages. This optimum reliability translates into a reserve margin, or additional generating capacity, for TVA of 15 percent average through 1997, 13 percent average for the years 1998 to 2010, and 12 percent average for the years 2011 to 2020. This decline in reserve margin is due to improved availability of generating resources.

The reserve margin proposed by TVA is in alignment with reserve margins established by other entities in the utility industry. Among members of the North American Electric Reliability Council, of which TVA is a member, forecast reserve margins range from 13.5 percent to 22.3 percent for 1995 and projections of 11.9 percent to 18.5 percent for the year 2000.

Conclusion

TVA has determined its need for power to be 800 megawatts by 1998 and 16,500 megawatts by 2020 based on the medium load forecast. To meet this future need, TVA has examined a broad range of options including both supply-side and customer service options. These options will be discussed in the following two chapters. Uncertainty in the load forecasts requires the development of plans that are flexible. Resource options must be available to meet a wide range of customer needs, but at the same time must not produce either a costly surplus of capacity or a shortage of capacity. This need for flexibility is analyzed in Chapter 9, Resource Integration/Alternative Strategy Comparisons.

Chapter Seven

Supply-Side Options

Chapter Seven: Supply-Side Options

Existing TVA plants will continue to be the backbone of TVA's power supply system for the Energy Vision 2020 planning period. However, TVA's load forecasting indicates that its customers' future needs for electricity will exceed its current generating capacity.

With four nuclear units in various stages of construction, a near-term decision was needed on whether to continue these projects. Several options were developed that involved completion, conversion, or cancellation of these nuclear projects.

TVA also created an extensive list of other generating options to meet new peaking, intermediate, base-load, and storage power supply needs through the year 2020. These included traditional technologies (e.g., coal plants, combustion turbines), as well as potential renewable and advanced technology facilities.

In addition, TVA identified options that would give TVA greater flexibility. These include the purchase of competitively priced power from other suppliers (e.g., independent power producers, cogenerators), options on future power delivery, and business partnering arrangements.

TVA characterized all of the supply-side options under consideration, describing their performance, cost, and relevant environmental emissions.

This Chapter Includes:

- Defining Supply-Side Options
- Identifying Supply-Side Options
- Characterization of Supply-Side Options

Supply-Side Options

TVA's load forecasting indicates that its customers' future electricity needs will exceed its current generating capacity. Two broad resource alternatives—energy conservation or energy generation from additional sources—are available to TVA to meet this increased demand. The best solution will probably include elements from both alternatives.

This chapter defines and identifies the broad range of supply-side options that TVA considered in Energy Vision 2020 and explains how these options are characterized according to their performance, cost, and environmental factors.

Existing plants will continue to be the backbone of TVA's power supply in the future; however, a broader definition of supply-side options captures the diverse range of possibilities open to power suppliers—like TVA—today.

Defining Supply-Side Options

Historically, electric utilities have generated, transmitted, and distributed power. Resources that generate or transmit electricity are referred to as supply-side options.

Like most utilities, TVA has satisfied most of its customers' growing electricity demand by either adding new plants to its system or increasing the amount of electricity produced at existing facilities. New generating plants are not the only way to satisfy increased customer demand, but they remain an important option for the future.

Existing plants will continue to be the backbone of TVA's power supply in the future; however, a broader definition of supply-side options captures the diverse range of possibilities open to power suppliers—like TVA—today. A more workable definition of "supply-side option" is "the actions a power supplier can take to increase the amount and reliability of power available for its customers." With this broader definition, options now include power purchased from other producers, power produced by joint ventures, and transmission system improvements. More options add opportunities for TVA to increase the value of power provided to its customers.

MEETING NEEDS FOR POWER

Demand for electricity changes constantly, which increases the need for different generating technologies. The four types of power generators are:

- **Peaking units** can respond quickly to changes in power demand, but normally operate only when demand for power is very high and not for extended periods. A gas-fired combustion turbine is an example of a peaking unit.

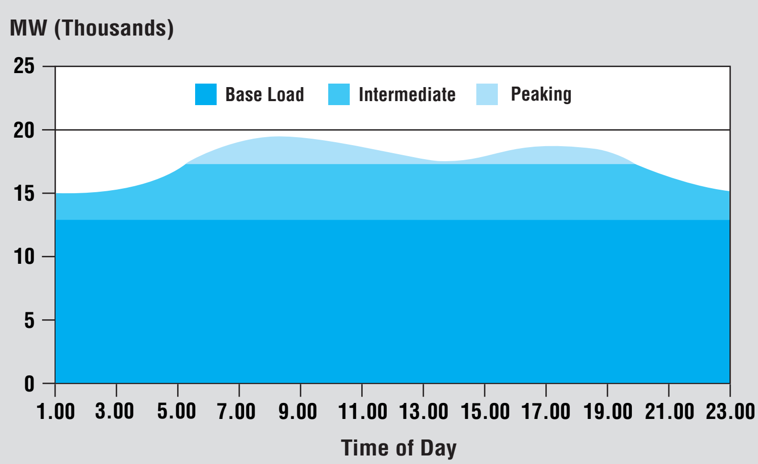
- **Intermediate units** operate to meet the next highest level of power demand. They have some of the same characteristics of peaking units; they must start and stop often and generate a wide range of power outputs. A gas-fired, combined cycle plant is an example of an intermediate unit.
- **Base-load units** meet a largely constant level of power demand and tend to be cycled on and off far less frequently than peaking or intermediate units. A nuclear power plant is an example of a base-load unit.
- **Storage units** usually serve the same power supply function as peaking units, but use low-cost off-peak electricity to store energy for generation later at peak times. An example of a storage unit is a hydro pumped-storage plant that pumps water to a reservoir during periods of low demand and releases it to generate electricity during periods of need. Consequently, a storage unit is both a power supply source and an electricity user.

Figure 7-1 illustrates the use of peaking, intermediate, and base-load generators. Although these categories are useful, the distinction between them is fuzzy. For example, a peaking unit may be called on to run continuously for some time period like a base-load unit, although it is less economical to do so. Similarly, many base-load units are capable of operating at different power levels, giving them some of the characteristics of an intermediate or peaking unit. Energy Vision 2020 considers strategies that take advantage of this range of operations.

The differences among the types of power generation can be characterized by their capital and operating costs. Peaking units generally have low capital costs and high operating costs. Base-load units usually have high capital costs and low operating costs. Costs for intermediate units tend to fall in the middle.

Figure 7-2 illustrates the costs for typical supply-side options as a function of capacity factor. As the figure shows, all options become less expensive the more they are operated. At low capacity factors, peaking units have lower costs than base-load units due to the peaking units' low capital costs. At higher capacity factors, base-load units have lower costs due to their lower operating costs.

FIGURE 7-1. **Representative Winter Day Load Profile**



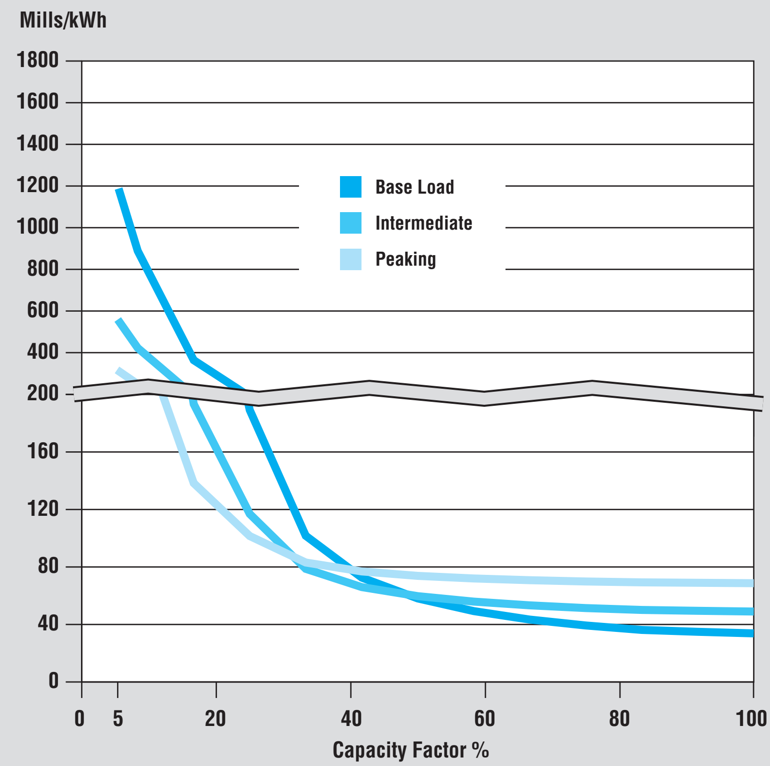
Different types of power generators are needed to meet variations in TVA's load demand.

CENTRALIZED AND DECENTRALIZED GENERATION

Most older generating plants are located in large power supply centers, or central stations, providing between several hundred and several thousand megawatts of capacity. Many available generating technologies are best suited for this type of application.

Other technologies offer the chance to locate the generation facility closer to the end user, a concept referred to as "distributed generation." Both central station and distributed generation technologies are included in the group of supply-side options considered in Energy Vision 2020. For Energy Vision 2020, however, TVA has included additional distributed generation technologies with low power levels (less than 20 megawatts) in the customer service options discussed in Chapter 8. These technologies tend to be closely tailored to customer needs, even though they satisfy the definition of a supply-side option.

FIGURE 7-2. **Cost of Producing Electricity as a Function of Capacity Factor**



While all options become less expensive when operated more, the "least cost" option changes. This characteristic, driven by the relationship between fixed and variable costs, defines whether an option is viewed as peaking, intermediate, or base load. (Capacity factor is the ratio of the actual energy output for a power plant over a certain period of time—typically one year—to the maximum achievable output over the same period of time.)

Identifying Supply-Side Options

TRADITIONAL SUPPLY-SIDE OPTIONS

Some supply-side options are traditional power supply technologies, such as the pulverized coal and natural gas-fired combustion turbine options. Other options involve projects that are unique to TVA. These include completing or converting the Bellefonte Nuclear Plant and increasing the capacity of the Raccoon Mountain pumped-storage facility. Still other options reflect ongoing research and development into new technologies including solar power, wind power, fuel cells, and some of the more advanced combustion technologies.

In developing its supply-side options, TVA faced the challenge of investigating a broad spectrum of options while keeping the total to a manageable number for Energy Vision 2020.

With four nuclear units in various stages of construction, the nuclear completion, conversion, and cancellation options were all included since near-term decisions regarding these projects are needed. (More information on these options can be found in Volume 2, Technical Document 8, Resource Integration.)

Traditional options were included because a number of these technologies are still viable—other utilities are still constructing plants using these technologies today.

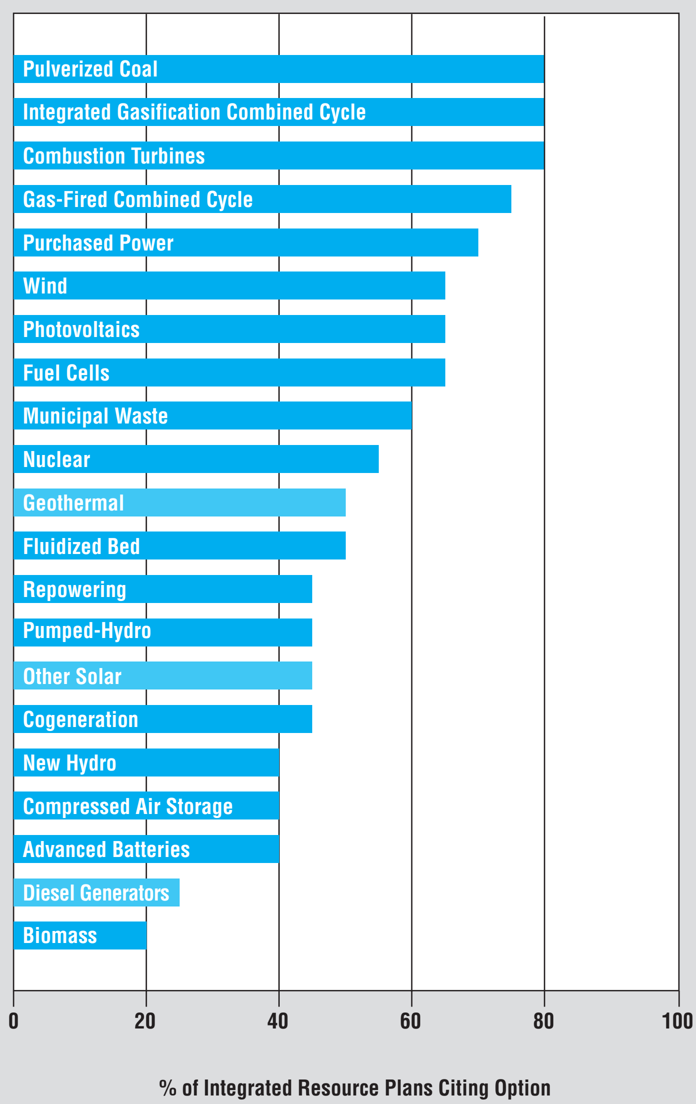
Even within the category of more traditional options, many variations are possible. Plant reliability (availability) can be increased, but usually at additional cost.

Similarly, environmental impacts can be limited to predetermined levels by using different fuels or by adding or altering environmental control equipment. The supply-side options included in Energy Vision 2020 generally include only representative projects for each technology.

TVA reviewed 20 other utility integrated resource plans to verify that its list of options was comprehensive. The treatment of supply-side options differed considerably in the plans examined, ranging from detailed option descriptions in some cases to a listing of only the most promising options in others. No clear, standard set of options emerged from this review. Nevertheless, a comparison of TVA's option list with other lists confirmed that TVA's list is comprehensive.

As shown in *Figure 7-3*, with the exception of geothermal options, large solar collectors and diesel generators, the TVA list is comparable to those in other utilities' integrated resource plans. With regard to the exceptions, TVA has not identified sufficient geothermal resources in the region to support geothermal energy options; large solar collectors are not economical compared with other solar options (i.e., photovoltaics); and diesel generators have been analyzed with customer service options.

FIGURE 7-3. **Comparison with Options Cited in 20 Other Integrated Resource Plans**



The TVA supply-side options list is comparable to those in other integrated resource plans with the exception of geothermal options, large solar collectors, and diesel generators.

RENEWABLES

Several renewable resource options are included as supply-side options. These include several biomass technologies, wind turbines, photovoltaics, landfill and coalbed methane recovery, and technologies that burn garbage as a fuel. Many of these technologies have characteristics that are beneficial compared to some of the other supply-side technologies. These characteristics include small modular size, the possibility of dispersed locations, and low environmental emission rates.

POWER FROM OTHER SUPPLIERS

The purchase of power from cogenerators and independent power producers has become a common practice in the utility industry. Contracts for outside power usually are procured through a bidding process after a utility has defined its needs (in terms of capacity type, amount of energy, and dates when power is needed). Proposals from a TVA bidding process (explained below) and certain unsolicited proposals were reviewed in Energy Vision 2020. Over the years, TVA has received a number of unsolicited proposals for power supply. TVA used these proposals as the basis for defining representative cogeneration and independent power producer projects for the supply-side options list.

OPTION PURCHASE AGREEMENTS

In July 1994, TVA issued a request for proposals for option purchase agreements. Option purchase agreements provide a means for TVA to secure reliable, competitively priced power. These agreements offer flexibility and could enhance TVA's ability to conduct business effectively in a competitive environment.

TVA asked potential suppliers to propose flexible contracts to supply peaking, intermediate, and base-load power. TVA indicated that it was interested in securing up to 2,000 megawatts of peaking capacity for the period from 1997 to 2006 and up to 2,000 megawatts of base-load capacity for the period from 2000 to 2006.

TVA solicited two kinds of option purchase agreements: a call option and a put option. With a call option, TVA pays the seller a price (premium) that gives TVA the right, but not the obligation, to purchase power from the seller at a given price at some specified time in the future.

A put option is the reverse. The seller of the power pays TVA a premium for the right, but not the obligation, to sell power to TVA at a given price at some specified time in the future. In this case, if the owner of the put option chooses to sell the power, TVA is obligated to buy it. Therefore, the put option increases the uncertainty that TVA must consider in planning future supply capacity, but TVA receives an upfront payment as compensation.

In its request for proposals, TVA explained that it would accept proposals from other electric systems, marketers and brokers, demand-side management projects, and developers. Any company could bid, thus opening the process to a variety of services.

In addition to proposals for call and put options, TVA also accepted proposals for forward contracts. A forward contract is not an option purchase agreement. It is simply a firm contract for TVA to buy power from a seller at a specified price at a future date.

TVA received 138 proposals from the request for proposals. These represent 9,800 megawatts of peaking capacity and 12,200 megawatts of base-load capacity.

Proposals received by TVA have been evaluated on the basis of their price, flexibility, and transmission capabilities, as well as their financial, technological, environmental, and economic development attributes. From the results of these

evaluations, the proposals were ranked, and TVA developed a "short list" of the best candidates. TVA will negotiate the price, amount of capacity, and premiums with these candidates.

A full description of the option selection process can be found in the document "Request for Proposal for Option Purchase Agreements," dated July 8, 1994, and a supplement, dated September 22, 1994.

FIGURE 7-4. **Typical Project Implementation Schedule**

Project Phase	Typical Duration
Site Selection, Environmental Studies, & Permitting	2 years
Contracting, Engineering, & Procurement	2 years
Construction & Startup	3 years
Total	7 years

The typical implementation schedule for an option involves three phases.

FLEXIBLE SUPPLY-SIDE OPTIONS

While Energy Vision 2020 outlines the amount and time frame of TVA's need for power, each supply-side option has its own lead time (time required for its implementation). Typically, the implementation of an option involves three phases. During the first phase, the preferred site for the option is identified (and possibly secured), environmental studies are performed, and environmental permits are obtained. During the second phase, engineering analysis and design are completed, and contracts for construction are placed. During the final phase, the plant is constructed and begins operation. While some overlap is reasonable, these phases generally are viewed as sequential activities. *Figure 7-4* provides a typical project implementation schedule, which is applicable to a number of options.

Overall project schedules can be shortened by selecting sites and performing environmental studies prior to making the decision to commit to the project. Although the usefulness of such studies can be limited, they usually remain valid for at least 5-10 years. In Energy Vision 2020, TVA considered the desirability of identifying sites and performing environmental studies for some options in order to shorten their lead times. This provided additional flexibility for some of the options.

POWER FROM OTHER UTILITIES

TVA also can buy power from other utilities. For the next few years, some utilities in the region are expected to have excess generating capacity. This excess capacity is expected to be depleted by the early 2000s. After that, power purchases from other utilities will still be possible, but prices will likely reflect the cost of adding new capacity.

TECHNOLOGIES NOT CURRENTLY COMMERCIALLY AVAILABLE

Identifying new technologies presented a challenge. Ongoing research and development are continuing to produce new technologies as well as significant improvements in existing applications. No one can predict the full range of options that will become available over the next 25 years.

Research and development efforts are underway for many potentially attractive new technologies, ranging from ideas on the drawing board to prototype technologies that have been tested but are not yet commercially available. It was neither feasible nor necessary to include every conceivable new technology in Energy Vision 2020. To be considered an option in Energy Vision 2020, a new technology had to be sufficiently well developed that its date of commercial availability, cost, and performance could be credibly estimated.

TVA identified these options through public comments, its own research and development, and utility industry research provided by the Electric Power Research Institute.

Forecasting cost and performance characteristics for a new technology includes many uncertainties. Nevertheless, some important trends in technology development have been observed. Estimates of cost and performance can be overly optimistic until prototypes have been tested and their detailed designs completed. Cost and reliability estimates improve as more units are built, although unforeseen problems may occur at any time.

Some promising new technologies are now being used outside the TVA region where climate and other conditions are favorable. This is true for wind turbines and solar photovoltaic cells. Since industry research and development are continuing to improve both the cost and performance of these options, they are included as supply-side options in Energy Vision 2020.

The costs for each supply-side option in Energy Vision 2020 include two ranges of uncertainty: one for the developmental status of the technology and another reflecting the accuracy of the cost estimate. Appropriately, both ranges are wide for technologies in early stages of development, allowing for either innovative breakthroughs or future problems. Both ranges narrow as development proceeds toward a standard commercial product, and costs become less uncertain.

NON-TRADITIONAL BUSINESSES AND BUSINESS ARRANGEMENTS

Conventional power plants owned and operated by utilities are not necessarily the ideal solution for obtaining additional capacity in the TVA region. By the same token, conventional power purchase agreements may also not be ideal. The changing competitive environment in the utility industry provides several new alternatives to consider.

Conventional power supply options typically use one of two approaches. A utility or independent power producer primarily generates power as a business and may make some minor side products. Alternately, a cogenerator may use a manufacturing process that generates small quantities of power as a byproduct. As technology advances, opportunities for more closely aligning manufacturing or chemical processes with power production appear increasingly attractive. TVA is exploring such arrangements, which are referred to as coproduction. At this time, the best opportunities for such an arrangement are associated with coal gasification technologies.

Finally, conventional utility projects have relied on utility ownership and financing. Although financing by a single entity remains feasible, partnership arrangements may also be beneficial. TVA is considering two partnership options for the Bellefonte Nuclear Plant—either complete it as a nuclear plant or convert it to a coal gasification plant. For the nuclear completion partnership option, TVA would invest no capital beyond that which it has already invested. For the coal gasification partnership option, additional capital may be required for equipment.

Other partnership opportunities may also be beneficial, particularly as a means of minimizing TVA's debt.

The rapid changes occurring in the utility industry will continue to challenge planners to look beyond conventional options for supplying power in a cost-effective, environmentally responsible way. In some cases, these opportunities may take the form of different business arrangements for implementing technologies that are already included in the supply-side option list (for example, a Bellefonte partnership). In others, new technologies or combinations of existing technologies may arise.

BELLEFONTE CONVERSION

One of the options being considered in Energy Vision 2020 is the conversion of the Bellefonte Nuclear Plant to an integrated gasification combined cycle plant that generates power and makes chemical products. Doing this as a partnership arrangement is also being considered.

The concept for the integrated gasification combined cycle with coproduction and partners is the same as for a conventional integrated gasification combined cycle, with the addition of chemical coproduction capability. Some of the syngas is diverted from the combustion turbines for use as a feedstock in a chemical process plant. The studies to date have indicated that methanol and some of its derivatives represent the most feasible coproduction alternatives. Under one scenario, the ultimate facility is assumed to consist of four 3,000 ton-per-day gasifiers providing syngas to fuel two combustion turbines plus the coproduction plant. The facility will be able to generate approximately 484 megawatts with the capability to produce 6,600 tons per day of methanol and associated products. It is also assumed that the gasification and coproduction plants are owned and operated by partners. TVA would own and operate the power block only. The chemical coproducts were assumed to be shipped to the Gulf Coast area by barge for sale to markets in that region.

The construction schedule for this concept is based upon a multi-phase installation. The integrated gasification combined cycle option described above is based on the successful demonstratoin of the use of integrated gasification combined cycle technology. An effort is under way to demonstrate at Bellefonte the feasibilty of integrated gasification combined cycle technology through the use of Department of Energy Clean Coal Technology funding. The demonstration facility will consist of one 3,000 ton-per-day gasifier and a combustion turbine combined cycle repowering of one of the Bellefonte nuclear units with a capacity of 400 megawatts. (The Department of Energy has tentatively approved resiting the Combustion Engineering Clean Coal II Springfield project to Bellefonte.) Approvals for construction of the demonstration plant are expected to be obtained by October 1997. Operation of the demonstration plant will occur in the latter part of 2000. Subsequent gasifiers could go into operation after a two-year demonstration period, as determined by economic considerations. Construction of the chemical coproduction facilities could proceed in parallel with the construction of these future gasifiers, as economically justified.

The concept is sufficiently flexible to allow several alternatives for the development of Bellefonte. TVA will be conducting an 18 to 24 month study to eval-

uate the various long-term conversion options. Meanwhile, the Department of Energy demonstration project will proceed on a schedule agreed to by both TVA and the Department of Energy. To meet this schedule, planning for the demonstration unit is under way.

Subsequent expansion could follow several different scenarios. The steam turbines at Bellefonte are sufficiently large to allow connection of several combustion turbine combined cycle units. For example, initial installations could consist of phased combined cycle units fueled by fuel oil or natural gas (if available) starting as peaking combustion turbines, then converted later to combined cycle operation. These units could then be updated to syngas operation by the construction of additional gasifiers as economics dictate.

TRANSMISSION OPTIONS

Consistent with a broader definition of supply-side options, TVA also considered the following two transmission system improvement options:

- A series of transmission system capital improvements would reduce transmission losses on the TVA system. Since TVA continually evaluates projects that reduce losses, those projects are not explicitly evaluated as a part of each strategy in Energy Vision 2020.
- The location of future generation in the western part of the power system can reduce losses and improve transfer capacity on transmission interfaces with other utilities. The loss reduction would be equivalent to about 45 megawatts per 1,000 megawatts of capacity and would mean a savings of $30 to $50 million.

ENVIRONMENTAL CONTROL OPTIONS

Compliance with the 1990 Clean Air Act Amendments' Phase II requirements for sulfur dioxide reduction is another consideration in Energy Vision 2020. Compliance is a dynamic activity that requires ongoing consideration of changes in fuel markets, sulfur dioxide allowance markets, cost of pollution control equipment, opportunities for power purchases, etc. Thus, defining a detailed strategy in Energy Vision 2020 is not feasible. However, TVA established a general approach to Phase II compliance from which appropriate strategies will emerge.

The capital and operating costs of sulfur dioxide emissions reduction options vary widely. Emissions control options include scrubbers and the use of low sulfur coal. Energy supply options include switching to an alternative fuel such as natural gas, converting a facility to a technology with lower emissions (i.e., repowering), or replacing coal-fired units with low emission generation capacity. Demand-side management or conservation options can also reduce sulfur dioxide emissions by reducing usage of existing facilities or avoiding the need for new capacity. Purchasing allowances from other regulated sources that exceed their emissions reduction requirements is also an option.

The costs of implementing any of these options depend on timing. For example, emissions reductions taken earlier than required or exceeding minimum requirements may be less expensive at one TVA source and delay the need for equivalent reductions at another source in the TVA system. The relative costs of

FIGURE 7-5. **Alternative Phase II Acid Rain Control Options**

Reference Case	Minimum Capital Borrowing	Repowering – Minimum Carbon Dioxide (CO_2) Impact
Wet flue gas desulfurization (scrub) at Paradise Unit 3 in 2002 and add coal reburn in 2000	Switch Paradise Unit 3 to 100% powder river basin coal in 2006	No scrubbers at Paradise Unit 3
Wet flue gas desulfurization at Allen Units 1-3 in 2004 and add coal reburn in 2000	Switch Allen Units 1-3 to 100% natural gas in 2000; no coal or gas reburn	Repower Allen and Johnsonville Units 1-10 with gas-fired combined cycle in 2004
Switch to eastern low sulfur coal at selected plants	Switch to medium and low sulfur coal at selected plants	Switch to low sulfur coal at selected plants
Build up allowance bank in Phase I; buy and sell allowances in Phase II	Sell excess allowances in Phase I; buy and sell allowances in Phase II	Build up allowance bank in Phase I; buy and sell allowances in Phase II

Energy Vision 2020 considers 3 alternatives to comply with the Clean Air Act: (1) a Reference Case, (2) Minimum Capital Borrowing, and (3) Repowering—Minimum Carbon Dioxide (CO_2) Impact.

achieving emissions reductions from TVA sources will depend on future environmental regulations, future costs of alternative fuels, and the development of new emissions control technologies.

Typical Phase II environmental control options can be formulated to address TVA's Energy Vision 2020 criteria. For example, a control option to minimize impacts on rates would include sulfur dioxide scrubbers, while a control option to minimize debt would minimize capital expenses and use extensive fuel switching. Other examples include control options that not only reduce sulfur dioxide emissions, but also minimize carbon dioxide emissions and maximize the use of new technologies for emissions controls and repowering.

The precise operational details of a control option must be worked out in response to future events (e.g., new regulations, generation demands). Prior to deploying specific pollution control projects, further environmental reviews would be conducted. *Figure 7-5* shows Phase II acid rain control options that are being considered in Energy Vision 2020.

In Energy Vision 2020, additional carbon dioxide mitigation was represented through options for cofiring biomass fuel at TVA's existing coal-fired plants. For the first option, it was assumed that the overall amount of biomass fuel would be 0.3 percent and in the second option, 1.3 percent.

Many of the options considered in Energy Vision 2020, such as repowering and demand-side management, could also help TVA comply with the Clean Air Act.

Characterization of Supply-Side Options

All of the supply-side options that TVA identified for consideration in Energy Vision 2020 were characterized using data describing their performance (e.g., capacity, heat rate), cost (e.g., capital cost, operation and maintenance

FIGURE 7-6A. **Conventional Supply-Side Options—Performance Characteristics**

Option Name	Status	Duty Cycle	Net Full Load Capacity (MW)	Net Full Load Heat Rate (Btu/kWh)	Fuel	Total Schedule (Yr)	Coproducts
Supercritical Pulverized Coal Plant (4x300 MW)	Mature Commercial	Base Load	1,200	9,522	High Sulfur Coal	8	None
Simple Cycle Combustion Turbine (1x150 MW)	Mature Commercial	Peaking	150	10,500	Natural Gas	5	None
Natural Gas-Fired Combined Cycle (1x470 MW)	Mature Commercial	Intermediate	470	7,000	Natural Gas	5	None
Compressed Air Energy Storage with Humidification (3x337 MW)	Initial Commercial	Peaking	1,011	5,874	Natural Gas	7	None
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	Initial Commercial	Base Load	740	7,230	High Sulfur Coal	8	Sulfur
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	Large Scale Demo	Base Load	840	8,200	High Sulfur Coal	8	None
Landfill Methane (1x2 MW)	Pilot Scale	Intermediate	2	6,450	Landfill Gas (Methane)	3	Waste Heat, Steam
Hydro Generation: Modernization at Existing Projects	Mature Commercial	Peaking	3,864	NA	NA	11	None
Bellefonte (BLN) Repowering – IGCC with Coproduction with Partners (2x242 MW)	Initial Commercial	Base Load	484	7,200	Syngas	8	Multiproducts
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	Mature Commercial	Intermediate	150	7,500	Natural Gas	5	None
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	Pilot Scale	Intermediate	200	NA	Wind	6	None
Power Purchase - Peaking	Mature Commercial	Peaking	300	12,000	NA	0	None

Figures 7-6A-E. Supply-Side Options – Conventional, Flexible, and Option Purchase Agreements. These figures show performance (7-6A), cost (7-6B), and environmental characteristics (7-6C) for some of the supply-side options. The flexible options (7-6D) are different than the conventional options in their schedules and costs (all other characteristics remain the same). By doing some work upfront, such as site identification and permitting, before a final decision is made to put an option in place, the total schedule can be significantly reduced. The accelerated schedule, the upfront cost to complete this preliminary work, and the remaining cost to complete the option are shown for the flexible options.

cost, fuel cost), and environmental emissions (e.g., air, water, solids).

Selected conventional supply-side options, characterized by performance, cost, and environmental emissions, are shown in *Figures 7-6A*, *7-6B*, and *7-6C*. Flexible TVA-built options are shown in *Figure 7-6D*, and option purchase agreements are shown in *Figure 7-6E*. These supply-side options are shown because they are included in the final set of strategies evaluated in Energy Vision 2020.

A complete list of the supply-side options identified for consideration in Energy Vision 2020 and their characteristics can be found in Volume 2,

FIGURE 7-6B. **Conventional Supply-Side Options—Cost Characteristics**

Option Name	Base Capital ($/kW)	Fuel Cost ($/MMBtu)	Base Fixed Operating &Maintenance ($/kW-Yr)	Base Variable Operating &Maintenance (Mills/kWh)	Base Fixed Additions &Improvements ($/kW-Yr)
Supercritical Pulverized Coal Plant (4x300 MW)	$1,345	$1.00	$20.0	1.3	$13.6
Simple Cycle Combustion Turbine (1x150 MW)	$360	$2.48	$2.0	2.6	$0.0
Natural Gas-Fired Combined Cycle (1x470 MW)	$655	$2.48	$4.7	1.25	$4.5
Compressed Air Energy Storage with Humidification (3x337 MW)	$315	$2.48	$2.2	2.5	$0.0
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	$1,524	$1.00	$20.8	1.2	$12.0
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	$1,126	$2.48	$18.6	0.9	$13.2
Landfill Methane (1x2 MW)	$1,034	$1.29	$9.8	1.7	$40.0
Hydro Generation: Modernization at Existing Projects	$52	NA	$6.9	0.0	$10.8
Bellefonte (BLN) Repowering - IGCC with Coproduction with Partners (2x242 MW)	$465	$3.59	$4.7	1.3	$4.5
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	$0	$2.48	$86.7	17.16	$0.0
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	$958	NA	$15.0	0.0	$0.0
Power Purchase - Peaking	$0	NA	$33.6	31.8	$0.0

Fuel cost data are in 1995 dollars. Other cost data are in 1994 dollars.

FIGURE 7-6C. **Conventional Supply-Side Options—Environmental and Other Characteristics**

Option Name	Sulfur Dioxide (lb/MMBtu)	Nitrogen Oxides (lb/MMBtu)	Carbon Dioxide (lb/MMBtu)	Thermal Discharge (MMBtu/MWh)	Solid Waste (lb/MMBtu)	Economic Development (Annual Average Employment)
Supercritical Pulverized Coal Plant (4x300 MW)	0.3	0.1	210	0	24.0	918
Simple Cycle Combustion Turbine (1x150 MW)	0	0.08	115	0	0	20
Natural Gas-Fired Combined Cycle (1x470 MW)	0	0.08	115	0	0	128
Compressed Air Energy Storage with Humidification (3x337 MW)	0	0.03	115	0	0	130
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	0.05	0.035	205	0	9.5	610
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	0.05	0.01	205	0	9.5	569
Landfill Methane (1x2 MW)	0	0.16	-798	0	0	1
Hydro Generation: Modernization at Existing Projects	0	0	0	0	0	619
Bellefonte (BLN) Repowering - IGCC with Coproduction with Partners (2x242 MW)	0.03	0.08	131	0	9.5	108
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	0	0.08	115	0	0	15
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	0	0	0	0	0	108
Power Purchase – Peaking	0	0.1	115	0	0	0

FIGURE 7-6D. **Flexible TVA Supply-Side Options**

Option Name	Original Schedule (Yr)	Accelerated Schedule (Yr)	Cost to Obtain Accelerated Schedule ($/kW)	Cost Remaining ($/kW)
Simple Cycle Combustion Turbine (1x150 MW)	5	1.5	$22	$338
Natural Gas-Fired Combined Cycle (1x470 MW)	5	2	$14	$641
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	8	3.5	$18	$1,506
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	8	3.5	$15	$1,111
Landfill Methane (1x2 MW)	3	1.5	$205	$829
Bellefonte Repowering – IGCC with Coproduction with Partners (2x242 MW)	8	3.5	$20	$445

The schedule for the landfill methane option is constrained by the commercialization of the fuel cell technology upon which it is based. Thus, an accelerated schedule would not reduce the timing of the initial availability of the option.

FIGURE 7-6E. **Option Purchase Agreements**

Option Type	Schedule (Yr)	Availability	Option Price ($/MW-Yr)	First Year Charges ($/MWh)
Base Load - Call	3	85 – 100%	100 – 65,000	$24 – 52
Peaking - Call	2	95 – 100%	150 – 1,346	$40 – 250

Technical Document 6, Supply-Side Options. A brief description of each option, identifying the primary source of data for characteristics of the option, is also found in Volume 2, Technical Document 6, Supply-Side Options.

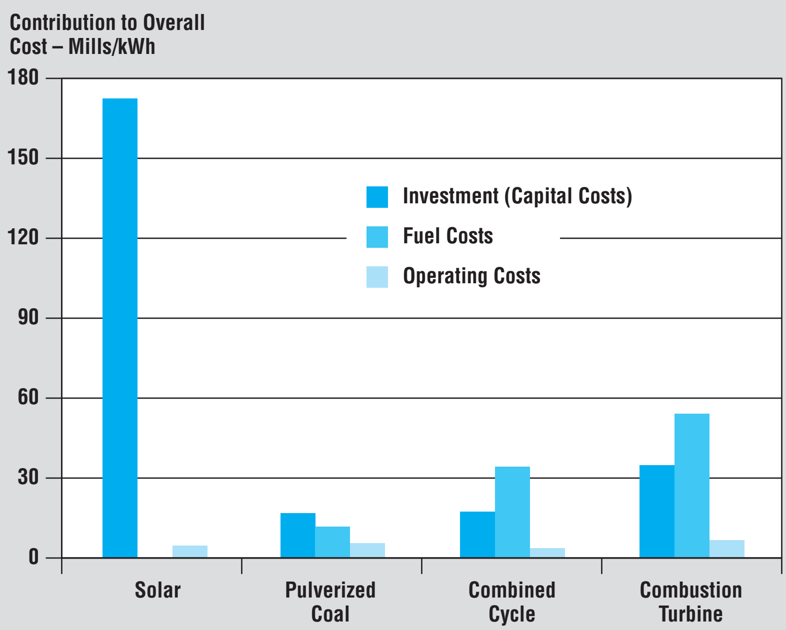
In developing Energy Vision 2020, TVA considered whether to use a single source or multiple sources of data to characterize the options. A single source provides better data consistency across options; however, multiple sources provide the advantage of a broader range of data and more recent data. TVA elected to use multiple sources, recognizing that this approach could introduce some differences in how costs are allocated in different categories and how critical factors such as contingencies are treated. In many cases, Electric Power Research Institute's Technical Assessment Guide was used as a source. This guide provides the most comprehensive assessment of supply-side options available. In other cases, option descriptions reflect information from proposals or other specific studies available only to TVA.

COST, PERFORMANCE, AND ENVIRONMENTAL CHARACTERISTICS

A review of *Figure 7-6* reveals the broad range of performance attributes, cost factors, and environmental emissions associated with the supply-side options. Comparing options across this full range is a daunting task, but some general guidelines can help.

Figure 7-7 shows the sensitivity of overall cost to various cost factors for four typical supply-side options. As shown in *Figure 7-7*, the magnitude of different cost factors varies considerably among different options; however, for most options either capital costs or fuel costs (or both) dominate.

FIGURE 7-7. **Cost Factor Sensitivities**



The relative magnitude of the contributing cost factors varies considerably among different options based on expected operating capacity factors.

While the cost of power is an important consideration for the selection of supply-side options in Energy Vision 2020, other factors are also significant. Environmental emissions differ dramatically depending on fuel type and technology. Each option also requires different capital investments, which will affect TVA's overall debt. TVA considers these effects within the framework of Energy Vision 2020. In general, the broad range of supply-side options support strategies that perform well from the perspectives of cost, environmental factors, rates, and debt.

SITING CONSIDERATIONS

Supply-side option costs and benefits are site-specific. Since Energy Vision 2020 is programmatic in nature, site-specific decisions will be made later. Therefore, for many supply-side options, TVA evaluated generic locations. Where specific conditions are necessary to conduct the review, such as for estimating transmission costs and effects, TVA considered a location at milepost 160 on the Tennessee River, which is in the western part of the TVA system.

Some options can only be implemented at a single location (for example, the completion of Bellefonte Nuclear Plant or its conversion to use of another fuel). For these options, the actual location was considered in estimating the effects on the transmission system and determining likely fuel costs.

Chapter Eight

Customer Service Options

Chapter 8: Customer Service Options

Customer service options are actions consumers can take on their side of the electric meter to obtain energy efficiencies and provide load management options for utilities. Customer service options also include actions consumers can take to use electricity to improve their productivity and quality of life.

TVA's catalog of customer service options contains traditional demand-side management (i.e., energy efficiency and load management), self-generation, beneficial electrification, and rate options. TVA designed the options to take advantage of existing and emerging technologies that could be effectively integrated into programs to meet varying customer and TVA needs.

These options were ranked by total resource cost as well as other evaluation criteria and combined into blocks of options suitable for analysis with power supply options. TVA's long- and short-term resource plans will include those customer service options that integrate well with desirable supply-side options and meet TVA's evaluation criteria.

This Chapter Includes:

- Range and Effects of Options
- Customer Objectives
- Key Areas for Customer Service Options
- Summary of All Customer Service Options
- Option Development Process
- Programs Used to Overcome Market Barriers
- Key Variables and Assumptions
- Results of Analysis
- Summary

Customer Service Options

Range and Effects of Options

The customer service options developed by TVA cover a wide range of technologies and pricing strategies. They also include other activities that change the way customers use electricity, providing both direct benefits to customers and resource benefits for the power system. These options would be implemented by TVA in partnership with distributors of TVA power for the benefit of end-use customers.

The integrated resource planning process also considers the indirect effects associated with customer service options; these include economic development, electricity prices, customer value, productivity, and the environment.

One of the primary goals of Energy Vision 2020 is to provide benefits to customers.

Customer Objectives

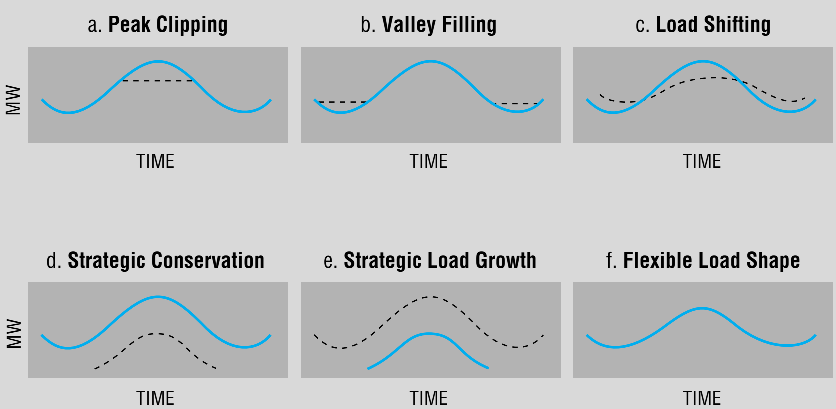
One of the primary goals of Energy Vision 2020 is to provide benefits to customers. In developing customer service options, TVA gave special consideration to the following objectives:

- **Minimum Rates** – Options that help TVA maintain competitive rates
- **Low Cost** – Options that are cost-effective for both the customer and the utility
- **Large Impacts** - Options that can quickly produce significant energy and capacity savings
- **Diversity** – Options that address all end uses (devices that use electricity) and improve the flexibility of the power system
- **Environmental Benefits** – Options that have important environmental benefits associated with them
- **Customer Service** – Options that create value for the customer by increasing productivity or lowering the costs of energy services
- **Social Equity** – Options that provide all ratepayers with an equal opportunity to participate in customer service programs and minimize the potential rate subsidies between one customer class and another

Customer service options are also associated with six different load shape objectives, as shown in *Figure 8-1*. A load shape shows the pattern of

electricity consumption in a utility's service territory over a period of time. One of demand-side management's objectives is to smooth the shape of energy demand to achieve a flatter load shape. A flatter load shape allows the utility to use generating facilities that have lower operating and fuel costs per unit of electricity produced and avoid the use of higher-cost peaking alternatives.

FIGURE 8-1. **Customer Service Options**
Load Shape Objectives for the Power System



Different load shape objectives for the power system suggest the need for a variey of customer service options.

FIGURE 8-2. **Load Shape Objectives for Customer Service Options**

Load Shape Objectives	Energy Efficiency	Load Management	Beneficial Electrification	Self-Generation	Rates
	OPTION TYPE				
Peak Clipping	●	●		●	●
Valley Filling		●	●	●	●
Load Shifting		●			●
Strategic Conservation	●			●	●
Strategic Load Growth			●	●	●
Flexible Load Shape	●	●	●		●

Customer service technologies and options that can meet various load shape objectives include energy efficiency (high-efficiency heat pumps), load management (water heater cycling), beneficial electrification (electric arc furnaces), self-generation (customer backup generation dispatched to optimize the power system), and rates (real time pricing options to flatten the load shape).

Key Areas for Customer Service Options

TVA developed customer service options in four key areas:

- Traditional demand-side management, which includes conservation and load management
- Self-generation
- Beneficial electrification
- Rates

Figure 8-2 shows which of the load shape objectives can be achieved by the different customer service options.

DEMAND-SIDE MANAGEMENT

Demand-side management options include energy efficiency measures such as insulation, building construction designs, and the use of more efficient appliances and equipment. Demand-side management is also achieved through load management options, where the utility controls the heating cycle for water heaters, the use of other appliances, or encourages customers to modify their pattern of energy use by using storage technologies in order to reduce demand during peak hours.

SELF-GENERATION

Self-generation options refer to relatively small decentralized power systems that customers can use to meet a portion of their energy needs and also improve reliability. Utilities can encour-

age use of these options through financing rate programs or partnerships to provide benefits to the power system. Self-generation systems include both fossil and renewable technologies.

BENEFICIAL ELECTRIFICATION

Beneficial electrification options promote the use of electricity by identifying new, efficient uses of electricity or by substituting it for other fuels to increase productivity and product quality. Beneficial electrification can also provide increased convenience for the customer or environmental benefits. Electric buses, microwave heating, and electric lawn mowers are examples of potentially valuable new uses of electricity.

RATE OPTIONS

Rate options refer to changing the level and structure of charges for electricity use by customers. These charges include a customer charge, a demand charge, and an energy charge. The customer charge is based on the non-energy-related costs of serving each customer. Non-energy-related costs include administrative costs. The demand charge is based on the quantity of generating capacity required to serve a customer. Finally, the energy charge is based on the variable production costs of each unit of electricity. Fuel costs are a large component of the energy charge. As shown in *Figure 8-2*, rate options can achieve all load shape objectives. Rate options also include charges based on time of use in order to reduce demand during hours of peak use.

FIGURE 8-3. **Customer Service Options Summary – Impacts for 2010**

Resource Acquisition (Saving)	Options	Megawatts
Energy Efficiency & Load Management	39	5532
Self-Generation	8	281
Rates (Time-of-Day)	3	892
Load Growth (Sales)	**Options**	**Megawatts**
Beneficial Electrification	14	205
Rates(Declining Block)	3	169

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date.The customer service options identify a potential to save 6,705 megawatts of alternative capacity. Beneficial electrification and declining block rates would increase the required electricity production capacity by 374 megawatts.

Summary of All Customer Service Options

Figure 8-3 summarizes the customer service options developed for consideration in Energy Vision 2020. In the demand-side management area, TVA has developed 39 options (23 for residential customers and 16 for commercial and industrial customers). There are 14 beneficial electrification options spanning all sectors of the economy. Eight self-generation options were developed for commercial and industrial customers. TVA also developed two rate options for each sector of the economy.

These options can change both the need for new generating capacity and the level of electricity sales that TVA would be required to provide. *Figure 8-3* shows that in 2010, more than 5,500 megawatts of electricity could be saved if all of the proposed energy efficiency options were adopted regardless of their cost-effectiveness. Small-scale self-generation could reduce direct demand on the TVA system by more than 280 megawatts.

Time-of-day rates for residential, commercial, and industrial sectors could reduce demand by 892 megawatts in 2010. Time-of-day rates charge customers more for energy use during hours when electricity must be produced

by the power plants that are the most expensive to operate. A declining block rate option, which charges a lower price for electricity use when use exceeds a certain amount, provides a benefit for customers who use large amounts of electricity. The declining block rate option could increase electricity demand by 169 megawatts. Beneficial electrification could increase demand by 205 megawatts.

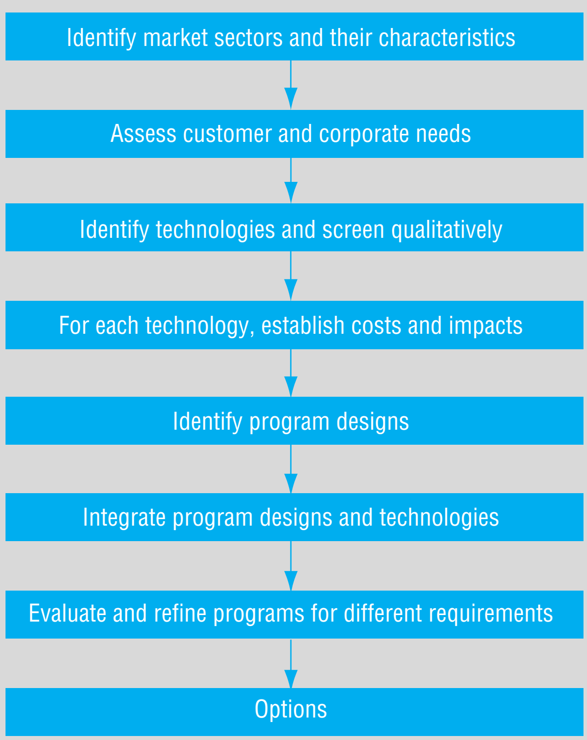
Option Development Process

TVA followed a specific process to develop and evaluate the initial set of customer service options. *Figure 8-4* illustrates the process used to develop customer service options, including energy efficiency, load management, self-generation, beneficial electrification, and to a limited extent, rate options.

IDENTIFY MARKET SECTORS AND ASSESS CUSTOMER NEEDS

TVA identified different market sectors and their characteristics to assess customer needs and to understand the kinds of technologies and programs that would be most effective in addressing those needs. TVA also met with distributors of its power to obtain their input for promoting energy-efficient technologies to end-use customers.

FIGURE 8-4. **Process for Development of Customer Service Options**



Customer service options use specific technologies delivered through a variety of program designs to meet customer needs and improve energy efficiency.

IDENTIFY AND QUALITATIVELY SCREEN TECHNOLOGIES

To ensure that a wide range of options was developed for analysis in Energy Vision 2020, TVA identified a large variety of efficient technologies. TVA then eliminated those with no potential application in the Valley. For example, evaporative air conditioners were dismissed because they are not compatible with the Valley's humid climate. Considerable care was taken not to eliminate technologies prematurely and to carry forward as many technologies as possible to the next stage of the analysis.

ESTABLISH AND RANK TECHNOLOGY COSTS AND IMPACTS

For all selected technologies, TVA gathered information on costs, energy requirements, and impacts on its capacity. This information was stored in a detailed database. Engineering simulations, as well as data from other utilities, technology vendors, and TVA field tests all contributed information to the

database. Once the database was developed, it was reviewed by a number of technology experts from the public and private sectors.

For each market segment, TVA ranked energy efficiency technologies from a total resource cost perspective. To ensure that TVA would have a comprehensive set of options, some technologies with benefits lower than the cost of the technology were included in one or more program options. Beneficial electrification measures were ranked according to their impact on average electricity prices. This ranking identified the technologies to be included in one or more of the beneficial electrification options.

IDENTIFY PROGRAM DESIGNS

A critical step in the process was the design of programs that would encourage customer acceptance, meet economic and financial objectives, and provide options for all customer classes. TVA reviewed other programs to identify strategies that would meet TVA, distributor, and customer objectives. Past and present TVA programs and other utility programs were examined to find best practices and program characteristics providing the greatest chance for success.
Programs included in TVA's customer service options were designed to:

- Increase energy efficiency by overcoming obstacles to the adoption of a new technology
- Increase customer value
- Promote market transformation and changes in consumer behavior

Programs providing customer value, such as microwave heating or laser cutting options, address environmental concerns and increase productivity. These factors often have a greater impact on business profits than do energy costs.

INTEGRATE PROGRAM DESIGNS AND TECHNOLOGIES

For customer service options, TVA combined technologies with delivery strategies to provide the most economical, efficient, and convenient services to customers. Technologies were integrated with program designs based on likely distribution channels, customer needs, and the characteristics and economics of the different technologies.

FIGURE 8-5. **Objectives Satisfied by Program Designs**

Program Concepts	PROGRAM OBJECTIVES Minimum Rates	Low Cost	Large Impact	Diversity	Customer Service	Social Equity
Financing/Leasing	●			●	●	
Technical Assistance					●	
Assistance with O & M					●	
Rebates			●	●		●
Direct Install			●		●	●
Audit	●	●		●	●	
Mail Order		●	●			●
Rates	●	●		●		
Custom Programs			●	●	●	
Shared Savings	●	●		●	●	

Customer service options use different program delivery mechanisms or concepts that best satisfy the range of customer objectives.

EVALUATE AND REFINE OPTIONS TO MEET DIFFERENT REQUIREMENTS

TVA compiled a wide variety of different customer service options to ensure diversity and comprehensiveness. TVA evaluated each option to determine its likely impact on the utility, its customers, and society. Delivery of technologies through a variety of program designs ensures that customer needs are met.

Programs Used to Overcome Market Barriers

Figure 8-5 lists the program concepts or delivery mechanisms that were used to develop the customer service options and shows the customer objectives that can be satisfied by these programs. Some programs are more technology-specific, while others are designed to assist customers in identifying efficiency opportunities unique to their home or business. These programs provide value to customers by making technologies more accessible to them and by overcoming obstacles that prevent customers from adopting energy efficiency measures on their own.

The obstacles to adopting energy-efficient technologies, often referred to as market barriers, can be classified into five types:

- Inadequate information
- Inconvenience and hassle
- Excessive risk
- Financial barriers
- Availability

Figure 8-6 shows how different program designs can overcome the market barriers identified above. Some program designs are more technology-specific than others.

Programs such as the following can be used to overcome these market barriers:

Financing/Leasing – Financing is offered to utility customers or alternatively, the utility owns the technology itself and leases it to customers.

Technical Assistance – Architectural and engineering firms, utility personnel, equipment vendors, or manufacturers assist customers with the new technologies.

Operating and Maintenance Assistance – Customers receive ongoing assistance in operating and maintaining equipment.

Rebates – Customers, equipment installers, or manufacturers receive monetary incentives for high-efficiency energy systems.

Direct Install – Customers receive high-efficiency equipment and direct installation at no charge or at a reduced charge.

Audit – Customers are offered help in determining the most cost-effective energy efficiency options for their homes or businesses. Tools and information also may be given to facilitate a self-audit.

FIGURE 8-6. **Market Barriers Overcome by Program Designs**

	MARKET BARRIERS				
Program Designs	Information	Inconvenience & Hassle	Risk	Financial	Availability
Financing/Leasing		●	●	●	
Technical Assistance	●		●		
Assistance with O & M	●	●	●		
Rebates			●	●	
Direct Install	●	●	●	●	●
Audit	●				
Mail Order	●	●	●	●	●
Rates				●	
Custom Programs	●		●	●	
Shared Savings			●	●	
Market Transformation	●	●			●

Program designs incorporate a variety of delivery mechanisms to overcome market barriers and deliver more energy-efficient technologies to customers.

Mail Order – Catalogs are distributed to promote appliances that are not widely available on a commercial basis, in order to discount cost and provide information for customers. Catalogs are most appropriate for smaller, easily installed items. This program is particularly attractive to people in rural or remote areas and to the elderly.

Rates – Customers get a special electricity rate that encourages use of various equipment or influences energy use patterns.

Custom Programs – Customers receive site-specific assistance to identify and install energy efficiency measures or make changes that will save energy.

Shared Savings – Utilities provide financing and assistance in implementing an efficiency program and share the savings with the customer.

Market Transformation – Utilities provide programs and support to activities that induce lasting structural or behavioral changes in the market that result in increases in the adoption and penetration of energy-efficient technology and practices.

Key Variables and Assumptions

TVA described and characterized the customer service options in terms of costs and benefits. To provide a reasonable estimate of the potential for energy efficiency, load management, small-scale self-generation, and beneficial electrification in the Valley, TVA used a number of assumptions to estimate the effects of these technologies on electricity use.

CUSTOMER ACCEPTANCE

Distributor and customer participation are critical in determining how an option will penetrate the market. Participation by both distributors and customers is assumed to be voluntary. Because of varying circumstances and needs, it is assumed that not all distributors and customers will participate in a given program. Participation rates for distributors and customers for each option can be found in Volume 2, Technical Document 7, Customer Service Options.

TECHNOLOGY ASSUMPTIONS

The energy savings of high-efficiency equipment depend on the average energy consumption of currently installed equipment and the number of units that might be replaced. TVA used surveys of residential and commercial customers to determine existing market shares of end-use equipment. For the industrial sector, TVA used equipment shares based on regional and national estimates, along with customer billing data.

The start date for options was assumed to be 1996 for the purpose of modeling program effects; however, any option or program could actually be started whenever needed. The number of participating customers and the impacts of many options could be scaled up or down, depending on how aggressively the options are pursued.

The Energy Vision 2020 load forecast includes a significant number of efficiency improvements driven by market and other forces. These forces include an underlying rate of technological innovation, price-driven efficiency improvements, and federal and state initiatives to improve appliance standards and building codes.

The options incorporate only those technologies that exceed the efficiency levels in existing or scheduled codes and standards. Emerging technologies may offer even greater efficiencies during the Energy Vision 2020 planning horizon. To the extent that data was available, TVA has included emerging technologies in its analysis.

FUTURE UNCERTAINTIES

There are a number of uncertainties in many of the key variables and assumptions in the customer service options development process. However, TVA's analysis indicates that some factors are more important than others in determining the cost-effectiveness of the various customer service options. TVA's current analysis indicates that the cost of energy saving technologies, the degree of customer acceptance, and the impact on the power system are the most significant factors influencing the cost-effectiveness of options. In order to test the sensitivity of the customer service options to these factors, TVA constructed both optimistic and pessimistic scenarios for the options. Optimistic scenarios assumed greater customer acceptance and lower costs for each technology, while pessimistic scenarios assumed the opposite.

Results of Analysis

DEMAND-SIDE MANAGEMENT

Using the process described earlier, TVA developed energy efficiency and load management options for residential, commercial, and industrial sectors. Together, these 39 options represent an energy savings potential of more than 23.0 billion kilowatt-hours and a peak demand reduction potential of 5,532 megawatts in the year 2010. These options are described below by sector.

Residential Sector

Residential Sector Overview

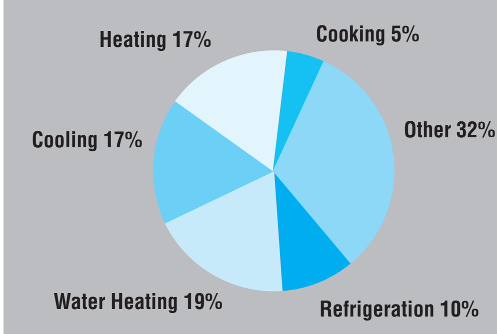
The TVA service area includes approximately 3 million residential households. Residential customers in the Valley purchase about 45 billion kilowatt-hours of electricity per year, which accounts for about 35 percent of all TVA sales. Residential electricity use can be categorized as shown in *Figure 8-7*. The combination of heating, ventilating, and air conditioning (HVAC) accounts for 34 percent of residential electricity use, while water heating accounts for 19 percent. Refrigeration and cooking use about 15 percent of residential electricity, with the remainder of residential electricity consumed by lighting and other appliances.

Eighty-five percent of Valley residents have central or window air conditioning. Electric water heaters are present in 77 percent of all homes, and electric space heaters are present in 47 percent. TVA identified options that can increase the efficiency of energy use for these end uses, as well as others.

Evaluation of Residential Technologies

TVA considered 107 residential efficiency measures and technologies, evaluating them in four end-use categories: heating, ventilating, and air conditioning; water heating; appliances; and lighting. *Figure 8-8* shows the number of technologies considered and those included in options by end-use category. Of the original 107 technologies that TVA considered, 42 are included in the residential options evaluated in Energy Vision 2020. Volume 2, Technical Document 7, Customer Service Options, lists the technologies evaluated in the residential option development process.

FIGURE 8-7. **Residential Uses of Electricity**



The percentage of residential electricity uses for water heating, space heating, and cooling suggests customer service options should focus on these end uses.

Residential Sector Option Features

TVA incorporated 42 technologies into program designs to create 23 residential options. The options use a variety of delivery systems and program features to overcome market barriers and to meet customer objectives (for example, low cost, equity, minimum rates). TVA included the following types of programs in the residential options.

Financing. TVA developed loan and leasing options for high-efficiency heat pumps and heat pump water heaters. Financing helps to overcome the relatively high initial cost of these technologies. When combined with financing of insulation measures, maintenance contracts, and strict efficiency and installation standards for the equipment, these options can provide significant energy savings and customer service benefits.

Direct Installation. This approach provides materials and equipment at no cost to participants. TVA developed such options for residential low-income home owners and rental properties. Measures include compact fluorescent lighting, low-cost water heating, air infiltration control measures, and attic insulation. When combined with a walk-through energy audit and an education session, TVA can save customers energy and money and reduce the need to generate power.

Rebates/Cash Incentives. TVA also developed options that would offer rebates for large appliances such as high-efficiency dishwashers, refrigerators, freezers, room air conditioners, horizontal axis clothes washers, and condensing clothes dryers. All appliance rebates would be offered at the retail level in cooperation with key trade allies (manufacturers,

FIGURE 8-8. **Technologies Considered for Residential Options**

End Use	Included in Options	Emerging Technology	Total Considered
HVAC	18	2	48
Water Heating	11	1	20
Appliances	10	11	31
Lighting	3	2	8
TOTAL	42	16	107

TVA considered technologies for all building types for those residential end uses which consume the majority of the sector's total electricity use.

engineering firms, construction contractors, etc.). Rebate levels range from 50 to 75 percent of the difference in cost between the more efficient and the less efficient appliances.

Another appliance option provides a savings bond to residential customers for turning in each working refrigerator or freezer to TVA or the distributor. These appliances would be properly disposed of, and appropriate materials would be recycled.

Options targeting the new construction and new manufactured housing markets provide cash incentives to home builders, as well as mobile home manufacturers and dealers who meet or exceed TVA's energy efficiency standards.

Mail Order. TVA could offer energy-efficient lighting products, programmable thermostats, and low-cost heating and hot water savings measures through a mail order catalog at low introductory prices. This option targets customers in rural or remote areas and typical mail-order shoppers.

FIGURE 8-9. **Residential Energy Efficiency Options – Impacts for 2010**

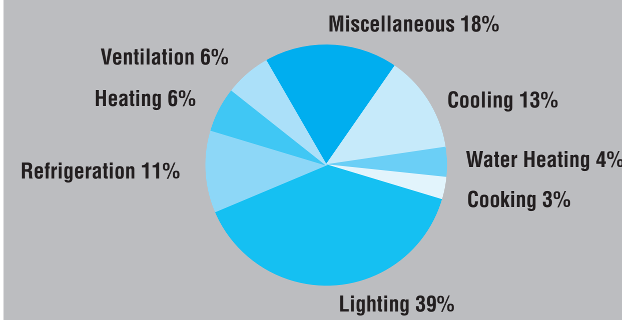
Energy Efficiency	Winter Megawatts	Summer Megawatts	Million Kilowatt-Hours	Thousands of Units	Total Resource Cost (1995 Cents/Kilowatt-Hour)
Heat Pump Loans	433	469	1347	254	5
Heat Pump Financing/Leasing	581	518	1688	266	1.6
Heat Pump Rebates	627	527	1787	375	3.3
Ground Source Heat Pump Leasing	58	62	179	26	8.1
Efficient Air Conditioning	0	133	233	124	7.6
New Homes	402	184	1142	118	3
Manufactured Housing	164	53	358	131	4.4
Low Income Weatherization	12	6	36	10	12.9
Low Income	165	75	467	251	2.8
Direct Install	845	386	2399	1163	2.3
Heat Pump Water Heater Leasing	262	103	995	452	3.2
Solar Water Heater	11	4	41	15	22.1
Efficiency Products Catalog	234	107	665	714	1.4
Lighting Retail Component	225	103	639	687	2.5
Appliance Rebates	39	41	304	1518	9.1
Refrigerator Turn-In	10	13	93	91	3.5
Student Self-Audit	53	23	150	1235	4.3
Self-Audit	42	19	120	102	2.6
Load Management					**1995 Dollars/Kilowatt**
Load Management - Air Conditioning	0	53	21	39	58
Load Management - Water Heater	212	84	0	158	55
Load Management - Storage Water Heater	100	39	0	75	934
Load Management - Supervisory Control and Data Acquisition	0	0	0	67	140
Load Management - New Technology	0	0	0	276	2039

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date. TVA developed 23 residential sector options for evaluation in Energy Vision 2020 with applications for all major end uses of electricity and for all types of housing.

Energy Audits/Education. Some options combine do-it-yourself energy audits for secondary school students or home owners. TVA or distributors would provide technical support with materials and analysis.

Load Management. Five load management options include TVA's control of air conditioners and water heaters using FM radio, SCADA systems (supervisory control and data acquisition systems), and new two-way communication systems that are under development at many utilities in partnership with the telecommunication companies. TVA could offer customers cash incentives or service packages under these options.

FIGURE 8-10. **Commercial Use of Electricity**



In the commercial sector customer service options targeted toward lighting, refrigeration, cooling, and heating should have the largest impact.

Residential Sector Results

Figure 8-9 summarizes projected costs and load and energy impacts for all residential energy efficiency and load management options. This figure shows that in 2010, more than 12.7 billion kilowatt-hours of energy savings and 3,002 megawatts of summer capacity savings could be achieved if all of the proposed options were implemented. Savings from energy efficiency options can be obtained at resource costs ranging from 1.4 to 22.1 cents per kilowatt-hour. In the process of ranking options, these costs can be compared to the alternative costs of generating electricity from a power plant and to the average residential retail rate of 5.95 cents per kilowatt-hour.

Commercial and Industrial Sectors

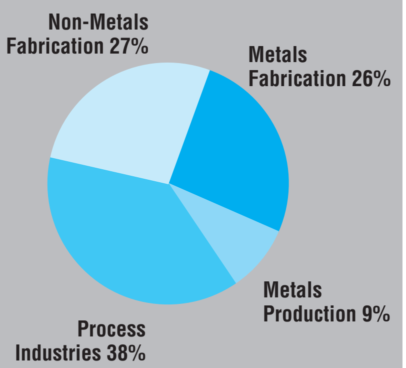
Commercial and Industrial Sector Overview

TVA and the distributors of its power serve about 486,750 commercial and industrial customers. These customers account for more than 4 billion square feet of floor space and consume almost 48 billion kilowatt-hours of electricity per year. Electricity is used to provide cooling in 70 percent of all commercial buildings, heating in 35 percent, and water heating in 45 percent. Industrial customers use electricity to operate all motor drives, to drive electrolytic processes that produce chemicals and primary metals, for lighting, and for a small fraction of the heat required in manufacturing processes.

Commercial customers use electricity in a variety of ways, as shown in *Figure 8-10*. Lighting accounts for 39 percent of energy use in the commercial sector, while heating, ventilation, and cooling use a total of 25 percent. The miscellaneous category, which includes office equipment, consumes 18 percent of electricity used and represents a rapidly growing load in the commercial sector. The remaining 18 percent is used in water heating, cooking, and refrigeration.

Figure 8-11 shows electricity use in the industrial sector by industry type. Process industries (e.g., paper-making) use 38 percent of the electricity in the

FIGURE 8-11. **Industrial Electric Market**



Energy efficiency opportunities in the industrial sector are concentrated in motors, drives and overall manufacturing process improvement.

industrial market, while non-metals fabrication (e.g., rubber gloves) uses 27 percent, and metals fabrication (e.g., iron foundries), 26 percent. Metals production (e.g., tin refining) consumes 9 percent of the electricity used in the industrial market.

Figure 8-12 shows how electricity is consumed in each industrial subsector and in the industrial sector as a whole. In the industrial sector, 67 percent of electricity is used for motors, 16 percent for electrolytic production and electrotechnologies (such as microwave drying), 8 percent for heat used in the manufacturing process, and 9 percent for lighting and other end-uses (eg., space heating and cooling).

Evaluation of Commercial and Industrial Technologies

In commercial markets, TVA identified and evaluated energy-efficient technologies for 10 different building types: offices, restaurants, retail stores, groceries, warehouses, schools, colleges, hospitals, lodgings, and miscellaneous commercial buildings.(eg. churches) TVA determined the energy and demand impacts of weather and schedule-sensitive technologies (e.g., office lighting) by performing simulations that modeled electricity consumption in each type of building.

For each type of building, TVA considered several technologies for each end use (e.g., heating, cooling, lighting, etc.).

For industrial markets, TVA investigated technologies such as high-efficiency motors and adjustable-speed drives; however, many industrial technology applications are unique to a particular industry. In such cases, program options examine whether various technologies are appropriate and cost-effective for a specific site. *Figure 8-13* lists the number of technologies that were included in the options for both the commercial and industrial sectors. Volume 2, Technical Document 7, Customer Service Options, lists the technologies considered.

Commercial and Industrial Option Features

TVA combined 62 technologies with various delivery strategies to form 16 commercial and industrial program options. The options are designed to overcome different market barriers and to address the needs of the different market segments or types of businesses within the commercial and industrial sectors. Some of these options promote specific technologies that have widespread application in commercial and industrial markets. Other options address customers' financial, productivity, or environmental needs and provide customized applications of energy-efficient technologies. The following programs were incorporated in the commercial and industrial options.

FIGURE 8-12. **End Uses as a Percent of Total Industrial Electric Use**

	Process Heating	Motor Drives	Electrolytics	Lighting & Other
Process Industries	< 1%	79%	11%	10%
Non-Metals Fabrication	15%	27%	53%	5%
Metals Fabrication	20%	69%	2%	9%
Metals Production	6%	83%	0%	12%
Total	8%	67%	16%	9%

Most electricity provided to the industrial sector is currently used to power motor drives.

Technology Rebates. Rebate options promote energy-efficient lighting; heating, ventilating, and cooling; water heating; refrigeration; and cooking technologies in the commercial sector. Rebates are also provided for high efficiency motors, adjustable-speed drives used in manufacturing equipment, and efficiency improvements for industrial customers producing compressed air. These options encourage customers to select higher-efficiency equipment by providing educational information and rebates. Rebate levels range from 50 to 75 percent of the additional cost of the high-efficiency equipment.

FIGURE 8-13. **Technologies Considered for Commercial and Industrial Options**

End Use	Included in Options	To Be Considered for Custom Applications	Emerging Technologies	Total Considered
Lighting	20	1	13	38
HVAC	16	15	5	39
Water Heating	8	2	2	12
Refrigeration	4	5	1	16
Industrial Process	5	3	2	10
Building Shell	6	1	-	10
Appliances	2	3	5	18
Miscellaneous	1	3	-	7
Total	62	33	28	150

Lighting, heating, ventilation, and air conditioning (HVAC), and water heating represent more than half of the technologies considered for the commercial and industrial sectors.

Comprehensive Measure Financing. This option provides financing for large commercial customers who retrofit buildings with comprehensive sets of energy-saving measures. Low-interest loans or shared-savings arrangements are offered with this option. These cover the cost of the energy-efficient investment and overcome the initial-cost barrier of these investments. Customers repay the loan with electric bill savings, which would also yield a positive cash flow for customers. Under a shared savings arrangement, customers pay a percentage of their energy savings in exchange for the service provided by TVA. By recovering program costs from the program participants, financing options could minimize the rate impact of energy efficiency programs or non-participants.

Comprehensive Measure Rebates. This option uses the same process as the Comprehensive Measure Financing option to identify comprehensive sets of energy-saving measures for buildings. It uses rebates to increase participation and thus obtains more energy savings.

Technical Assistance. Technical assistance is combined with rebates and financing for new construction in the large commercial sectors. In new construction, technical assistance provided to customers includes incentives for architects and engineers to include energy-efficient systems in building design. Building commissioning (a careful tuning of all building energy systems) is also included for new construction to ensure that energy-efficient systems operate optimally. For older, large commercial buildings, technical assistance helps identify the optimal set of energy efficiency measures for the whole building, often with the use of customized technology applications.

Direct Installation. This program is for small commercial businesses and provides the installation of low-cost energy-efficient measures at no cost to the customer. While on site, the program calls for TVA to perform an audit to identify

additional cost-effective energy savings opportunities. Participants are then introduced to other programs offered by TVA.

Operation and Maintenance. This heating and cooling program is directed at small commercial businesses and other commercial customers who do not have building maintenance staffs. The customer's heating and cooling system is maintained for a small monthly charge included in the customer's electric bill. The program maintains the optimal operation of heating and cooling equipment to reduce electricity use.

Load Management. Three load management options were developed for the commercial sector. Two options encourage the adoption of thermal storage technologies for use with chillers or rooftop cooling units by offering rebates and technical assistance to design the installation. The other option provides the customers with bill credits for curtailing electricity use when notified to do so by the utility. Customers could choose the load reduction strategy that best fits their business operations. To participate in this option, customers must be able to reduce load or make arrangements to join with other customers in reducing load at times of high demand for TVA electricity.

Process Efficiency Improvements. Most of the energy savings potential in the industrial sector involves changing the actual nature of the various production processes. Customized applications of energy-efficient technologies include high-efficiency motors, adjustable-speed drives for manufacturing equipment, and other electric technologies. This program provides customers with technical assistance to identify cost-effective energy efficiency opportunities and to quantify any additional non-energy benefits related to a proposed project. Incentives include rebates for demand reduction or for energy savings.

Commercial and Industrial Results

The 16 program options for the commercial and industrial sectors provide ways to promote energy-efficient technologies. *Figure 8-14* summarizes the projected costs and impacts of these options in the year 2010.

The commercial and industrial options shown in *Figure 8-14* could account for more than 10.5 billion kilowatt-hours of energy savings and 2,530 megawatts of summer peak demand reduction in the year 2010 if all of these options were implemented. Energy savings in the commercial and industrial markets can be obtained at a resource cost of between 2 cents per kilowatt-hour to 13.7 cents per kilowatt-hour. This compares to the average commercial retail rate of 5.73 cents per kilowatt-hour and distributor industrial rate of 4.28 cents per kilowatt-hour. The demand reduction potential of all the options shown in *Figure 8-14* would be 17 percent of the total commercial and industrial sector demand in the year 2010. Similarly, potential energy savings are about 10 percent of the forecast energy use in these two sectors in the same year.

SELF-GENERATION AND RENEWABLE GENERATION

Overview

TVA used a set of customer characteristics and needs to identify the specific market segments most suitable for fossil fuel and renewable energy self-generation. These characteristics include:

- Industrial production processes generating byproducts or waste material that can be used to power a self-generation system.
- Facilities with a relatively constant high heating requirement. Waste heat from a cogeneration system could support the facility's heating needs.
- Situations where electrical outages or disturbances could result in excessive lost production or business for the customer, create a hazardous situation, or cause a violation of environmental standards.
- Customers having a high peak demand and paying a high rate for peak demand electricity.
- Customers having access to renewable fuels or creating a renewable fuel as a byproduct of its manufacturing process.

FIGURE 8-14. **Commercial and Industrial Options Summary – Impacts for 2010**

Option Name	Winter Megawatts	Summer Megawatts	Million Kilowatt-Hours	Units (Million sq.ft.)	Total Resource Cost (1995 Cents/Kilowatt-Hour)
COMMERCIAL TECHNOLOGY REBATES					
Lighting Rebates	265	511	2845	1626	2.0
Heating, Ventilation, and Air Conditioning Rebates	255	223	670	630	7.7
Appliance Rebates	40	69	364	501	3.2
New Construction	124	188	762	360	4.4
New Construction - Renewables	94	40	159	30	7.4
SMALL COMMERCIAL SECTOR					
Retrofit-Direct Install	65	98	465	315	3.1
Heating, Ventilation, and Air Conditioning Maintenance	38	26	87	236	13.7
LARGE COMMERCIAL SECTOR					
Comprehensive Measures Financing	120	170	713	284	4.9
Comprehensive Measures Rebates	242	311	1278	449	4.9
COMMERCIAL LOAD MANAGEMENT					
Commercial Cool Storage	0	93	3	44	167 [1]
Rooftop Cool Storage	0	120	13	59	453 [1]
Commercial Group Load Curtailment	244	242	227	2240 [2]	169 [1]
INDUSTRIAL PROGRAMS					
Industrial Technology Rebates	21	24	167	2100 [2]	3.2
Industrial Process Energy Efficiency - Direct Serve	149	169	1057	11226 [3]	4.1
Industrial Process Energy Efficiency - Distributor Serve	167	190	1325	8420 [3]	4.0
Energy Efficient Rates (opt-out)	50	56	394	2504 [3]	3.2

1 Cost in $/kW
2 Number of participants
3 Participant defined as industrial customer with one million kWh of energy use

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date. TVA developed commercial and industrial options for evaluation in Energy Vision 2020 with applications for all major uses of electricity and for all types of buildings.

Based on these characteristics, TVA identified four industrial and seven commercial market segments as candidates for self-generation systems. The industrial candidates are the food, wood, pulp and paper, and chemical industries. The commercial market segments are transportation, supermarkets, restaurants, finance and insurance, hotel/motel, hospitals, and nursing homes. TVA also identified the potential for customer-owned generation using landfill gas, wood waste, and small head hydro systems. Photovoltaic options (power produced from sunlight) were also considered, but current technology costs limit their use to highly specialized or remote applications.

Evaluation of Self-Generation and Renewable Generation Technologies

TVA examined technologies limited to the 100 kilowatt to 20 megawatt range. Units of this size, which are appropriate for the markets considered above, are used either as self-generation units or as emergency power units. Technologies that have suitable designs, commercial availabilities, and costs for integration with the power system are:

- Reciprocating Engine Systems (100-kilowatt to 3-megawatt systems)
- Gas Turbine Systems (4-megawatt to 21-megawatt systems)
- Coal-Fired Steam Turbine Systems (20-megawatt systems)
- Fuel Cells (2-megawatt systems)
- Wood Waste-Fired Steam Turbine Systems (800-kilowatt systems)
- Small Head Hydro Systems (various sizes)

Installation costs for these systems range from $988 per kilowatt for a 10.7-megawatt gas turbine to $2,557 per kilowatt for a 100-kilowatt reciprocating engine system. Photovoltaic options currently cost approximately $5,000 per kilowatt, but are predicted to drop in price in the near future. Consequently, TVA studied the potential impacts of photovoltaics if the technology cost were to fall below $3,000 per kilowatt.

Self-Generation and Renewable Generation Option Features

Options were developed for the following markets:

New Industrial Systems

TVA or distributors would contract to purchase excess power from commercial or industrial customers or would pay customers for generating their own power during times of peak demand. An incentive payment would be paid each year per kilowatt of capacity provided.

New and Existing Commercial Systems

TVA or distributors would contract to purchase excess power from the customer or pay the customers incentives each year for each kilowatt generated during times of peak demand for TVA power.

FIGURE 8-15. **Renewables and Self-Generation Options Summary – Impacts for 2010**

Option Name	Winter Megawatts	Summer Megawatts	Million Kilowatt-Hours	Number of Participants	Total Resource Cost 1995 Cents/Kilowatt-Hour
RENEWABLE GENERATION PROGRAMS					
Landfill Gas - Fuel Cells	74	74	585	36	6.0
Small Head Hydro	5	5	29	5	5.9
Biomass: Wood Waste	54	54	374	62	3.6
Photovoltaics	1	1	5	1975	33.0
Photovoltaics - Technology Advancements	3	3	11	4600	19.0
CUSTOMER-OWNED COGENERATION					
Commercial Existing Cogeneration	95	95	118	416	7.7
Commercial New Cogeneration	18	18	51	84	12.1
Industrial New Cogeneration	30	30	17	208	8.8

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date.The greatest potential for self-generation is from landfill gas, wood wastes, and existing commercial cogeneration.

Renewable-Based Energy Systems

Customers would be offered incentives for generating energy with combustible renewable resources such as wood or other renewable products. For non-combustible renewable resources, such as hydroelectric power and photovoltaics, customers would be offered an incentive for each kilowatt-hour produced. The incentives would cover the higher costs and higher uncertainties associated with energy produced from renewable resources and reflect the environmental benefits of renewable and non-combustible resources. As part of this option, information on the cost and performance of renewable resources would be gathered and documented to better assess the applicability of these technologies to the TVA system.

TVA would provide technical assistance to vendors and customers to ensure project feasibility and proper installation as well as synchronization between local distribution systems and the customer's facility. Payments to participants for their power would be based on capacity and energy savings (e.g., avoided costs) for TVA. Incentives for renewable resources would be higher to encourage investment in these emerging technologies.

Self-Generation and Renewable Generation Results

TVA has developed eight self-generation/renewable generation options for the commercial and industrial sectors. *Figure 8-15* summarizes the estimated participation in these options, the options' projected costs, and their potential energy and peaking capacity savings in the year 2010. In 2010, more than 1.1 billion kilowatt-hours of energy savings and 281 megawatts of capacity savings are projected for these proposed options.

BENEFICIAL ELECTRIFICATION

Overview

Beneficial electrification options include technologies that take advantage of the unique characteristics of electricity (such as ease of control, flexibility of application, and high energy efficiency) and improve productivity and quality. The use of an electrotechnology (such as microwave drying) in manufacturing or using electric vehicles for transportation could also reduce adverse environmental impacts. Generally, electrotechnologies limit environmental pollutants to those produced by an electric generating plant. In this case, the pollutants are more easily controlled so there is less harm to the public or the environment. These beneficial electrification options address transportation and electric manufacturing technologies, as well as commercial and residential options for cooking, heating, security lighting, and water heating.

FIGURE 8-16. **Technologies Considered for Beneficial Electrification**

Sector	Technologies Considered	Included in Option
Residential	12	11
Commercial	13	13
Industrial	87	35
Transportation	5	3
TOTAL	117	62

More than half of the technologies considered were in the industrial sector. Heating, ventilation, and cooling were important technologies considered in the residential and commercial sectors.

Evaluation of Beneficial Electrification Technologies

TVA evaluated 117 beneficial electrification technologies and measures for four market sectors. *Figure 8-16* lists the number of technologies considered in each sector. Currently, 43 beneficial electrification technologies are included in the Energy Vision 2020 options. More than half of the technologies TVA considered and included in beneficial electrification options come from the industrial sector. Volume 2, Technical Document 7, Customer Service Options, lists the technologies and measures evaluated.

Beneficial Electrification Option Features

TVA integrated technologies with programs to form 14 beneficial electrification options covering the 4 major sectors as follows:

Industrial Electrotechnologies

Seven options cover process heating, melting, curing and drying, and specific applications in the chemical, metals, food, and textile industries. Industrial electrotechnology options do not use any program rebates or direct financial incentives. Technologies would be promoted on their own merits. These include the enhancement of the customer's competitiveness through reduced operating and maintenance costs, increased productivity, improved product quality, increased operating flexibility, and contributions toward long-term environmental compliance. TVA's primary role would be to provide information and technical assistance in conjunction with consultants and trade allies.

Commercial Sector

TVA developed two options for the commercial sector. Suitable commercial buildings would be targeted for high-efficiency air-source and water-source heat pumps, as well as heat pump water heaters. Restaurants, hotels, and other commercial facilities would be targeted for high-efficiency electric cooking and

security lighting equipment. These options would use the same efficiency standards and incentives as the commercial energy efficiency options.

Residential Sector

The first of two residential options targets customers replacing natural gas, oil, propane, and wood space heating or water heating. It encourages these customers to use high-efficiency electric heat pumps and heat pump water heaters. Incentives and efficiency standards would reflect those for the residential energy efficiency options. The second option would promote electric lawn mowers to customers in non-attainment areas (environmentally sensitive because of dirty air) and security lighting to customers in high crime areas.

Transportation Sector

The three electric transportation options target electric buses, fleet vehicles (vans, carts, forklifts), and cars. These options focus on the benefits of electric transportation in urban non-attainment areas. Options would be limited to technologies that could penetrate the market without state or federal mandates. The beneficial electrification options developed for Energy Vision 2020 do not use any direct financial incentives such as rebates or special rates.

FIGURE 8-17. **Beneficial Electrification Options Impacts in 2010**

Option Name	Units	Millions Kilowatt-Hours	Megawatts
INDUSTRIAL SECTOR			
Process Heating	228	609	87
Melting	29	549	79
Food Processing	29	368	53
Textiles	64	19	3
Chemicals & Metals	49	37	5
Curing and Drying	425	123	18
Environmental Technology	140	227	33
COMMERCIAL SECTOR			
Institutional Facilities	30300	294	21
Cooking & Security Lighting	10917	112	25
RESIDENTIAL SECTOR			
HVAC & Water Heating	101256	374	-119
Security Lighting/Lawn Mowers	236407	51	0
TRANSPORTATION			
Electric Buses	259	9	0
Fleet Vehicles	503	4	0
Electric Autos	1774	6	0
TOTAL		2782	205

Values are the impacts occurring only in the year 2010 for the cumulative participation in the program to that date. The industrial sector options have the most impact in beneficial electrification. Commercial institutional facilities (primarily heating and cooling) and residential heating and cooling are also significant.

Beneficial Electrification Results

Figure 8-17 summarizes the potential impacts of all beneficial electrification options in the year 2010. This figure shows that in 2010, these options would be responsible for more than 2.7 billion kilowatt-hours of increased electricity use and an increase in electricity demand of about 200 megawatts. Industrial electrotechnology options account for 70 percent of the projected increase in electricity use and the need for additional generating capacity.

RATES

The bulk of TVA's revenue is generated from the wholesale rate that TVA charges the 160 power distributors that purchase power for resale to end-use customers. The wholesale rate structure presumes the wholesale rates for different types of service will be the foundation for the associated retail rates. Each distributor applies retail rates that reflect the appropriate TVA wholesale charges, distributor losses in transmitting power to the end-use customer, and distributor-specific distribution costs.

FIGURE 8-18. **Alternative Rate Impacts - Impacts for 2010**

Option Name	Summer Megawatts
Time-of-Day Rates	892
Declining Block Rates	169

Time-of-day rates would save 892 megawatts of electricity, while declining block rates would increase sales by 169 megawatts.

In accordance with this principle, TVA has developed a set of wholesale and retail time-of-day rate options. These options have charges that vary according to TVA's cost of generation and distribution, by time of day and season. The cost of producing electricity is greatest during times of peak demand for TVA electricity, such as summer afternoons, and lower in off-peak periods such as evenings and weekends.

Retail time-of-use rates are designed to give end-use customers price signals to curtail use during peak periods and to shift electricity consumption to off-peak periods. Wholesale time-of-use rates can encourage distributors to offer programs or to participate in TVA programs to shift electricity use from peak to off-peak periods.

A set of declining block rate options was also developed. Declining block rates have higher charges for initial electricity usage with progressively lower charges for higher levels of usage. Declining block rates can encourage the use of electrical products over competing alternatives. *Figure 8-18* shows the potential impact of these two rate options in 2010.

FIGURE 8-19. **Customer Service Options Blocks for Energy Efficiency and Load Management (Impacts for 2010)**

Block 1 1,482 Megawatts

PROGRAM
- Commercial Cool Storage
- Rooftop Cool Storage
- Commercial Group Load Curtailment
- Residential Load Management – Air Conditioning
- Residential Existing Load Management – Air Conditioning
- Residential Existing Load Management – Water Heaters
- Residential Heat Pump Financing/Leasing
- Residential Efficiency Products Catalog
- Industrial Technology Rebates – High-Efficiency Motors
- Residential Lighting Products – Retail Component
- Comprehensive Measures Financing
- Residential Ground Source Heat Pump Leasing

Block 2 1,264 Megawatts

PROGRAM
- Residential Self-Audit
- Residential New Homes
- Commercial Lighting Rebates
- Residential Low Income Program
- Residential Load Management – Water Heaters
- Commercial New Construction
- Commercial Appliance Rebates
- Refrigerator Turn-In
- Residential Student Self-Audit
- Small Commercial Retrofit

Block 3 1,497 Megawatts

PROGRAM
- Residential Load Management – Supervisory Control and Data Acquisition
- Comprehensive Measures Rebates
- Industrial Energy Efficiency – Distributor Serve
- Industrial Energy Efficiency – Direct Serve
- Industrial Technology Rebates – Adjustable Speed Drives
- Energy Efficient Rates
- Residential Heat Pump Water Heating Leasing
- Residential Direct Install
- Commercial HVAC Rebates
- Residential Manufactured Housing Program

Block 4 1,289 Megawatts

PROGRAM
- Residential Load Management – New Technology
- Commercial HVAC Maintenance Program
- Residential Heat Pump Loans
- Residential Efficient Air Conditioning
- Residential Heat Pump Rebates
- Residential Load Management – Storage Water Heaters
- Industrial Technology Rebates – Compressed Air Efficiency
- Residential Appliance Rebates Program
- Residential Low Income Weatherization Program
- Residential Solar Water Heater Program
- Commercial New Construction – Renewables

Summary

For consideration in Energy Vision 2020, TVA has more than 60 customer service options that address all relevant sectors and end uses in the Valley economy. TVA has developed options to smooth system load shape using traditional demand-side management (energy efficiency and load management), self-generation, beneficial electrification, and rate options.

The costs and impacts of the options are interdependent. Option costs depend on the market penetration rate and number of technologies that are required to achieve specific energy and capacity savings.

FIGURE 8-20. **High and Low Impact Blocks for Beneficial Electrification**

High Beneficial Electrification	Low Beneficial Electrification
INDUSTRIAL SECTOR	
Process Heating	Process Heating
Melting	
Food Processing	Food Processing
Textiles	
Chemicals & Metals	
Curing and Drying	Curing and Drying
Environmental Technology	Environmental Technology
COMMERCIAL SECTOR	
Institutional Facilities	
Cooking & Security Lighting	
RESIDENTIAL SECTOR	
HVAC & Water Heating	HVAC & Water Heating
Security Lighting/Lawn Mowers	
TRANSPORTATION	
Electric Buses	
Fleet Vehicles	
Electric Autos	

High beneficial electrification included all options. Low beneficial electrification included those options that had a low total resource cost and reduced rates the most.

CUSTOMER SERVICE OPTION BLOCKS

The customer service energy efficiency and load management options were placed into blocks of approximately 1,000 to 1,500 megawatts of capacity savings in the year 2010. Customer service options were placed in these blocks to simplify their integration with supply-side technologies that are generally much larger than any single customer service option. Different numbers of blocks were then incorporated into the strategies that were evaluated in Energy Vision 2020. Options were placed in the blocks, as shown in *Figure 8-19*, based on the following criteria, in order of importance:

- Resource cost
- Impact on rates
- Equity (opportunity for all customers to participate)
- Competitiveness (preservation of long-term customer relationships)
- Other evaluation criteria used in Energy Vision 2020

Thus, programs included in Block 1 are low cost, have minimal effects on TVA rates, and rank high on the other evaluation criteria that have been identified for Energy Vision 2020. For example, program options in Block 1 provide energy savings at an average total resource cost of 2.7 cents per kilowatt-hour and, as discussed later in the chapter on integration, have only a small impact on TVA rates. Programs in Block 1 would be the first to be selected by TVA for implementation in Energy Vision 2020 because of their low cost and low rate impacts.

The energy savings in Block 2 can be obtained at a total resource cost of 2.8 cents per kilowatt-hour, but the constituent programs have a greater impact on TVA rates than those in Block 1. The average total resource cost of ener-

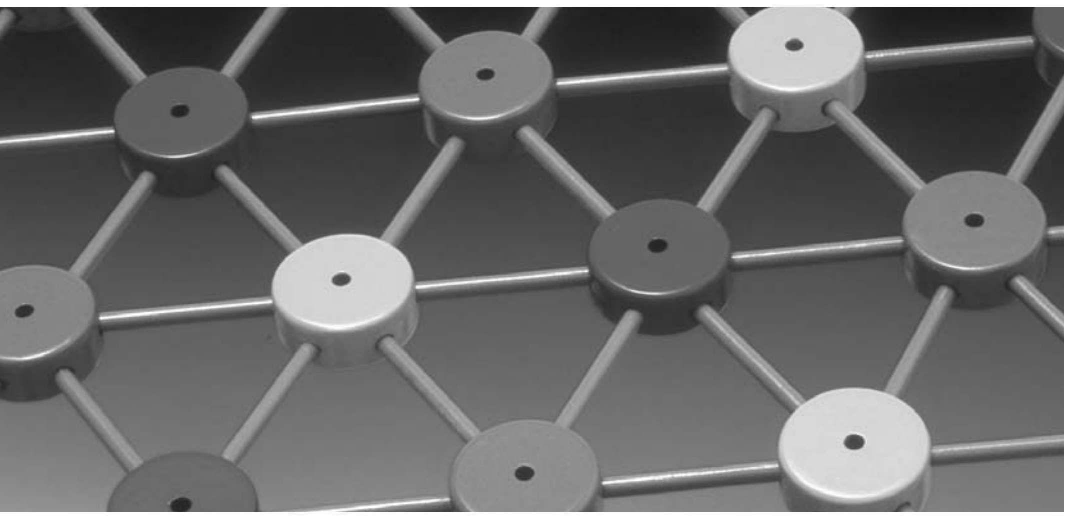
gy savings associated with options in Block 3 is 3.9 cents per kilowatt-hour while in Block 4 the average cost is 5.2 cents per kilowatt-hour. Blocks 3 and 4 also have larger impacts on TVA rates than do Blocks 1 and 2.

Peak demand savings potential in the year 2010 from Block 1 represents 4.7 percent of the forecast summer peak demand, and energy savings constitute 2.5 percent of total projected system sales in 2010. For Blocks 1 and 2 combined, the peak demand savings potential in the year 2010 is 8.7 percent of the forecast summer peak demand, and projected energy savings are 6.3 percent of total projected system sales. For all four blocks, peak demand savings potential in the year 2010 is 15.9 percent of forecast summer peak demand, and associated energy savings are 12.8 percent of total projected system sales.

The beneficial electrification options also were separated into two blocks, shown in *Figure 8-20*, according to the criteria discussed previously. Likewise, the self-generation and renewable generation options in *Figure 8-15* were placed in a separate block option. Different combinations of the four blocks of energy efficiency and load management options, one of the blocks of beneficial electrification options, the self-generation options, and rate options can be integrated with various supply options to form different resource strategies for Energy Vision 2020. Each of these different strategies is then evaluated using TVA's multi-attribute trade-off process in order to identify the best strategies for meeting future energy needs. This process is discussed in Chapter 9.

Chapter Nine

Resource Integration/ Alternative Strategy Comparisons



Chapter 9: Resource Integration/ Alternative Strategy Comparisons

The resource integration phase of Energy Vision 2020 identified over 2,000 strategies using various mixes of supply-side and customer service options. From an extensive series of evaluations, several strategies emerged that offer competitive electricity for TVA's customers.

Seven strategies produce low cost, low electric rates, low debt, and low environmental impacts. At the same time, these strategies increase customer value and opportunities for economic development.

Options and strategies were also evaluated for several key uncertain events in the future (e.g., load growth, natural gas prices). These evaluations have identified several strategies, which provide flexibility to adapt to uncertain events.

The overall results of the resource integration are summarized in the long-term plan at the end of this chapter.

Much of the material in this chapter describes the results of computer analyses of many variables related to planning the power system. As such, some of the material is quite complex. For this reason, graphical charts have been included to show many of the key results that have been considered for future resource decisions.

Readers interested in a more qualitative summary of the results can review this Chapter's Final Evaluation section and the last section, which deals with the long-term plan.

This Chapter Includes:

- What Does Integration Mean?
- Review of Criteria and Options
- Uncertainties and Futures Development
- Strategy Development
- Decision on Nuclear Power
- Final Strategy Evaluation
- Environmental Consequences
- Managing Risk – Hedging Uncertainties
- Final Evaluation
- The Long-Term Plan – Preferred Alternative

Resource Integration/ Alternative Strategy Comparisons

What Does Integration Mean?

Energy Vision 2020 has its own language. Integration means combining options to create strategies and combining uncertainties to create futures. Strategies and futures are then combined to create scenarios. These scenarios are then evaluated against the plan's criteria.

As discussed in Chapter 2, Energy Vision 2020 uses multi-attribute trade-off analysis to integrate strategies, futures, and evaluation criteria. This integration process is summarized in *Figure 9-1*. Input from the public and TVA employees was a starting point for Energy Vision 2020. TVA received more than 1,300 comments, which were translated into evaluation criteria, resource options, and uncertainties.

One of the primary goals of Energy Vision 2020 is to develop a long-term plan that provides flexibility.

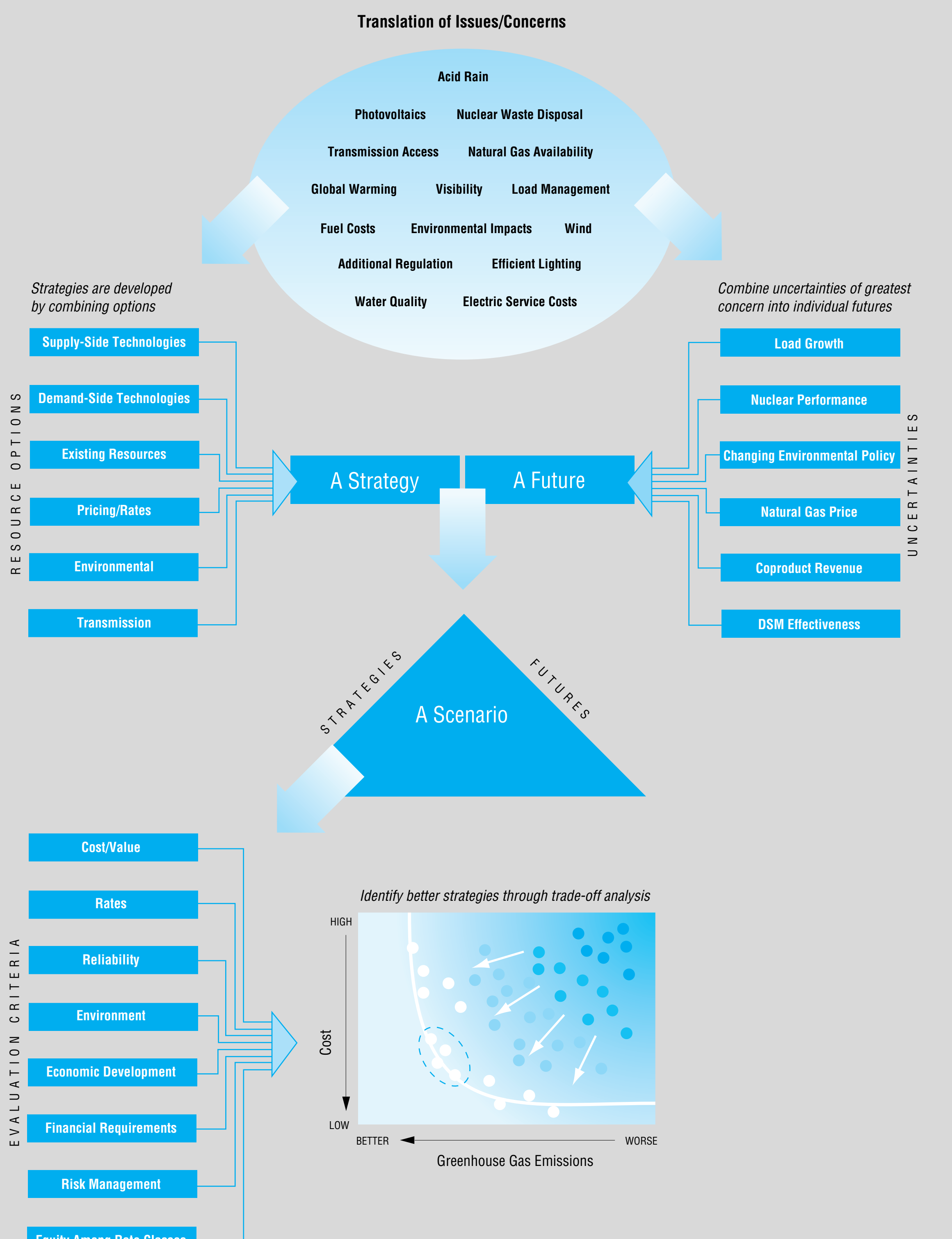
Evaluation criteria are based on values people hold; they are used to define and judge different resource plans or strategies. As indicated in *Figure 9-1*, criteria were identified in eight areas: cost and value, electric rates, reliability, environment, economic development, financial requirements, risk management, and equity among rate classes.

Strategies are based on actions TVA can control and are largely based on supply-side options, demand-side technologies, existing resources, and environmental control options. Several pricing or electric rate options and transmission options were considered, but not to the extent of the other resource options.

Each strategy was designed to meet the capacity requirements for either the low, medium, or high load forecast. Beginning with the existing coal, nuclear, and other power resources, new resource options were added to meet the capacity requirements. These options included peaking and base-load supply-side and demand-side resources as well as environmental control technologies to reduce pollutants such as sulfur dioxide, nitrogen oxides, and carbon dioxide.

From the public input, uncertainties were identified and combined into futures. Futures are largely outside of TVA's control. The key uncertainties are load growth, nuclear performance, changing environmental policy, natural gas prices, the price or revenue from chemical coproducts and the effectiveness of demand-side management programs. The futures create a highly uncertain environment that creates cost, electric rate, and other risks to TVA's customers. These risks must be managed in order to create a desirable strategy.

FIGURE 9-1. **Energy Vision 2020 Process**



The Energy Vision 2020 process translates concerns into evaluation criteria, options, and uncertainties. Options are combined into strategies and uncertainties into futures. Strategies and futures are combined into scenarios. Each scenario is evaluated against the criteria and analyzed using trade-off analysis.

Strategies and futures are combined into a scenario—thus, one strategy and one future produces one scenario. Since each scenario is evaluated using the same criteria, all strategies and resource options—supply or demand—are evaluated on a level playing field.

Since each scenario contains a strategy for a given future, the strategies can be judged or evaluated on all the criteria.

To evaluate these strategies, TVA uses a number of custom and off-the-shelf computer applications. One of these applications, MIDAS, is a program tailored for TVA by the Electric Power Research Institute. The MIDAS computer application can take 30 years of power demand forecasts and simulate how the TVA power system would be run. At the same time, MIDAS also estimates financial results under various assumptions. These assumptions deal with such variables as load growth, the price of fuel, or a change in rates. As assumptions change—for example, load growth increasing from 2 percent a year to 3 percent—a new simulation is run. Each simulation provides forecasts of future capacity, type of capacity, generation, and financial forecasts of cost, debt, and electric rate measures.

The results of the evaluations produce estimates for each of the 42 criteria. The estimates of the criteria are provided for each possible combination of strategies and futures. The process produces thousands of data elements that must be analyzed.

The large volume of results is analyzed systematically using the trade-off analysis. This trade-off analysis is necessary because more than one evaluation criterion or measurement is relevant to evaluating the strategies.

The purpose and nature of trade-off analysis are shown graphically in *Figure 9-1*. The axes of the graph identify two evaluation criteria or attributes. In this example, the cost of electricity ($/kilowatt-hour) is on the vertical axis and greenhouse gas emissions (tons) are on the horizontal axis. The results for each strategy are plotted on the graph for various futures.

If there were only two criteria that TVA had to consider, the ideal strategy would be located closest to where the two axes meet (in the lower left hand corner). In this example, strategies within the dotted line would be those with the lowest electricity costs and the lowest greenhouse gas emissions.

Once trade-offs are analyzed, strategies are modified and improved where possible to move them closer to the corner. In cases where an unavoidable trade-off exists, the decision-maker must choose between strategies. As an example, if there is no strategy with both the lowest costs and the lowest greenhouse gas emissions, the decision-maker may have to choose one over the other. After extensive reviews of different trade-offs, those strategies that, in the opinion of the decision-maker, best meet the criteria and provide flexible choices are developed into the long-term resource plan.

The result of this integration is a plan that can be interpreted objectively. It sounds complicated, but it is not so difficult when broken down step by step. It is TVA's intention to ensure every possibility is reviewed to provide a better tomorrow for the Tennessee Valley. This process creates a valuable management tool for TVA's decision-making during the next 25 years.

Review of Criteria and Options

As explained in Chapter 5, TVA established 42 criteria in the early stages of the Energy Vision 2020 process. Of these, 8 are related to cost and rates, 2 are related to debt, 2 are related to economic development in the Valley, and the remaining 30 are related to the environment. These criteria represent stakeholder values and are used to evaluate strategies.

Of the 188 resource options considered, 120 are supply-side options, 60 are customer service options, 2 are rate options, 4 are environmental control options, and 2 are transmission options. Chapter 7 explains how supply-side options were developed, and Chapter 8 covers customer service options. Discussions about environmental control options are also found in Chapter 7.

TVA sorted and ranked all 188 options according to selected criteria. The rankings were used as an aid in developing strategies. Ranking results are found in Volume 2, Technical Document 8, Resource Integration.

Uncertainties and Futures Development

Uncertainties also were evaluated. As explained in Chapter 2, uncertainties are those concerns that impact the Valley's energy future and are beyond TVA's control. For example, the future level of natural gas prices is an uncertainty and is significant because natural gas is a source of fuel for several supply-side options.

TVA identified 40 uncertainties, which were reduced to the 7 most important: load growth, nuclear cost and performance, greenhouse gas (carbon dioxide) regulations, air and water quality regulations, price of natural gas, revenue from chemical coproducts, and effectiveness of demand-side management. A description of how TVA accounted for uncertainty is found in Volume 2, Technical Document 8, Resource Integration. The uncertainties identified in the plan are shown in *Figure 9-2*.

TVA combined the seven uncertainties in every imaginable combination to produce possible futures. For example, one future included high electricity sales growth, high cost of natural gas as a fuel, and increased regulation of greenhouse gases. This exhaustive process produced 972 futures.

FIGURE 9-2. **Range of Values of Key Uncertainties**

	Low	Medium	High
1. LOAD GROWTH (Peak)			
• 1994-2000	0.0%	2.2%	3.4%
• 2000-2020	0.0%	1.9%	3.2%
2. NUCLEAR ISSUES			
• Capacity Factor	55%	67%	86%
• O&M (94$) all escalate at 4.5%	55 $/kW	69 $/kW	83 $/kW
• Capital Cost ($m)			
– Bellefonte Unit 1	1311	2622	3470
– Bellefonte Unit 2	912	1824	2420
– Browns Ferry Unit 1	1187	2374	3150
– Watts Bar Unit 2	1097	2194	2910
3. CARBON DIOXIDE COMPLIANCE (94 $) (Control cost over 1990 level)	0 $/Ton	5 $/Ton	10 $/Ton
4. AIR & WATER CONTROLS (94 $) (Add to existing coal units 2004)	0 $/kW	150 $/kW	250/425 $/kW
5. PRICE OF NATURAL GAS			
• Price (2000 $)	256 ¢/MBtu	342 ¢/MBtu	418 ¢/MBtu
• Escalation	2.4%	5.3%	7.9%
6. COPRODUCT REVENUE (2000 $)	91 $/Ton	262 $/Ton	320 $/Ton
7. DSM EFFECTIVENESS (MW peak reduction in 2010)	3124	5494	8219

Over 40 uncertainties were evaluated, and the 7 uncertainties with the greatest impact on the criteria are shown in this figure. For each uncertainty, low, medium, and high values are shown.

Strategy Development

In developing strategies, TVA attempted to identify ones that best addressed the evaluation criteria and uncertainties. Using the ranking process, TVA combined the customer service options into four demand-side management blocks and two beneficial electrification blocks, as explained in Chapter 8. The supply-side options were combined into 31 categories, including coal, gas, nuclear, renewables, and independent power production. These 31 categories were used to create diverse strategies to address the established criteria and uncertainties. There were three environmental control options, two electric rate options, and two transmission option. Each strategy contained short- and long-term supply-side options, customer service options (demand-side management or beneficial electrification), environmental control options, electric rate options, or transmission options.

From the 6 customer service blocks, 31 categories of supply-side options, 3 environmental control options, 2 electric rate options, and 2 transmission options, over 2,000 strategies were produced. Each strategy was further subdivided into a short-term period, 1996-2005, and a long-term period, 2006-2020.

TVA examined all of these strategies using the multi-attribute trade-off analysis described earlier in this chapter and in Chapter 2. In these early evaluations each strategy was evaluated for each criterion. This process created over 40,000 estimates of the evaluation criteria.

From these early evaluations many strategies were eliminated and new strategies were created. Strategies were eliminated based on the evaluation criteria. Strategies were generally eliminated only if there were clearly superior strategies. These evaluations resulted in 7 strategies emphasizing the evaluation of customer service options, 14 strategies relating to supply-side options including nuclear options, and 16 strategies that were mixed strategies or combinations of supply, customer service, environmental control, pricing, and transmission options. These 37 strategies best addressed the evaluation criteria and uncertainties.

These strategies were combined with futures, then scenarios were evaluated using the multi-attribute trade-off analysis. This process produced another set of thousands of estimates of evaluation criteria for the different futures.

The evaluation of 37 strategies was reviewed with the stakeholder Review Group at its January meeting. As the analysis continued, some strategies were eliminated, while others were refined to make new strategies. These new strategies were reviewed at the February and March meetings of the stakeholder Review Group.

During these three rounds of reviews, additional analysis concentrated on two areas. First, during the January review, there were no strategies with both low rates and low environmental emissions, particularly carbon dioxide (CO_2) emissions, in the 37 strategies evaluated. (Carbon dioxide is generally a good indicator of the air quality performance of all strategies.) In subsequent rounds, low cost renewables—which have few emissions—were given a more prominent position, and the rates/environment trade-off improved. The stakeholder Review Group recommended several strategies to improve on this trade-off.

Second, changes in the electric utility industry are creating additional uncertainty. Increasing competition increases the uncertainty in load growth and the future price of electricity. Since both load growth and price uncertainty create cost and electric rate risks to customers, TVA developed a set of resource options that provide the flexibility to adapt to these uncertainties. These resource options permit TVA to manage the risk associated with uncertain load growth and electric prices.

As described in Chapter 7, these flexible resource options are similar to call options found in financial markets. Based on a request for proposals, hundreds of call options for purchasing power were identified. In addition, TVA identified flexible internal options. These options are largely based on traditional supply- and demand-side options, but with the flexibility to stop or start construction on a project or program.

These flexible resource options, along with the traditional resource options, were evaluated using new techniques. These techniques are based on financial options valuation models and extensions of decision analysis models.

Approximately 400 flexible resource options were evaluated. From these evaluations, the best flexible resource options were identified and strategies containing these options were developed.

The three rounds of evaluations and the additional analysis performed during the period resulted in 21 strategies. These 21 strategies were reviewed by the stakeholder Review Group in March. These strategies are identified in *Figure 9-3*.

For purposes of comparison, TVA also retained Strategy D. Strategy D is the reference or "No Action" strategy for Energy Vision 2020. The "No-Action" strategy was to identify those resource options that TVA would most likely have employed to meet demand in the absence of the information and analysis produced as a result of the Energy Vision 2020 process. Taking into account the difficulties TVA has encountered in completing the nuclear units that it has had under construction, it was determined that TVA would likely have looked to some mix of combined cycle combustion turbines, new coal-fired units, and limited amounts of purchased power. These became the core elements of the Energy Vision 2020 "No Action" strategy and formed the reference strategy for purposes of analysis and benchmarking integration results across alternative strategies.

Decision on Nuclear Power

During the course of Energy Vision 2020, TVA's staff performed a review of issues involving unfinished or inoperative nuclear units and their impacts on rates, debt, long-term costs, and flexibility for meeting future power needs. This review was based on the more than 2,000 strategies evaluated using the multi-attribute trade-off analysis.

The three major concerns identified by TVA stakeholders—debt, competitiveness, and nuclear power—are interrelated. In the opinion of many stake-

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies**

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
STRATEGY A Minimum CO_2 - Natural Gas Repowering of Existing Coal	Supply-side expansion relies on low emission options • Natural gas combined cycle repowering of several existing coal units • Combustion turbines • Combined cycle • Fuel cells • Hydro modernization	Maximum use of DSM (three blocks) reduces need for generation	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
STRATEGY B Minimum CO_2 - Natural Gas Repowering of Existing Coal and Renewables	Supply-side expansion relies on low emission options and renewables • Natural gas combined cycle repowering of several existing coal units • Combustion turbines • Landfill and coalbed methane • Wind • Refuse-derived fuel repowering of an idled coal plant • Biomass-fueled plants • Fuel cells • Hydro modernization	Maximum use of DSM (three blocks) reduces need for generation	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost-of-generation options to shift generation to lower emission sources • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
STRATEGY C Low-Cost Producer (Coal-Based)	Supply-side options emphasize coal for all base-load options • Combustion turbines • Small pulverized coal plant at existing site (Shawnee 11) • Pulverized coal with scrubbers • Clean coal technologies • Hydro modernization	Maximum use of DSM (one block) reduces need for generation	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing fossil units	Time-of-day rates reduce peak demand growth
STRATEGY D Combined Cycle, Purchased Power, Coal (Reference)	Supply-side options emphasize a blend of TVA-built, IPPs, and cogenerators to reduce production cost and debt • Combustion turbines • Combined cycle • IPP and cogeneration natural gas combined cycle • IPP coal • Clean coal technologies	Low-price block of DSM (block one) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing fossil units	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy E Maximum Customer Value Index - Off-System Sales, High Beneficial Electrification, Declining Block Pricing	Supply-side options mix emphasizes coal expansion for low production cost • Combustion turbines • Small pulverized coal plant at existing site (Shawnee 11) • Clean coal technologies • Pulverized coal with scrubbers • Hydro modernization	Attempt to increase customer value (low rates and low-cost services) by a combination of: • Low-price block of DSM (block one) reduces demand with minimum rate increase • High level beneficial electrification provides services and increases power sales • Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	Declining block pricing promotes electricity use
Strategy F Low Total Resource Cost/High DSM	Supply-side options mix emphasizes coal expansion and low-cost renewables for low production cost • Combustion turbines • Clean coal technologies • Landfill and coalbed methane • Pulverized coal with scrubbers • Hydro modernization	Maximum use of DSM (three blocks) reduces need for generation	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy G Maximum Sales	Supply-side options mix emphasizes coal expansion and low-cost renewables for low production cost • Combustion turbines • Clean coal technologies • IPP coal plant • Pulverized coal with scrubbers • Hydro modernization • Compressed air energy storage • Combined cycle • Small pulverized coal plant at existing site (Shawnee II)	No DSM High-level beneficial electrification Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing fossil units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy H Maximum Capacity Diversity	Supply-side options mix emphasizes many diverse smaller options • Combustion turbines • Combined cycle • IPP and cogeneration combined cycle • IPP coal plant • Clean coal technologies • Compressed air energy storage • Landfill and coalbed methane • Wind • Fuel cells • Biomass (short rotation woody crop) plant • Refuse-derived fuel stoker plant • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
Strategy I Bellefonte Nuclear Partnership	Supply-side options include traditional expansion options with a Bellefonte Nuclear Partnership • Combustion turbines • Combined cycle • IPP and cogeneration combined cycle • IPP coal plant • Clean coal technologies • Bellefonte nuclear partnership	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
Strategy J Bellefonte Coproduct, Renewables, IPPs	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy K Defer and Build BFN 1 and WBN 2 with Reference Expansion	Supply-side expansion features completion of two nuclear units and traditional expansion options • Combustion turbines • BFN 1 and WBN 2 • IPP and cogeneration combined cycle • Combined cycle • Clean coal technologies • IPP coal plant	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units	No special pricing policy is used
Strategy L Minimum CO_2 with Less DSM (a variation of Strategy B)	Supply-side expansion relies on low emission options and renewables • Natural gas combined cycle repowering of several existing coal units • Combustion turbines • Combined cycle • Landfill and coalbed methane • Wind • Refuse-derived fuel repowering on an idled coal plant • Biomass fueled plant • Fuel cells • Hydro modernization	Low-price and low-cost DSM (two blocks) reduces need for generation	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • Moderate level of biomass (waste wood) cofiring (1.3%) at existing fossil units	No special pricing policy is used
Strategy M Combined DSM and Off-System Sales (a variation of Strategy F)	Supply-side options mix emphasizes coal expansion and low-cost renewables for low production cost • Combustion turbines • Pulverized coal at an existing plant • Clean coal technologies • Landfill and coalbed methane • Pulverized coal with scrubbers • Hydro modernization	Low-price and low-cost DSM (two blocks) reduces need for generation Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy N Decentralized Generation with More Renewables	Supply-side options mix emphasizes many diverse options • Combustion turbines • Combined cycle • IPP and cogeneration combined cycle • IPP hydro plant • Landfill and coalbed methane • Wind • Fuel cells • Refuse-derived fuel stoker plant • IPP coal plant	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy O Bellefonte Coproduct, More DSM, More Off-System Sales (a variation of Strategy J)	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price and low-cost block of DSM (two blocks) reduces need for generation Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy P Low-Cost Renewables, Low-Price DSM, Repowering	Supply-side expansion relies on low emission options and renewables • Natural gas combined cycle repowering of several existing coal units • Combustion turbines • IPP combined cycle • Clean coal technologies • Compressed air energy storage • Landfill and coalbed methane • Wind • Pulverized coal • Refuse-derived fuel repowering of an idled coal plant • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy Q Flexible Strategy with External Options	Supply-side expansion features purchase options with rights, but not obligations, to purchase power • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Purchase of peaking capacity • Flexible base capacity purchase • Flexible peaking capacity purchase • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy R Flexible Strategy with Internal Options	Supply-side expansion features preplanning, design, and siting work to support flexible start dates of TVA-built options • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Combined cycle • Purchase of peaking capacity • Flexible base capacity purchase • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales	SO_2 • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy S Low Cost, Low Rates, Improved Environment (a variation of Strategy O)	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • IPP combined cycle • Landfill and coalbed methane • Clean coal technologies • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales spread fixed cost over more sales	SO_2 • Scrubbers are added at several existing units • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used
Strategy T Low-Cost Renewables, Low-Price DSM, Repowering, Bellefonte Coproduct Partnership (a variation of Strategy P)	Supply-side expansion relies on low emission options, renewables, and an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Natural gas combined cycle repowering of several existing coal units • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Combustion turbines • IPP combined cycle • Clean coal technologies • Compressed air energy storage • Landfill and coalbed methane • Wind • Pulverized coal • Hydro modernization	Low-price block of DSM (block 1) reduces demand with minimum rate increase	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

FIGURE 9-3. **Characteristics of Energy Vision 2020 Strategies** *CONTINUED*

No./Name	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls	Pricing
Strategy U Low-Cost Renewables, More DSM, Repowering, Bellefonte Coproduct Partnership (a variation of Strategy P)	Supply-side expansion relies on low emission options, renewables, and an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Natural gas combined cycle repowering of several existing coal units • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Combustion turbines • IPP combined cycle • Clean coal technologies • Compressed air energy storage • Landfill and coalbed methane • Wind • Pulverized coal • Fuel cells • Hydro modernization	Low-price and low-cost DSM (two blocks) reduces need for generation	SO_2 • Gas repowering of some existing coal • Switching to lower sulfur coals at several existing units CO_2 and other fossil emissions • CO_2 penalty added to assumed cost of generation options to shift generation to lower emission sources • A level of biomass (waste wood) cofiring of 0.3%	No special pricing policy is used

holders, high debt is generally associated with a poor competitive position. Since the large capital expenditures necessary to complete TVA's nuclear units would increase TVA's debt, the possibility of completing these units contributes to a perception that TVA's competitiveness will suffer.

The question of how to proceed with four nuclear units—Bellefonte Nuclear Plant Units 1 and 2, Watts Bar Nuclear Plant Unit 2 and Browns Ferry Nuclear Plant Unit 1—is critically important to TVA and the region it serves. The total cost to complete or restore them to service as nuclear units is estimated to be about $9 billion—unquestionably a major investment by TVA's customers. But in addition to these costs, TVA considered these factors:

- Need for power in the future
- Cost and operating performance of other options that could replace the nuclear units
- TVA's long-term costs
- TVA's rising debt
- Impact of any decision on short- and long-term rates
- Environmental effects of various resource options

After receiving the staff's review, TVA's Board of Directors announced that TVA will not fund the completion of Bellefonte Units 1 and 2 and Watts Bar Unit 2 as nuclear units. In addition, Browns Ferry Unit 1 will continue in its current inoperative status. TVA will keep open alternatives for these units that would minimize short-term rates, increase long-term flexibility, minimize long-term costs, and limit debt.

Alternatives to completing these units as nuclear units include:

- Converting the units to another technology such as natural gas or coal gasification with a chemical coproduct
- Replacing these units with different types of supply- and demand-side resource options

The nuclear power report is found in Volume 2, Technical Document 8, Resource Integration.

Final Strategy Evaluation

The 21 strategies that remained following the third round of evaluation were compared using the evaluation criteria.

TVA used the 42 criteria to quantitatively compare the strategies. Several were selected as representative of the 42 criteria. These include a customer value test; total resource cost; impact on short-term rates; impact on total debt; emissions of carbon dioxide, sulfur dioxide, and solid waste; and annual average income in the TVA region.

Strategies were combined with futures to develop 20,000 scenarios. The scenarios were then evaluated against all 42 of the criteria, creating more than 850,000 data points. Each of these data points represents the numerical value for one criteria and one scenario.

In Energy Vision 2020, TVA used multi-attribute trade-off analysis extensively as an evaluation tool. Five trade-off graphs appear as illustrations in this section. These trade-off graphs provide a comparison of the 21 strategies for representative criteria for a mid-range future. This mid-range future consists of:

- Medium load growth
- Medium natural gas price
- Medium chemical coproduct price
- Medium nuclear performance
- Medium demand-side management effectiveness
- No additional environmental regulations
- No additional carbon dioxide regulations

(Medium values are identified with the list of uncertainties in *Figure 9-2.*) This mid-range future is judged to be one of the more probable futures and is used in the initial evaluations.

Figures which follow show trade-off graphs in which the 21 strategies are evaluated against debt, long-term costs, short-term rates, carbon dioxide

emissions, economic development, and customer value. Trade-off graphs are plotted such that the best performing strategies (relative to the other strategies) appear in the lower left corner of the graphs. Best performing strategies have the lowest (or highest) value for the two criteria plotted on the chart. Strategies in this area are enclosed within a box. A discussion of the strategies within the box that will be carried forward for further analysis follows:

Debt in Year 2001 Versus Total Resource Costs

Nine strategies result in low debt and low long-term costs (long-term costs to customers over the 25-year period are identified as total resource costs [TRC]). These 9 are Strategies F, J, M, O, Q, R, S, T, and U. (See *Figure 9-4.*) One of the major concerns identified by the public is TVA's debt, i.e., the current level of debt and the prospects of the growth in debt if TVA would have completed the unfinished nuclear plants.

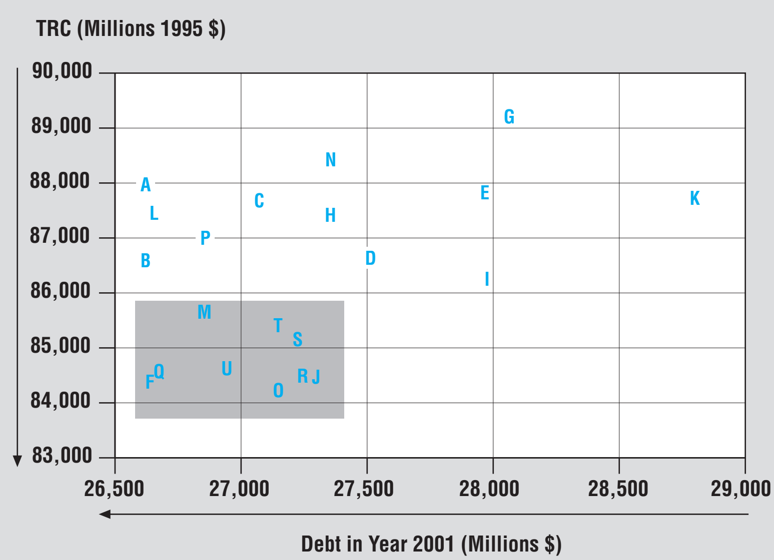
The amount that TVA borrows in the future adds to the debt. TVA borrowings are generally equal to TVA capital expenditures on existing and new plant and equipment less any internal funds that are generated for reinvestment in existing or new plant and equipment. Internal funds for reinvesting in plant and equipment are largely based on depreciation or amortization charges for existing plant and equipment.

All of the strategies identified in *Figure 9-4* indicate that TVA, by itself, will not complete Bellefonte Units 1 and 2, Watts Bar Unit 2, or restore Browns Ferry Unit 1 as nuclear plants. Reducing expenditures on the capital-intensive nuclear plants is one of the major reasons that the projected debt level in 2001 remains below $28 billion.

In addition, the nine low-cost and low-debt strategies include the completion of Watts Bar Unit 1 and Browns Ferry Unit 3 in 1996. These revenue- producing units require relatively small capital expenditures to complete and will be depreciated when the units go into service, thereby providing internal funds to manage debt.

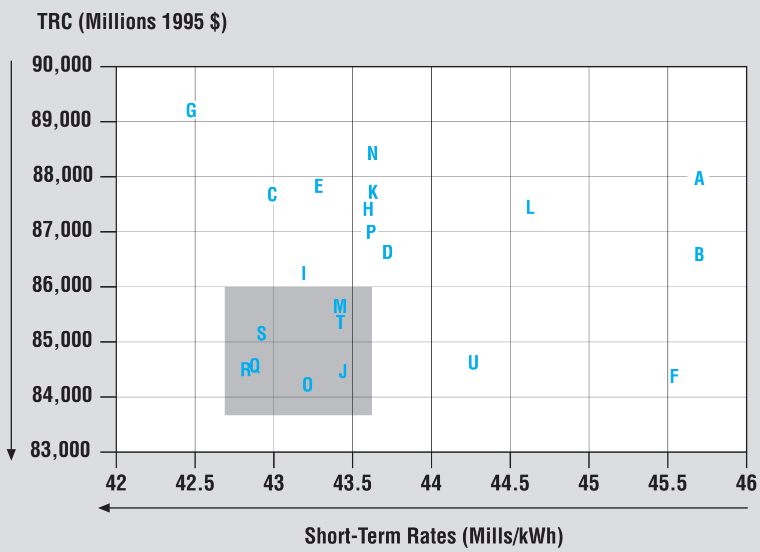
Peaking capacity needs beginning in 1998 and base-load capacity needs in 2001 are met by low capital cost and small-size combustion turbines and combined cycle plants, purchased power from other utilities or purchases of options on future power delivery, demand-side management, and other low-capital cost resource options. These resource options result in lower capital expenditures and help maintain the TVA debt level

FIGURE 9-4. **Strategy Trade-Off for Debt in Year 2001 vs. Total Resource Costs**



The nine strategies within the box have relatively low debt and low costs.

FIGURE 9-5. **Strategy Trade-Off for Short-Term Rates vs. Total Resource Costs**



The seven strategies within the box have relatively low short-term rates and low costs.

below the $30 billion statutory limit.

TVA also closely scrutinizes, monitors, and controls capital expenditures on existing plant and equipment. Most capital expenditures other than for safety or regulatory compliance are subjected to cost-effective tests to maintain low costs and electric rates, as well as reduce TVA's need to borrow additional money.

Thus, the strategies identified in *Figure 9-4* indicate that TVA can manage its debt by controlling capital expenditures on existing and new plants. By controlling capital expenditures, these expenditures will not exceed the amount of internal funds and therefore require little or no new borrowing. Without borrowing additional money, TVA can maintain or lower the level of debt.

Most importantly, TVA's Board of Directors indicated that TVA would limit its debt. This limit on debt would be less than TVA's statutory limit of $30 billion. These strategies result in debt that is $2 to $3 billion less than TVA's statutory limit of $30 billion. Long-term costs are in a range of $84 to $86 billion or a range of 2.4 percent.

Short-Term Rates Versus Total Resource Costs

Seven strategies result in low short-term rates and low long-term costs. These are Strategies J, M, O, Q, R, S, and T. (See *Figure 9-5.)* Strategies F and U have high rates but low costs. Strategy G has high costs but low short-term rates.

All of the strategies that are low cost, with the exception of Strategies M and F, contain the Bellefonte conversion to a coal gasification plant with the production of both electricity and a chemical coproduct.

The Bellefonte conversion option alone reduces the total resource costs approximately $1,500 million. The Bellefonte conversion option reduces both costs and electric rates. Costs and rates are reduced because the sale of the chemical coproduct provides benefits that reduce the cost of electricity. In addition, this option minimizes electric rates because much of the existing plant at Bellefonte can be used in the conversion that reduces the potential write-off of unused plant and equipment.

Without the Bellefonte conversion options, there would be more of a trade-off between costs and short-term electric rates.

Several strategies, such as Strategy F and Strategy U, have relatively low total resource costs but higher short-term rates. For example, Strategy F has electric rates that are 2 to 2.5 mills greater, or 5 to 7 percent greater, than the

low-cost and low-rate strategies in *Figure 9-5*. In addition, Strategies B, L, and F could be lower cost if they included the Bellefonte conversion option.

Strategies B, L, U, and F all contain more demand-side management (2,500-5,000 megawatts in 2010) than the seven low-cost and low-rate strategies (1,500 megawatts in 2010) shown in the shaded area of *Figure 9-5*. Strategies with more demand-side management tend to reduce total resource costs.

Although the strategies that have more demand-side management can have lower costs, they also have higher short-term and long-term electric rates.

As indicated in Chapter 5, Evaluation Criteria, the total resource costs measure the net benefits, benefits minus costs, to participants in the demand-side management programs. The participants in demand-side management receive benefits from reduced electric bills. Generally, the benefits exceed the cost of installing demand-side management measures. The non-participants' benefits in demand-side management programs are negative (costs exceed benefits) since the electric rates increase—raising their electric bills without a corresponding savings. Electric rates are increased since the revenue loss from reduced sales plus direct demand-side management costs exceeds the benefits of reduced generation costs. The total resource costs are generally reduced by demand-side management activities because the benefits to participants exceed the costs to non-participants in the demand-side management activity.

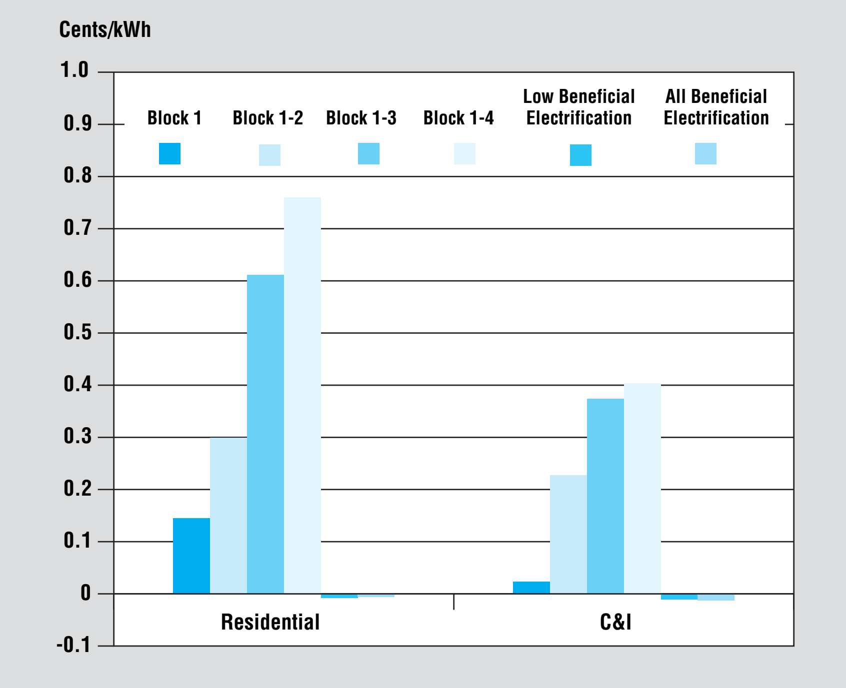
Although there is a reduction in total resource costs with more demand-side management, a portion of the benefits received by the participants is paid by non-participants' increased electric rates and bills. This is commonly referred to as cross-subsidization between participants and non-participants. The higher electric rates and bills for non-participants can be for consumers within the same rate class (e.g., residential) or for consumers in other rate classes, such as industrial customers.

The multi-attribute trade-off analysis examines both total resource costs and electric rates as important criteria for choosing strategies.

An alternative to choosing lower cost or lower rate strategies is to mitigate the effect on electric rates associated with demand-side management activities. There are several possible approaches to mitigating the electric rate effects of demand-side management.

First, demand-side management activities that do not increase electric rates can be implemented. Activities can be implemented such as load management, which reduces peak demands on the power system, and market transformation activities in which the participants or beneficiaries of the demand-side management activity pay the costs. Of the demand-side management activities identified in Chapter 8, the load management of residential and commercial water heating and cooling reduces peak demands without increasing electric rates to non-participants. Two important market transformation activities identified in Chapter 8 are the manufactured homes program and the comprehensive commercial and industrial finance program. With these programs the consumers that receive the benefits of increased energy efficiency and lower electric bills will pay more of the direct costs, resulting in lower impacts on electric rates

FIGURE 9-6. **Rate Changes by Class of Service Due to Demand-Side Management for Fiscal Year 2000**



to the non-participating consumers.

Second, electric rate increases can be more appropriately allocated to the residential or commercial and industrial rate classes. If costs and the loss of revenues are allocated to those classes of service receiving the benefits of demand-side management, then the rate increases will differ from the average rate increase.

The increase in electric rates for residential, commercial, and industrial customer classes for the four blocks of demand-side management and the two blocks of beneficial electrification are shown in *Figure 9-6*. The rate increases are shown for the year 2000. Residential electric rates will increase by a larger amount than commercial and industrial rates for all blocks of demand-side management. Commercial and industrial electric rates show almost no change for the first block of demand-side management. Beneficial electrification results in almost no change in electric rates.

Thus, the electric rate increases are associated with the classes of customers that generally receive the benefits from the demand-side management activity. Note that within a rate class the non-participants will experience an increase in electric rates.

Third, the revenue loss that results from increased demand-side management activities can be reduced by more closely matching cost savings with the revenue changes by changing the overall rate structure or pricing policy. By more closely matching the revenue loss with the costs savings or benefits, the effect on electric rates can be reduced or eliminated. Two such approaches are real-time pricing mechanisms and the unbundling of electric services. With real-time pricing, prices of electricity on an hour-by-hour basis are based on the incremental costs of electric supply. Thus, for any changes in electricity demand, revenue changes match cost changes, which eliminates any cross-subsidization among consumers. TVA's Economy Surplus Power program is a form of real-time pricing for non-firm or interruptible electric power.

The changing competitive structure of the electric industry is resulting in services associated with the delivery of electric power being unbundled. For example, recent proposed actions by the Federal Energy Regulatory Commission (FERC) are likely to result in transmission services being separately priced from generating services associated with the delivery of electric power. Likewise, other ancillary services to transmission, such as voltage control, could be separately priced in the delivery of electricity. Generating

services could also be unbundled by time period (e.g., time-of-day rates) or by type of generation such as peaking, base-load generation, and back-up power for emergencies. This unbundling of services results in prices more closely matching the cost of delivering such services and again reducing the cross-subsidization associated with changes in electricity demands. TVA is currently reviewing and investigating its real-time pricing options and the unbundling of electric services.

All of these approaches to reducing the impact of electric rates of demand-side management activities are being, or will be investigated by TVA now or in the near future. As these investigations are concluded and rate or pricing policies change, TVA will re-evaluate the changes in costs and electric rates associated with demand-side management activities.

Carbon Dioxide Emissions Versus Total Resource Costs

Nine strategies have low carbon dioxide emissions and low long-term costs. These 9 are Strategies F, J, M, O, Q, R, S, T, and U. Strategies B and L have lower emissions but higher costs. Most environmental measures are correlated (they track with one another); therefore, carbon dioxide emissions are a good surrogate for all environmental measures.

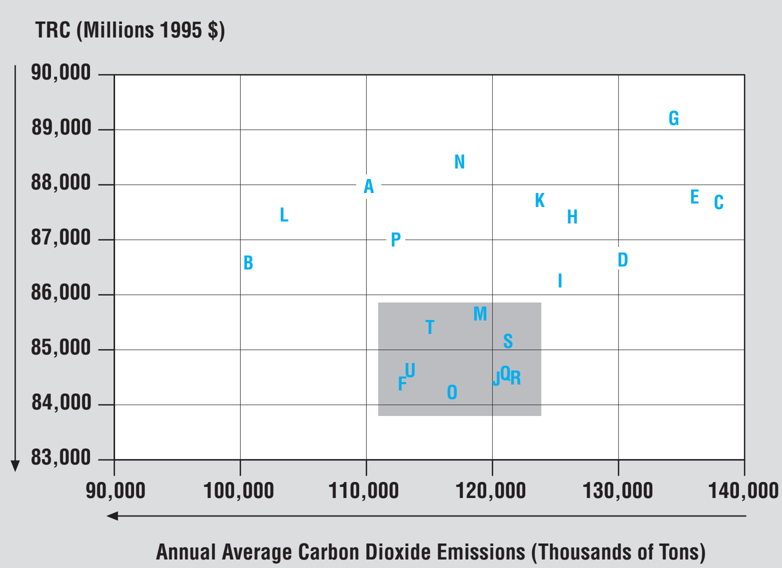
Lower environmental emissions could have been achieved with more demand-side management (Strategies B and L), but only at higher costs as shown in *Figure 9-7*, and higher short-term electric rates shown in *Figure 9-5*.

As indicated in the previous discussion of strategy development, the trade-off between lower electric rates and lower environmental emissions was mitigated. This mitigation occurred through strategies that included clean coal technologies such as integrated gasification combined cycle; renewables such as wind power, the burning of landfill methane in fuel cells, and hydro modernization; and the use of lower carbon dioxide emitting technologies such as natural gas combined cycle, coalbed methane burned in fuel cells, and the repowering of existing coal units with natural gas.

Economic Development (Personal Income in the TVA Region) Versus Total Resource Costs

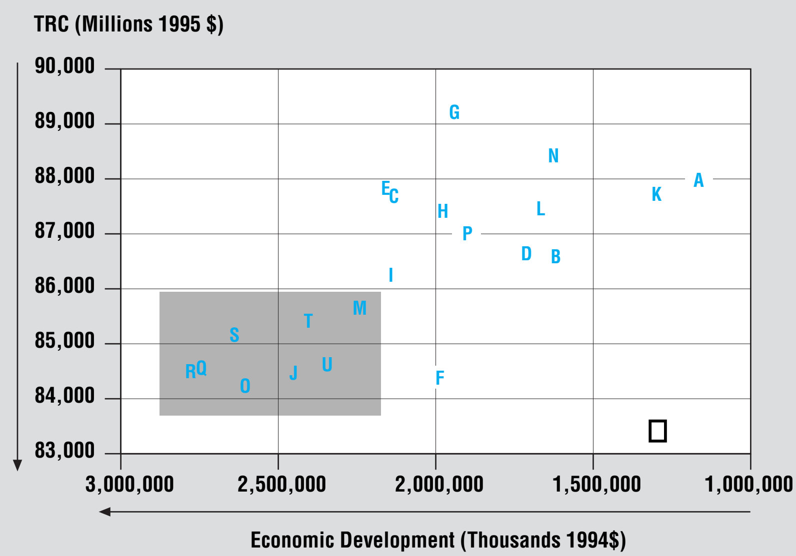
Eight strategies have a positive impact on regional income and low long-term costs. These are Strategies J, M, O, Q, R, S, T, and U. (See *Figure 9-8*.)

FIGURE 9-7. **Strategy Trade-Off for Average Annual Carbon Dioxide Emissions vs. Total Resource Costs**



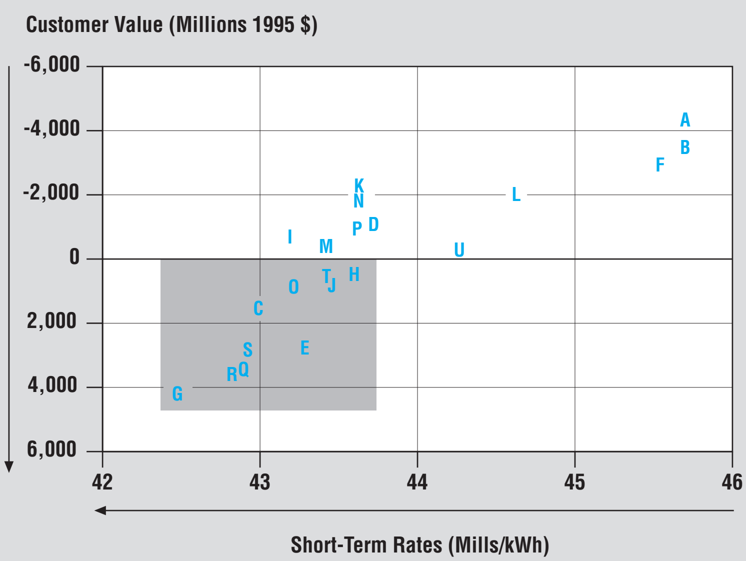
The nine strategies within the box have low to moderate levels of carbon dioxide emissions and relatively low costs.

FIGURE 9-8. **Strategy Trade-Off for Economic Development vs. Total Resource Costs**



The eight strategies within the box have low costs and high levels of economic development benefits. Economic development is measured by personal income in the TVA region.

FIGURE 9-9. **Strategy Trade-Off for Short-Term Rates vs. Customer Value**



The ten strategies within the box have low short-term rates and high customer value.

Short-Term Rates Versus Customer Value

Ten strategies have low short-term rates and high customer value. These are Strategies C, E, G, H, J, O, Q, R, S, and T. (See *Figure 9-9.*) Four strategies—C, E, G, and H—had not been previously identified as best performers. They emphasize additional off-system sales and beneficial electrification. Since off-system sales and beneficial electrification increase value, these activities also are included in strategies M, O, Q, R, and S.

A summary of trade-off graphs for the 21 strategies as compared to the reference case is shown in a strategy index, illustrated as *Figure 9-10*. The numbers in bold type represent im-provements over the reference case.

From the trade-off graphs and the summary (*Figure 9-10*), there are 13 strategies that could possibly produce two or more of the following: low cost, low debt, low electric rates, low environmental emissions, high economic development, and high customer value. From these strategies several were eliminated.

- Strategies F and U produce low cost and improved environment, but were eliminated due to the higher short-term electric rates.
- Strategies G and E produced high customer value, but increased environmental emissions and debt. In these strategies value was created by beneficial electrification and off-system sales. These customer service options were included in other strategies such as Q, R, and S.
- Strategy C also had higher value, but was eliminated due to high environmental emissions.
- Strategy H also had high value,

FIGURE 9-10. **Summary of Strategy Evaluations**

		Customer Value Test Contribution Split ($mil.)	TRC ($mil.)	Short-Term Rates (mills/kWh)	Total Debt 2001 ($mil.)	CO_2 (kTons/yr.)	SO_2 (kTons/yr.)	Solids (kTons/yr.)	Annual Average Income ($mil.)
D	Reference (Combined Cycle, Purchased Power, Coal)	(1,076)	86,634	44	27,514	130,352	563,048	6,166,437	1,711
		Relative to Reference Case	**Percent of Reference Case**						
A	Min CO_2—Nat Gas Repowering of Existing Coal	(4,331)	1.02	1.05	**0.97**	**0.85**	**0.86**	**0.79**	0.68
B	Min CO_2—Nat Gas Repowering of Existing Coal and Renewables	(3,470)	1.00	1.05	**0.97**	**0.77**	**0.86**	**0.82**	0.95
C	Low-Cost Producer (Coal-Based)	**1,633**	1.01	**0.98**	**0.98**	1.06	**0.98**	1.22	**1.25**
D	Reference (Combined Cycle, Purchased Power, Coal)	(1,076)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E	Max Customer Value Index—Off-System Sales, High BE, Declining Block Pricing	**2,779**	1.01	**0.99**	1.02	1.04	**0.92**	1.29	**1.26**
F	Low TRC/High DSM	(2,925)	**0.97**	1.04	**0.97**	**0.87**	**0.87**	**0.96**	**1.16**
G	Maximum Sales	**4,210**	1.03	**0.97**	1.02	1.03	1.02	1.02	**1.13**
H	Maximum Capacity Diversity	**486**	1.01	1.00	**0.99**	**0.97**	1.01	1.00	**1.16**
I	Bellefonte Nuclear Partnership	(681)	1.00	**0.99**	1.02	**0.96**	**0.97**	**0.99**	**1.25**
J	Bellefonte Coproduct, Renewables, IPPs	**820**	**0.97**	**0.99**	**.99**	**0.92**	**0.96**	**0.94**	**1.43**
K	Defer and Build BFN 1 and WBN 2 with Reference Expansion	(2,197)	1.01	1.00	1.05	**0.95**	**0.96**	**0.98**	0.76
L	Minimum CO_2 with Less DSM	(2,005)	1.01	1.02	**0.97**	**0.79**	**0.88**	**0.83**	0.97
M	Combined DSM and Off-System Sales	(397)	**0.99**	**0.99**	**0.98**	**0.91**	**0.91**	1.08	**1.31**
N	Decentralized Generation with More Renewables	(1,891)	1.02	1.00	**0.99**	**0.90**	1.01	**0.97**	.95
O	Bellefonte Coproduct, More DSM, More Off-System Sales	**872**	**0.97**	**0.99**	**0.99**	**0.90**	**0.92**	**0.94**	**1.52**
P	Low-Cost Renewables, Low-Price DSM, Repowering	(938)	1.00	1.00	**0.98**	**0.86**	**0.92**	**0.87**	**1.11**
Q	Flexible Strategy with External Options	**3,450**	**0.98**	**0.98**	**0.97**	**0.93**	**0.90**	**0.97**	**1.61**
R	Flexible Strategy with Internal Options	**3,511**	**0.98**	**0.98**	**0.99**	**0.93**	**0.93**	**0.96**	**1.62**
S	Low Cost, Low Rates, Improved Environment	**2,829**	**0.98**	**0.98**	**0.99**	**0.93**	**0.93**	**0.96**	**1.54**
T	Low-Cost Renewables, Low-Price DSM, Repowering, BLN Coproduct Partnership	**542**	**0.99**	**0.99**	**0.99**	**0.88**	**0.92**	**0.85**	**1.40**
U	Low-Cost Renewables, More DSM, Repowering, BLN Coproduct Partnership	(284)	**0.98**	1.01	**0.98**	**0.87**	**0.91**	**0.85**	**1.37**

All 21 strategies are evaluated for selected criteria and compared to the reference or no action alternative strategy (Strategy D). The customer value is measured in millions of dollars and the other criteria are compared to the reference strategy. The reference strategy is indexed as1.0. Strategies whose criteria are in bold type are better than the reference strategy.

but was eliminated due to the high resource costs. In addition, this strategy contained many options contained in Strategies J, M, Q, R, S, and T.

This analysis identified seven strategies as having low cost, low debt, low electric rates, low environmental emissions, high customer value, and high impact on economic development. These strategies are as follows:

- Strategy J – Bellefonte Coproduct, Renewables, Independent Power Producers

- Strategy M – Combined Demand-Side Management and Off-System Sales
- Strategy O – Bellefonte Coproduct, More Demand-Side Management, More Off-System Sales
- Strategy Q – Flexible Strategy with External Options
- Strategy R – Flexible Strategy with Internal Options
- Strategy S – Low Cost, Low Rates, Improved Environment
- Strategy T – Low-Cost Renewables, Low-Price Demand-Side Management, Repowering, Bellefonte Coproduct Partnership

Environmental Consequences

This section summarizes potential environmental impacts associated with alternative energy strategies. It compares the impacts of alternative strategies and provides the important findings of TVA's environmental analysis for Energy Vision 2020.

TVA'S ANALYTICAL APPROACH REDUCES THE RISK OF ADVERSE ENVIRONMENTAL IMPACTS ASSOCIATED WITH STRATEGIES

The analytical approach used for Energy Vision 2020 is the multi-attribute trade-off method. This approach allows TVA to integrate—quantitatively—the identified environmental impacts and formulate strategies that mitigate them.

TVA developed more than 2,000 different strategies for Energy Vision 2020. These strategies consist of different combinations of energy resource options that were first screened for acceptable performance using multiple criteria, including environmental criteria. In this process, the environmental performance of the strategies was fully integrated into the evaluation in the same manner as financial, rate, economics, and other criteria. Environmental impacts of each strategy are compared to all other evaluation criteria and to all other strategies on an objective basis. This process identified real trade-offs among criteria. One of the most important trade-offs occurred between better environmental performance and electric rates. Achieving better environmental performance (less impacts) typically produces higher costs or rates. In the past, utilities usually have had to choose between lower costs or rates or better environmental performance.

The integrated multi-attribute trade-off method allowed TVA to mitigate potential environmental trade-offs by reformulating strategies to lessen the degree of trade-off. Energy resource options that were primarily responsible for producing undesirable results in either rates or environmental areas were replaced by options that produced more desirable results. These modified strategies were then reintegrated and their performance with respect to the evaluation criteria and trade-offs was reexamined. This was done several times until seven modified strategies were created that respond reasonably well to all Energy Vision 2020 criteria, including environmental criteria. Potential trade-offs were sharply reduced.

With the seven strategies, it is possible to meet the future needs of TVA's customers with much better environmental performance compared to the reference strategy and other unmitigated strategies.

AIR IMPACT SUMMARY

This section summarizes the differences among TVA's final energy strategies with respect to potential impacts on air resources. Chapter 3 provides an overview of air quality issues, existing air quality impacts, sources of air emissions, air pollution trends, and emerging regulations. The air impacts considered in Energy Vision 2020 are human health impacted by inhalation, visibility, crop and forest productivity, materials damage, and greenhouse gases.

FIGURE 9-11. **Air Quality Impact Environmental Indices for Each Strategy and Impact Area**

Strategy	Health-Inhalation	Visibility Impairment	Forest & Crops Productivity	Materials Damage	Greenhouse Gases
D- Reference	1.00	1.00	1.00	1.00	1.00
J	0.98	0.97	0.98	0.97	0.93
M	0.94	0.93	0.95	0.93	0.91
O	0.95	0.94	0.96	0.94	0.90
Q	0.94	0.92	0.95	0.93	0.93
R	0.95	0.94	0.96	0.95	0.93
S	0.95	0.94	0.96	0.95	0.93
T	0.91	0.91	0.91	0.91	0.87

Air indices have been developed for health-inhalation impacts, visibility impairment, forest and crop productivity, materials damage, and greenhouse gases.

Indices were developed to help characterize how the emissions associated with alternative strategies might contribute to these four air impact categories. *Figure 9-11* shows these indices for the final strategies. How these indices were derived is explained in Volume 2, Technical Document 1, Comprehensive Affected Environment. TVA's final strategies were compared to the "No Action" strategy, which is the reference strategy (Strategy D). As indicated, Strategy D was assigned a value of 1.0. The values for the other final strategies then indicate whether they are better or worse than Strategy D with respect to the impact in question (a value greater than 1.0 indicates a worse effect, less than 1.0 a better effect).

TVA's Existing Energy Resources Are the Primary Contributors to Impacts

One of the most important conclusions to be drawn from TVA's Energy Vision 2020 evaluation is that TVA's existing coal-fired units are responsible for most of TVA's contribution to the identified environmental impacts. TVA's coal-fired plants produce air pollution, water pollution, and solid waste. These environmental outputs are associated with a number of environmental problems.

TVA's contribution to many environmental problems has been substantially reduced over the years and is being reduced still further. For example, TVA's sulfur dioxide emissions from its coal-fired units have been reduced by over 60 percent since the mid-1970s and will be reduced still further in response to the Clean Air Act Amendments of 1990. These reductions lessen TVA's contribution to such impacts as acid rain and visibility impairment. However, compared to most new energy resource options, TVA's existing coal-fired units are significantly worse environmental performers.

Energy Vision 2020 focuses primarily on what additional energy resource options, if any, should be added to TVA's system in the future. Consequently,

repowering of selected less-efficient coal-fired units is one of the better options for reducing emissions.

Greenhouse Gas Emissions

There remains considerable uncertainty regarding the possible effect of carbon dioxide and other emissions on global climate. However, at the Earth Summit in Rio de Janeiro, Brazil in June 1992, the United States and over 150 other nations signed the United Nations Framework Convention on Climate Change, establishing the objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous manmade interference with the climate system. In October 1993, the President announced the Climate Change Action Plan which has the goal of returning United States greenhouse gas emissions to 1990 levels by the year 2000. As part of this action plan the United States Department of Energy initiated the Climate Challenge which is a voluntary program to manage United States electric utility greenhouse gases through reduction, avoidance, or sequestering of greenhouse gases.

On April 20, 1994, the Climate Challenge Memorandum of Understanding was signed by the Department of Energy, four utility organizations, and TVA. Subsequently, 104 individual Climate Challenge Participation Accords have been signed with the Department of Energy that represent 487 utilities including TVA. The efforts taken by TVA and the other 450 plus Climate Challenge participants will help mitigate possible negative effects utility emissions may have on global climate in a more cost-effective manner than other control measures such as emissions regulations or carbon taxes. A 22.7 million ton reduction in carbon dioxide by the year 2000 is committed to in TVA's Climate Challenge Participation Accord. These reductions are projected from TVA's 1987 to 1990 baseline emissions and the emissions projected by a year 2000 modified reference case. Primarily, TVA greenhouse gas reductions by the year 2000 come from increased use of nuclear power, biomass cofiring, demand-side management programs, fossil-fueled power plant efficiency improvements, transmission system improvements, and hydroelectric power plant modernization.

Other Air Quality Impacts

A number of other conclusions can be derived from Energy Vision 2020's assessment of potential air resource impacts:

- Although coal usage is projected to increase under all strategies, sulfur dioxide and nitrogen dioxide emissions are expected to decrease compared to 1996 levels.
- Sulfur dioxide emissions are projected to decrease from 1996 levels by 47-51 percent in 2020, depending on the strategy.
- Nitrogen oxides emissions are projected to decrease by 10-20 percent by 2000, then increase, but still remain some 3-13 percent below 1996 levels.
- For all strategies, decreases in TVA's contribution to human health impacts, visibility impairment, decreased forest and crop productivity, and materials degradation are expected.

- TVA's contribution to ozone-related impacts is expected to be reduced under all strategies, but TVA's reductions are likely to be offset by emission increases elsewhere in the region. (Mobile source emissions are projected to increase substantially.)
- Among the final strategies, only Strategy D (the reference strategy) and Strategy T (including low-cost renewables) show a noticeable difference in air resource impacts. The reference or "No Action" strategy uses the most coal and has the greatest impacts. Strategy T repowers several existing coal-fired units and uses the most natural gas and renewable resources. This results in a reduction in TVA's contribution to impacts ranging from 9 to 13 percent.

WATER RESOURCE IMPACT SUMMARY

This section summarizes the differences among TVA's final strategies with respect to potential impacts on water resources. Three water-quality impacts were considered: human health impacts by ingestion, impacts on water supply and waste assimilation, and impacts on fish, aquatic life, and aquatic biodiversity. Chapter 3 provides an overview of water quality issues, existing water quality impacts, sources of pollution, water pollution trends, and regulation.

FIGURE 9-12. **Water Quality Impact Environmental Indices for Each Strategy and Impact Area**

Strategy	Health-Ingestion	Water Supply & Waste Assimilation	Fish and Aquatic Life and Biodiversity
D - Reference	1.00	1.00	1.00
J	1.00	1.00	0.99
M	1.01	1.00	1.00
O	1.00	0.99	0.99
Q	1.01	0.99	0.99
R	1.01	1.00	1.00
S	1.01	1.00	1.00
T	0.92	0.99	0.96

Water indices have been developed for health-ingestion, water supply and waste assimilation, and fish and aquatic life and biodiversity.

As with air resource impacts, indices were developed to help characterize how alternative energy resources strategies may contribute to these impact categories. *Figure 9-12* shows these indices. TVA's final strategies are compared to the "No Action" strategy, which is the reference strategy for Energy Vision 2020 (Strategy D). As indicated, there are only slight differences among TVA's final seven strategies and Strategy D for most water resource impacts. Because less coal is burned under Strategy T (low-cost renewables) and coal use produces some water resource-related impacts, only this strategy shows a noticeable improvement with respect to potential impacts.

The water health by ingestion index uses three weighted measures: power production from nuclear, coal-fired, and peaking hydro. Hydro peaking and nuclear power production are constant for all seven final strategies, as well as the reference strategy. As a result, differences in coal-fired (existing plants) power production governs the index. Strategies M, Q, R, and S all have increased coal-fired power production from existing plants compared to the reference strategy. This results in index values slightly greater than 1.0.

A number of conclusions can be derived from Energy Vision 2020's assessment of potential water resource impacts. These include:

- The effects of damming rivers, including operation of existing hydroelectric units, is responsible for the more important water resource impacts. However,

since no new dams are proposed in the final strategies or the reference strategy, this impact is the same across all strategies.
- Increasing the capacity of TVA's existing hydroelectric plants is environmentally beneficial. This produces new capacity without constructing new plants. New plant construction, particularly a new hydroelectric dam, is more environmentally damaging. Also, new turbine designs used in increasing the capacity of existing hydroelectric plants incorporate technology that introduces oxygen into the water released through the turbine. This increases dissolved oxygen and helps combat the low dissolved oxygen problem that exists today below a number of TVA dams.
- TVA's existing coal-fired plants are responsible for most of TVA's contribution to water pollution. As described in the section on Air Resource Impacts, cost-effective repowering of selected less-efficient coal-fired units provides some of the best options for water quality.
- Repowering or adding capacity at any existing facility is preferable from a water resource perspective because it lessens the risk of impacts to these resources.

LAND RESOURCE IMPACT SUMMARY

The primary land resource issues for Energy Vision 2020 are potential changes in land use and impacts to land resources. Chapter 3 provides an overview of land resource issues and uses. Because land resource impacts tend to be so site-specific in nature, developing indices for such impacts was not helpful. Land resource impacts can be more fully and meaningfully evaluated when proposals to put specific energy resource options in place are made in the future. These impacts will be addressed in subsequent environmental reviews.

However, certain conclusions or observations can be made at this programmatic level of review based on the generic attributes of various energy resource options. *Figure 9-13* shows the estimated total acreage (land use) that would likely be affected by TVA's final strategies and Strategy D, the reference, "No Action," strategy. From the standpoint of land consumption, Strategy T uses the most land. This is due primarily to the extensive acreage that is needed to support wind turbines.

Other conclusions include:
- Resource options that involve expansions at existing plants or the repowering of existing units have little or no land resource impacts.
- The 2,000 megawatts of wind energy capacity in Strategy T is estimated to require 50,000 acres of land at high elevations where the wind resource tends to be found in or close to the TVA region. Wind turbines are also visually prominent and would have some of the most important aesthetic impacts among the various resource options.
- All of TVA's final strategies, including the reference strategy, expand TVA's use of coal. Coal mining and coal combustion waste disposal are two indirect land uses that have

FIGURE 9-13. **Estimates of Direct Land Use for Plant Siting, Power Transmission, and Plant Access for Each Strategy**

Strategy	Megawatts (Year 2020)	Total Land Use (Acres)
D-Reference	16,037	10,883
J	16,456	17,711
M	14,765	16,299
O	15,406	16,080
Q	16,100	15,335
R	16,720	15,685
S	15,976	16,541
T	17,715	61,957

undesirable land resource impacts. Total coal use rises about 35 percent for most strategies compared to current coal use. Only Strategy T is noticeably different, using about 12 percent less coal than the reference or, "No Action," strategy.

- There is sufficient land in the TVA region to allow energy resource options to be put in place without impacting sensitive land resources such as wetlands or endangered species. Land resources should not be a constraint on putting any of the energy resource options identified in TVA's final strategies in place, with the possible exception of wind turbines.

FIGURE 9-14. **Value of Flexibility**

Resource Type	Net Benefits $/MW-Year
PEAKING	
Inflexible combustion turbine (CT)	4,900
Call option (1-year contract)	5,000
Flexible combustion turbine (CT)	6,400
BASE LOAD	
Inflexible combined cycle (CC)	-21,500
Inflexible independent power producers (IPP)	-20,000
Inflexible integrated gasification combined cycle (IGCC)	-6,300
Flexible combined cycle (CC)	800
Flexible integrated gasification combined cycle (IGCC)	1,701
Call option (multi-year contract)	5,000
Call option (1-year contract)	7,000
BLN/coproduct	71,000

The net benefit of flexible options—both TVA-built and external—are greater than the net benefit of inflexible options.

Managing Risk – Hedging Uncertainties

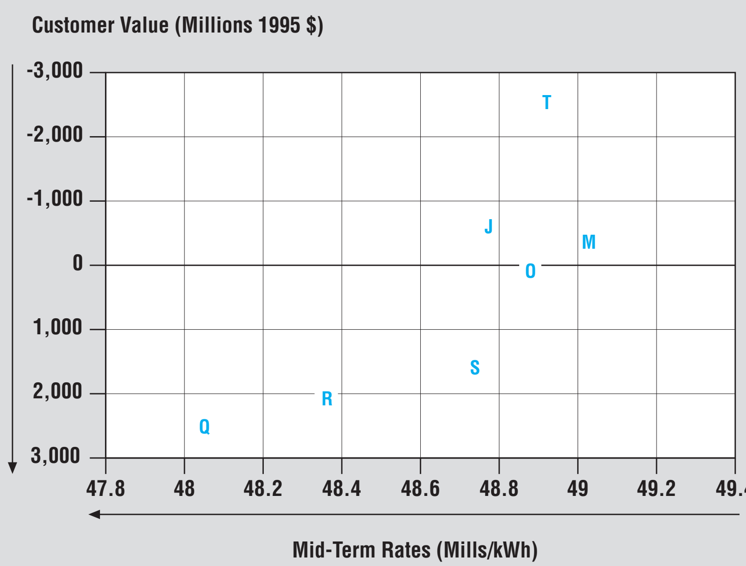
Energy Vision 2020 seeks to provide a robust and flexible set of resource strategies. Robust strategies successfully meet key evaluation criteria for a large range of uncertainties. Flexible options can provide TVA with the ability to respond or adapt to a changing environment as it moves into the 21st century.

Trade-off analysis was used to identify strategies that hedge uncertainties. A strategy hedges an uncertainty if it limits the risk of cost increases compared to other strategies. *Figures 9-14* through *9-21* illustrate the analysis done for the uncertainties of load growth, natural gas pricing, environmental regulations, and nuclear power performance.

UNCERTAINTY IN LOAD GROWTH

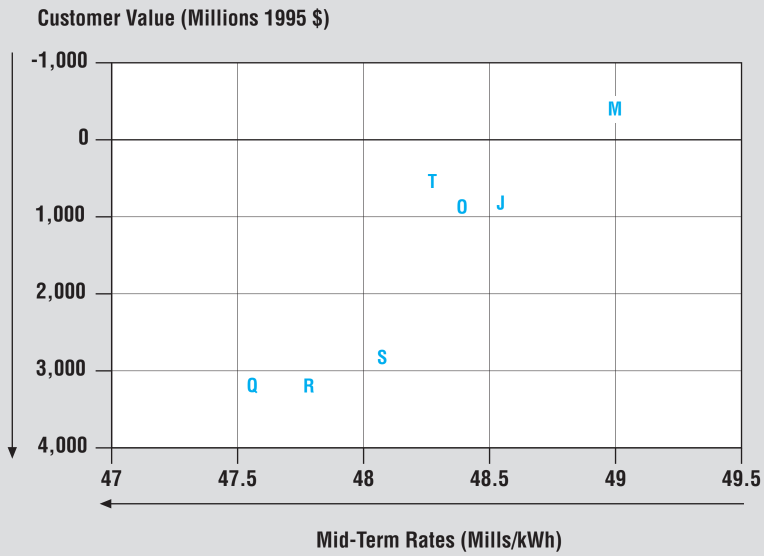
The range of forecasts of future load growth is quite large, indicating, for one, the uncertainty in future competitive conditions. Two strategies were developed that provide resource alternatives and are flexible in the face of uncertain load growth. Strategy Q contains call options on future power. Call options provide TVA the right to buy future power without obligation to buy from suppliers. TVA can buy the right to the power and decide at a later date whether to purchase it. Likewise, Strategy R contains flexible supply-side

FIGURE 9-15. **Value of Flexibility for Load Growth Uncertainty—High Load Growth**



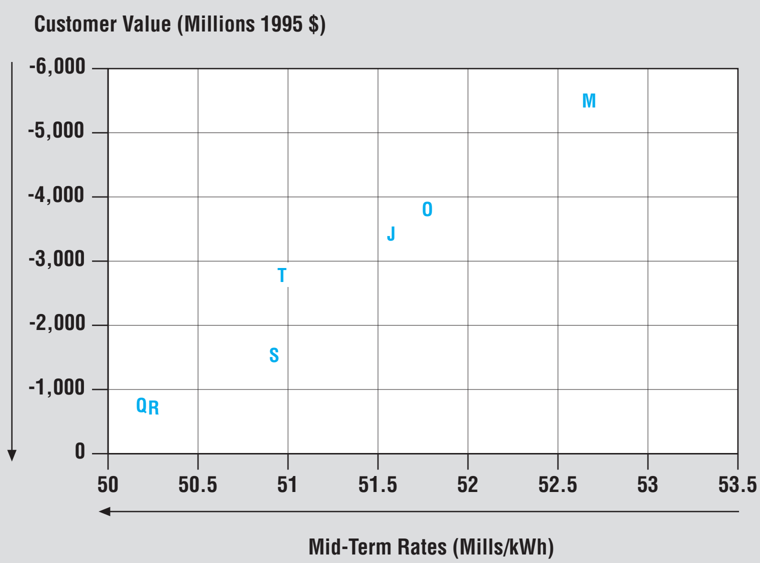
The flexible strategies (Q and R) have lower short-term rates and high value compared to the other key strategies.

FIGURE 9-16. **Value of Flexibility for Load Growth Uncertainty – Medium Load Growth**



The flexible strategies (Q and R) have lower short-term rates and high value with medium load growth as well as high load growth.

FIGURE 9-17. **Value of Flexibility for Load Growth Uncertainty – Low Load Growth**



The flexible strategies (Q and R) have lower short-term rates and high value with low load growth as well as medium and high load growth.

options that TVA would build. These TVA-built options have shorter lead times compared to the inflexible options. (An inflexible option results in significant cost penalties if construction is stopped.)

The net benefits of buying flexible options compared to resource alternatives that do not have flexibility are shown in *Figure 9-14*. The inflexible options, such as a combustion turbine, independent power producer, integrated gasification combined cycle plant, or clean coal plant tend to have negative net benefits. The flexible options for the peaking call option, base-load call option, and flexible integrated gasification combined cycle plant tend to have positive net benefits. Thus, the flexible options tend to have a higher value than the inflexible options.

Trade-off graphs for customer value and electric rates for high, medium, and low load forecasts are shown in *Figures 9-15*, *9-16,* and *9-17*. In these graphs, the flexible strategies—Q and R—tend to have higher value and lower electric rates regardless of the load forecasts. Since these strategies include beneficial electrification, customer value is used as the measure of benefits and costs, rather than total resource cost. As a measurement, total value better captures the benefits and costs associated with increases in electricity consumption from beneficial electrification and variation in load growth.

UNCERTAINTY IN NATURAL GAS PRICES

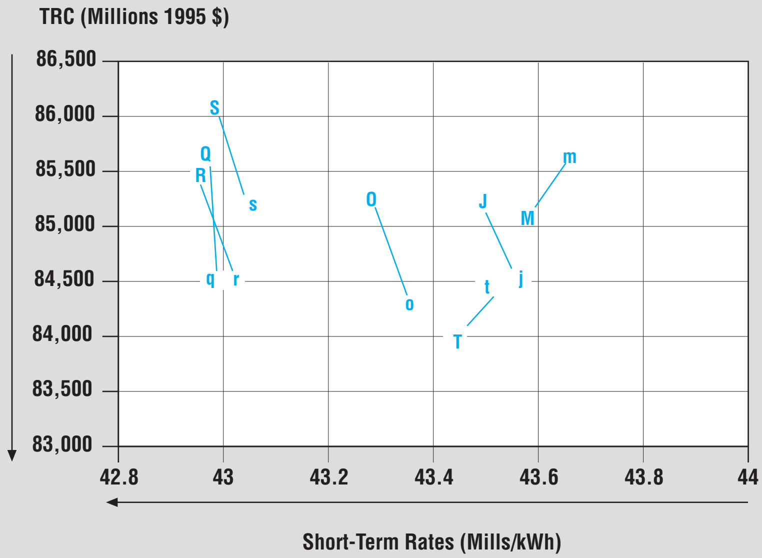
In trade-off analysis, the difference was examined between medium and low natural gas prices. *Figure 9-18* shows the analysis of strategies for the medi-

um and low natural gas prices. (In terms of uncertainty in natural gas prices, most of the public comments indicated TVA's natural gas price forecasts were too high. Recognizing those comments, TVA concentrated on the medium and low natural gas prices.) In *Figure 9-18*, the uncertainties other than natural gas were held at their mid-range values.

In the figure, low natural gas prices are shown in uppercase letters and medium natural gas prices are shown in lowercase letters. The line between the medium and low gas prices indicates the change in total resource cost for each strategy.

Strategies M and T contain clean coal technologies. With Strategy T, costs will increase less than for Strategy M with rising natural gas prices, since Strategy T also contains renewables. Flexibility to adapt to changing gas prices can be provided by including clean coal technologies and renewables in strategies. For example, TVA could build a combined cycle plant with natural gas as the fuel and, at a later time, add coal gasification if natural gas prices increase.

FIGURE 9-18. **Cost Risk Due to Uncertainty in Natural Gas Prices**



J	Low	**j**	Medium	**R**	Low	**r**	Medium
M	Low	**m**	Medium	**S**	Low	**s**	Medium
O	Low	**o**	Medium	**T**	Low	**t**	Medium
Q	Low	**q**	Medium				

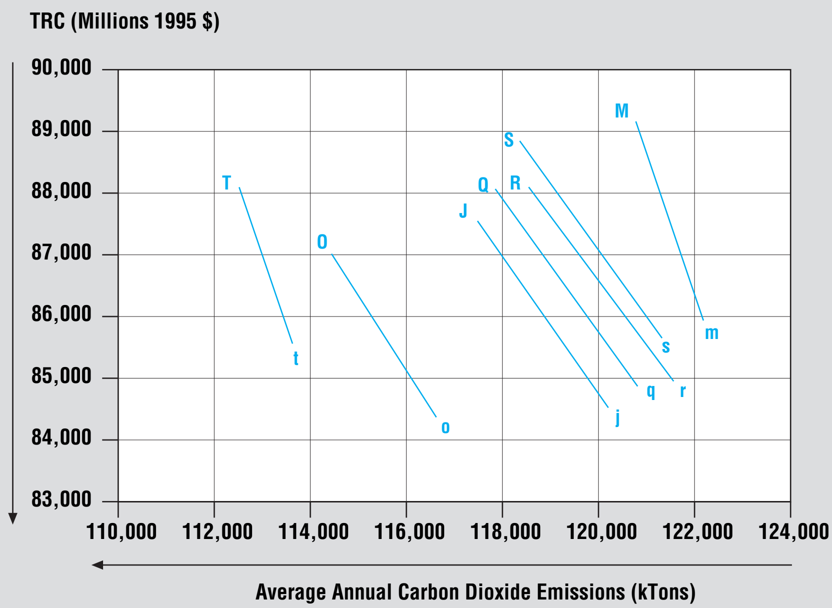
Low natural gas prices are indicated with uppercase letters and medium or higher natural gas prices are indicated with lowercase letters. The length of the line indicates the change in costs due to natural gas price variations.

Several strategies—particularly Strategies J, O, Q, R, and S—contain coal gasification with the production of a chemical coproduct. Chemical coproducts traditionally have been produced with natural gas; therefore, prices of coproducts are based on natural gas prices. High natural gas prices will result in higher prices of the chemical coproduct and lower costs for strategies that contain this option. In other words, for these strategies, higher natural gas prices result in lower costs. The chemical coproduct provides a hedge or offset to rising natural gas prices.

UNCERTAINTY IN CARBON DIOXIDE REGULATIONS

The mid-range future assumes there will be no additional carbon dioxide regulations. *Figure 9-19* illustrates the analysis of the change in costs and carbon dioxide emissions if there are regulations on carbon dioxide emissions. The analysis assumes, as a worst case, a cap on carbon dioxide emissions, with purchases and sales of carbon dioxide allowances at $10 per ton of carbon dioxide. (Carbon dioxide regulations have been modeled similar to current acid rain regulations, which permit buying and selling of sulfur dioxide allowances.)

FIGURE 9-19. **Low-Cost Risk Due to Carbon Dioxide Regulations**



CO_2 Regulations	J	M	O	Q	R	S	T
No Regulations	j	m	o	q	r	s	t

Lowercase letters indicate costs and carbon dioxide emissions with no carbon dioxide regulations; uppercase letters indicate costs and emissions with carbon dioxide regulations. The length of the line indicates the increase in costs for carbon dioxide regulations.

The analysis indicates that the lower cost strategies are robust; they remain lower cost, even with carbon dioxide regulations. For example, Strategies J, O, Q, and R have relatively low costs without carbon dioxide regulations (lowercase letters) and low costs with carbon dioxide regulations (uppercase letters), compared to other strategies. These strategies are relatively robust because they contain options that have low carbon dioxide emissions or offset carbon dioxide emissions, such as natural gas-based combined cycle plant, fuel cells using landfill methane, renewables, and demand-side management options.

UNCERTAINTY IN AIR AND WATER QUALITY REGULATIONS

The mid-range future was based on current air and water regulations including compliance with the acid rain provisions of current Clean Air Act regulations. Additional air and water quality regulations could occur, which would increase the cost of compliance. The effect on selected strategies for additional air and water regulations is shown in *Figure 9-20*. Sulfur dioxide emissions are used to measure the impacts of both air and water regulations. Current regulations are shown in lowercase letters, and more stringent regulations are shown in uppercase letters. Strategies J, O, R, and Q have lower costs regardless of the uncertainty in air and water regulations.

For some strategies the lines connecting the no regulations case with the regulations case cross. For example, if one begins with a flexible approach such as with Strategy Q, both costs and sulfur dioxide emissions can be minimized with no regulations. With regulations, one might want to switch strategies to Strategy O, which contains more renewables to minimize emissions and costs.

UNCERTAINTY IN NUCLEAR PERFORMANCE

The uncertainty in nuclear performance is represented by variations in capacity factor, operation and maintenance costs, and the cost to complete the nuclear units. All of the strategies except for Strategy K assume that Watts Bar Unit 2 and Browns Ferry Unit 1 are kept in deferral status and canceled in the year 2000. Strategy K assumes that these two units will be kept in deferral status until 2000, at which time construction will resume. Strategy K also assumes that work

on Watts Bar Unit 2 and Browns Ferry Unit 1 would be completed in 2005 and 2006, respectively.

Three levels of nuclear performance were considered: poor, moderate and good. As indicated in the trade-off graph in *Figure 9-21*, with moderate or poor performance, the lowest cost strategy—Strategy D, the reference case—defers and cancels both nuclear units. With good nuclear performance, the lowest cost strategy—Strategy K—defers and then completes the nuclear units.

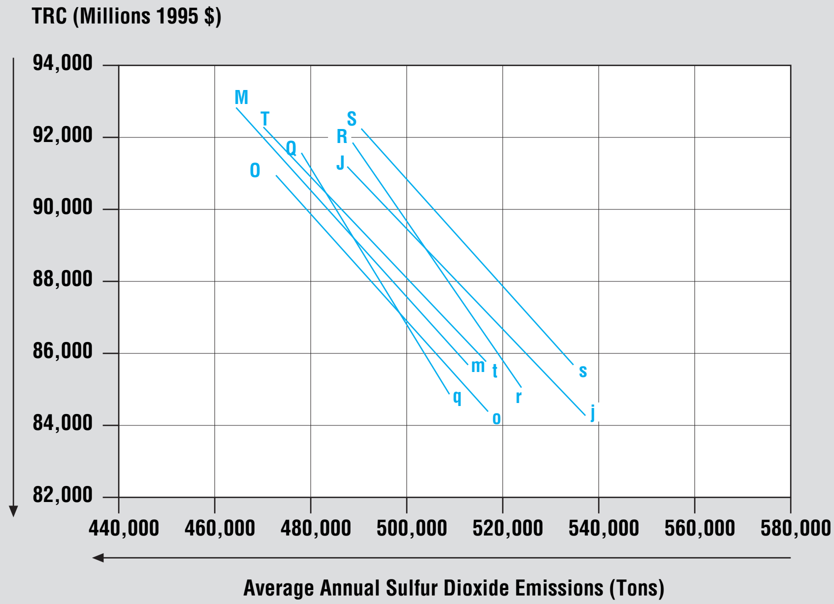
Final Evaluation

A summary of strategy evaluations according to customer value, total resource cost, short-term rates, environment, debt, and economic development, and five uncertainties—load growth, natural gas prices, environmental regulations, nuclear performance, and customer services effectiveness—is illustrated in *Figure 9-22*. Note that the environmental uncertainty combines the uncertainty in carbon dioxide regulations and additional air and water regulations.

After evaluation, seven strategies have emerged that offer lower cost, lower debt, better value, and improved environmental performance and economic development impact, compared to the other strategies. These strategies are as follows:

- Strategy J - Bellefonte Coproduct, Renewables, Independent Power Producers
- Strategy M - Combined Demand-Side Management and Off-System Sales
- Strategy O - Bellefonte Coproduct,

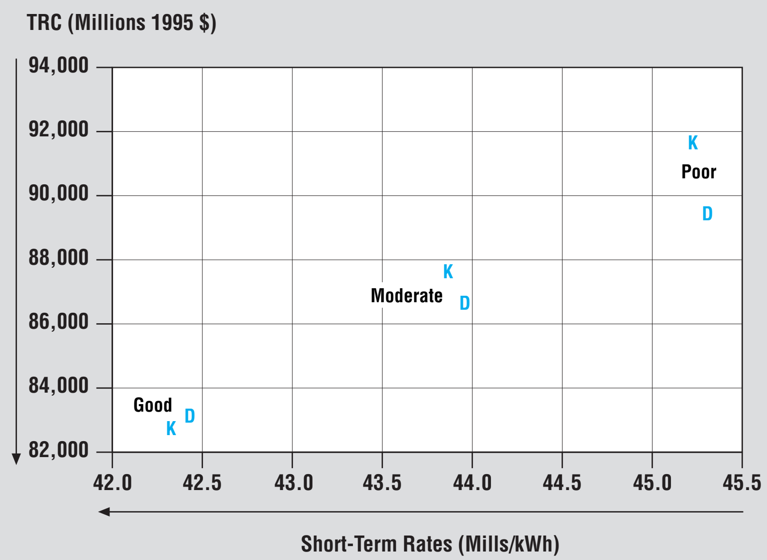
FIGURE 9-20. **Cost Risk Due to Additional Air and Water Regulations**



Additional Regulations	J	M	O	Q	R	S	T
Current Regulations	j	m	o	q	r	s	t

Current air and water regulations are indicated with lowercase letters, and additional air and water regulations are indicated with uppercase letters. The length of the line indicates the cost risk to additional air and water quality regulations.

FIGURE 9-21. **Cost Risk Due to Nuclear Performance Uncertainty**



Nuclear performance uncertainty represents three uncertainties: operation and maintenance cost, capacity factor, and cost to complete construction. Cost and rates are shown for poor, moderate, and good nuclear performance. Except for good nuclear performance, completing Watts Bar Unit 2 and Browns Ferry Unit 1 leads to higher costs.

FIGURE 9-22. **Strategy Performance Matrix**

Strategy	CRITERIA						UNCERTAINTY				
	Value	**Cost**	**Rates**	**Environ.**	**Debt**	**Econ. Dev.**	**Load Growth**	**Natural Gas Prices**	**Environ. Reg.** [1]	**Nuclear Perf.**	**Customer Service Effective-ness**
A Minimum CO_2—Natural Gas Repowering of Existing Coal	Poor	Poor	Poor	Good	Good	Poor					
B Min CO_2—Natural Gas Repowering of Existing Coal and Renewables	Poor	Mod.	Poor	Good	Good	Poor			Hedge		
C Low-Cost Producer (Coal-Based)	Good	Mod.	Good	Poor	Good	Mod.		Hedge			
D Reference	Good	Mod.	Poor	Poor	Good	Poor					
E Maximum Customer Value Index—Off-System Sales, High BE, Declining Block Pricing	Good	Poor	Mod.	Poor	Mod.	Mod.	Hedge	Hedge			
F Low TRC, High DSM	Poor	Good	Poor	Good	Good	Mod.		Hedge			
G Maximum Sales	Good	Poor	Good	Poor	Mod.	Mod.	Hedge				
H Maximum Capacity Diversity	Mod.	Mod.	Mod.	Poor	Good	Mod.			Hedge		
I Bellefonte Nuclear Partnership	Mod.	Mod.	Good	Mod.	Mod.	Mod.			Hedge	Hedge	
J Bellefonte Coproduct, Renewables, IPPs	Mod.	Good	Mod.	Mod.	Good	Good		Hedge	Hedge		
K Defer and Build WBN Unit 2 and BFN Unit 1	Poor	Mod.	Mod.	Mod.	Mod.	Poor				Hedge	
L Minimum CO_2 with Less DSM	Poor	Poor	Poor	Good	Good	Poor			Hedge		
M Combined DSM and Off-System Sales	Mod.	Good	Mod.	Mod.	Good	Mod.		Hedge			
N Decentralized Generation with More Renewables	Mod.	Poor	Mod.	Mod.	Good	Poor			Hedge		
O Bellefonte Coproduct, More DSM, More Off-System Sales	Good	Good	Good	Mod.	Good	Good		Hedge	Hedge		Hedge
P Low-Cost Renewables, Low-Price DSM, Repowering	Mod.	Mod.	Mod.	Good	Good	Mod.					
Q Flexible with External Options	Good	Good	Good	Mod.	Good	Good	Hedge	Hedge	Hedge		
R Flexible with Internal Options	Good	Good	Good	Mod.	Good	Good	Hedge	Hedge	Hedge		
S Low Cost, Low Rates, Improved Environment	Good	Good	Good	Mod.	Good	Good		Hedge	Hedge		
T Low-Cost Renewables, Low-Price DSM, Repowering, BLN Coproduct Partnership	Good	Good	Good	Good	Good	Good		Hedge	Hedge		
U Low-Cost Renewables, More DSM, Repowering, BLN Coproduct Partnership	Good	Good	Mod.	Good	Good	Good		Hedge	Hedge		

[1] Includes uncertainty in air, water, and CO_2 regulations

The evaluation of strategies is summarized qualitatively for key evaluation criteria and for the key uncertainties. The qualitative assessment was based on a ranking of the strategies with "good" representing the upper third; "moderate," the middle third; and "poor," the lower third.

More Demand-Side Management, More Off-System Sales
- Strategy Q - Flexible Strategy with External Options
- Strategy R - Flexible Strategy with Internal Options
- Strategy S - Low Cost, Low Rates, Improved Environment
- Strategy T - Low-Cost Renewables, Low-Price Demand-Side Manage- ment, Repowering, Bellefonte Coproduct Partnership

These strategies also provide hedges against the key uncertainties that allow TVA to manage risks.

The Long-Term Plan – Preferred Alternative

Energy Vision 2020 integration results are captured in the long-term plan. The plan sets forth a range of actions TVA can take to meet future needs of its customers.

In developing the long-term plan, TVA has selected a portfolio (also referred to as a bundle) of resource options from the seven key strategies. All of the resource options contained in the seven strategies are included in the portfolio. Much like a portfolio of stocks is chosen to manage risk and accomplish specific objectives, the portfolio of resource options enables TVA to meet customer needs at an acceptable level of risk and meet the objectives of balancing costs, rates, environmental impact, debt, and economic development.

When TVA refers to "balancing" the "environment" or "environmental impacts" in the context of these objectives it is referring to costs of meeting environmental requirements, the consequences of environmental uncertainties, and environmental impacts, expressed both quantitatively and qualitatively, of proposed actions or strategies.

To manage risk, the portfolio provides a robust and flexible set of resource options. Options that are robust can withstand a large range of uncertainties. Flexible options can be altered or modified as TVA moves into the 21st century. Robust and flexible options were identified in the analysis of managing risk.

The long-term plan is presented in *Figure 9-23*. As illustrated, a portfolio of resource options (taken from seven strategies) provides for TVA's supply-side (peaking and base load), customer service, and environmental requirements.

For example, combustion turbines, purchases of peak power, and call options on peaking power will supply peaking power for 1996-2005. For 2005-2020, compressed air energy storage is added as a supply-side peaking option.

Nine options supply base-load power for 1996-2005. These include call options on base-load power, improvements to existing hydro system, combined cycle plant with pre-siting and engineering, purchases from independent power producers with and without cogeneration, combined cycle repowering of coal-fired plants, renewables—landfill methane and refuse-derived fuel, coalbed methane, Bellefonte or greenfield coal gasification and coproducts with partners, and an additional coal-fired unit at Shawnee Fossil Plant.

FIGURE 9-23. Long-Term Plan

This long-term plan is defined to meet key objectives. The plan is organized by supply-side options for the short term (1996 – 2005) and the long term (2006 – 2020), customer service options and actions which hedge key uncertainties.

Develop a preferred portfolio of resource options for the long term from key strategies. Objectives of the portfolio are:

1. Balance costs, rates, environment, debt, and economic development.
2. Provide a robust set of resource options or flexibility to adapt to uncertain load growth, future market prices, changes in environmental regulations, and changes in market regulations to manage risk.

Strategies

- J – Bellefonte Coproduct, Renewables, IPPs
- M – Combined DSM and Off-System Sales
- O – Bellefonte Coproduct, More DSM, More Off-System Sales
- Q – Flexible Strategy with External Options
- R – Flexible Strategy with Internal Options
- S – Low Cost, Low Rates, Improved Environment
- T – Low-Cost Renewables, Low-Price DSM, Repowering, Bellefonte Coproduct Partnership

Options		1996 – 2005	2006 – 2020
Supply	Peaking	● Combustion turbines, purchases of peak power, and call options on peaking power	● Compressed air energy storage (CAES)
	Base Load	● Call options on base-load power ● Improvements to existing hydro system ● Combined cycle with pre-siting and engineering ● Purchases from independent power producers with and without cogeneration ● Combined cycle repowering of coal-fired plants ● Renewables—landfill methane and refuse-derived fuel ● Coalbed methane ● Bellefonte coal gasification and coproducts with partners ● Additional coal unit at Shawnee ● Improvements in existing system ● Nuclear partnership	● Wind turbines ● Coal refinery ● Cascaded humidified advanced turbine (CHAT) ● Integrated gasification combined cycle (IGCC) ● Integrated gasification with CHAT (IGCHAT)
Customer Service		● DSM—low price and cost (examples of programs)	● Residential new construction ● Commercial and industrial comprehensive finance ● Industrial motors
		● Beneficial Electrification (examples of programs)	● Residential heating, air conditioning, and water heating ● Commercial cooking ● Industrial electrotechnologies
		● Flexible DSM and Beneficial Electrification	
Environmental		● Pursue a flexible strategy of fuel switches, scrubbers ● Global climate challenge—improvements to existing system, biomass cofiring	

RESOURCE ALTERNATIVES TO MANAGE RISK

Uncertainty	Options
● Load Growth	● Call options on purchases from external suppliers ● Flexible internal supply options ● Small modular options—landfill methane, coalbed methane, and distributed resource alternatives ● Flexible DSM options
● Natural Gas Prices/Coproduct Prices	● Integrated gasification combined cycle (IGCC) ● Integrated gasification cascaded humidified advanced turbine (IGCHAT) ● Bellefonte coal gasification with a chemical coproduct
● Environmental Regulation—Air, Water, CO_2 Regulation	● Renewables—wind, landfill methane, biomass ● Coalbed methane ● Aggressive DSM and beneficial electrification ● Natural gas-based resource alternatives

Base-load power for 2005-2020 will be supplied by wind turbines, a coal refinery, the cascaded humidified advanced turbine (CHAT), an integrated gasification combined cycle plant, and integrated gasification with CHAT.

In the short- and long-term, TVA will rely on demand-side management and beneficial electrification. Examples of demand-side management include energy efficiency improvements, residential new construction and commercial and industrial finance plans to improve demand-side management. Examples of beneficial electrification include residential heating, air conditioning and water heater programs; commercial cooking programs; and industrial electrotechnology programs.

A flexible strategy of fuel switches and scrubbers, along with system improvements addressing global climate changes and biomass cofiring, are the long-term environmental control options.

In addition, 10 options address 3 key uncertainties: load growth, price of natural gas and coproducts, and environmental regulations.

Call options from external suppliers, flexible internal supply options, and small modular options like landfill methane, coalbed methane, distributed resource alternatives, and flexible demand-side management address load growth uncertainty.

Three options address uncertainty in natural gas and coproduct prices, including an integrated gasification combined cycle plant, integrated gasification cascaded humidified advanced turbine, and Bellefonte coal gasification with a chemical coproduct.

Renewables—wind, landfill methane, and biomass; natural gas-based resource alternatives; coalbed methane; repowering of existing coal-fired plants; and aggressive demand-side management and beneficial electrification address environmental regulations.

The long-term plan or portfolio provides resource options that are largely derived from the seven best strategies previously identified. These resource options will be implemented as necessary to meet customer needs. Thus, this long-term plan also provides for low cost, low debt, low electric rates, improved environment, and high economic development compared to all strategies.

The long-term portfolio is compared to all strategies for the key criteria in *Figure 9-24*. For example, the range of total resource costs for all strategies is from $84.2 to $89.2 billion. The long-term portfolio has a range at the lower end of this range of $84.2 to $85.6 billion. Thus, the long-term portfolio results in the best values for the key criteria.

FIGURE 9-24. **Long-Term Plan – Range of Values for Criteria**

	All Strategies	Long-Term Portfolio
Total Resource Costs (Billions of $)	$84.2 – $89.2	$84.2 – $85.6
Total Debt in 2001 (Billions of $)	$26.7 – $28.8	$26.7 – $27.2
Short-Term Rates (Mills/kWh)	42.5 – 45.7	42.8 – 43.4
Annual Average CO_2 Emissions (Millions of Tons)	101.0 – 138.0	115.0 – 121.6
Personal Income (Millions of $)	$1,100 – $2,770	$2,240 – $2,770
Customer Value (Millions of $)	$-4,100 – $4,100	$-400 – $3,510

ENVIRONMENTAL IMPACTS OF PORTFOLIO ALTERNATIVE

As explained earlier in this chapter, TVA has identified a portfolio of options—taken from the seven final strategies—as its preferred strategy for the long-term plan. Thus, potential impacts depend on those options eventually implemented. Although the impacts cannot be definitively assessed, the impacts of the seven final strategies are likely to provide the boundaries—best and worst case—for the portfolio.

Concerning the environment, it is unlikely that implementation of portfolio options would achieve better or worse environmental performance than the range of impacts for the seven strategies. In any event, impacts of the portfolio are likely to be much less than those associated with the "No Action" alternative, Strategy D.

All the options included in this portfolio are available to TVA management. The specific choices recommended to TVA for implementation are included in the short-term action plan presented in the next chapter.

Chapter Ten

Short-Term Action Plan

Chapter Ten: Short-Term Action Plan

The short-term action plan identifies specific actions to meet TVA's customer needs from 1996-2002. The short-term action plan is derived from the portfolio of options presented in the long-term plan, which was discussed in the preceding chapter.

The short-term action plan relies heavily on flexible supply-side and demand- side resources. These resources meet Energy Vision 2020 criteria and manage risk by providing flexibility in the face of uncertain load growth and other factors.

Because the future usually does not turn out as expected, the short-term action plan will need revisions as TVA learns more about the future. The long-term plan provides the guidance and flexibility to do this.

This Chapter Includes:

- Development of the Plan
- Description of the Plan
- Implementation of Resource Options
- Investigation/Research and Development (R & D)
- TVA's Compliance with Environmental Regulations Will Provide a Safety Net

Short-Term Action Plan

Development of the Plan

TVA has developed a short-term action plan from the long-term plan described in the last chapter. The short-term action plan incorporates actions TVA will take over the next three years to meet customer needs from 1996-2002. For customer needs after 2002, TVA has the time and the opportunity to choose among many of the resource options in the long-term plan. Thus, no short-term actions are necessary at this time to meet the needs after 2002.

The short-term action plan incorporates resource options from several strategies and identifies specific TVA actions to meet customer needs from 1996-2002.

The actions recommended for implementation in the short-term action plan *(Figure 10-1)* are derived from the portfolio (see Chapter 9). The short-term action plan relies heavily on the flexible strategies.

A number of different criteria were used in the evaluation of energy resource strategies in Energy Vision 2020. These included long-run cost/value, rates, reliability, environment, economic development, financial requirements, risk management, and equity among rate classes. As can be seen in the trade-off graphs in Chapter 9, Figures 9-4 through 9-10, many strategies were considered in trying to create a balance among all the evaluation criteria. The long-term and short-term resource plans achieve this balance.

The short-term strategy is based on the implementation of flexible resource options due to the large uncertainty in future load growth. There were concerns expressed in the planning process about whether the load forecast is too high and about the large uncertainty in future load growth. By implementing flexible resource options, if load growth is low (no growth) then these options will not be purchased, but if load growth is higher, these resource options can be implemented.

The customer service options in the short-term action plan are based on new and expanded demand-side management programs including energy efficiency, load management, and beneficial electrification.

TVA has identified customer service options in the short-term action plan for immediate full scale implementation or for implementation as flexible demand-side management options. The flexible demand-side management options will be implemented at a reduced scale at first, but can ramp up quickly in response to resource needs. Through actions taken in the short-term action plan, TVA will be developing a marketing infrastructure along with knowledge of program concepts, technologies, and delivery strategies to enable TVA to meet changing market conditions. TVA will build capabilities and develop partnerships with distributors and trade allies to deliver large scale demand-side management programs as needed. Full-scale and flexible programs implemented in the short-

FIGURE 10-1. **Short-Term Action Plan**

Short-Term Actions—Supply-Side	Milestones
Purchase Call Options	
• Base-Load Coverage - 2001 – 2002	Implement up to 3,000 MW
• Winter and Summer Peaking Coverage - 1998 – 2002	
Hydro Modernization Projects	
• Invest in hydro modernization projects between 1996 – 2007	Achieve 150 MW
Bellefonte Nuclear Plant Conversion to Combined Cycle Plant	
• Converting the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel has been identified as one of the most viable alternatives. Such an alternative provides the opportunity to utilize a substantial portion of the Bellefonte non-nuclear plant equipment. However, there is a degree of uncertainty and market risk associated with this alternative which requires further in-depth engineering and financial examination. Accordingly, TVA will use an outside, independent team of technical and financial experts to assess and develop the Bellefonte conversion strategy more fully over the next 18 to 24 months. During the course of the study, TVA will also pursue the evaluation and development of a demonstration gasification plant with the Department of Energy. In the meantime, the Bellefonte plant and Watts Bar Nuclear Plant Unit 2 will continue in a deferred status. TVA will continue to be receptive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities in partnership with TVA.	18 – 24 month study
• Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.	
Renewables	
• Implement cost-effective biomass cofiring	
- Cofiring precommercial demonstration runs at existing TVA coal-fired plants	1996
- Initiate first commercial wood waste cofiring project operation	1997
• Investigate biomass energy facilities	1996 – 97
• Implement a flexible wind project	1996 – 97
• Determine coalbed methane resources feasibility	1996 – 97
• Inventory sites suitable for landfill methane	1996
• Initiate 25-kW landfill methane fuel cells pilot	1997 – 98
Additional Capacity Development	
• Acquire three sites and develop preliminary engineering modules suitable for coproduction, combined cycle, combustion turbines, cascaded humidified advanced turbines, and compressed air energy storage	1996 – 1998
• Investigate cogeneration and other unique energy supply arrangements	1996
Implement a Flexible Phase II Acid Rain Strategy	
• Strategy/Plan Definition	1996
• Initiate early implementation options	1996 – 97

term action plan will provide the foundation of programs that can be relatively quickly scaled up or down as conditions warrant.

TVA has included all of the demand-side activities in the low price block (Block 1) in the short-term action plan. In addition, TVA included options from Blocks 2 and 3 in the short-term action plan to address lost opportunities (energy-efficient new homes) and to promote market transformation (heat pump water heater, manufactured housing, home self-audit, and student self-audit). Equity among customers is addressed through a flexible program to improve the energy efficiency of low income housing.

FIGURE 10-1. **Short-Term Action Plan** *CONTINUED*

Short-Term Actions—Customer Services	**Milestones**
DEMAND-SIDE SAVINGS	Up to 650 MW - 2002, Up to 2,200 MW - 2010
Residential	
Full Scale Programs	Revisions in Place
• Heat Pump Leasing / Financing	1996–97
• Ground Source Heat Pump Leasing	1996–97
• New Homes Program	1996–97
• Manufactured Housing - New Construction	1996–97
• Residential Self-Audit	Launch 1996–97
• Load Management	Revisions in Place
- Air Conditioners	1996–97
- Water Heaters	1996–97
Flexible Residential Demand-Side Programs for Selected Market Segments	Launch Phase 1
• Efficiency Products Catalog - Mail Order	1997
• Lighting Products Retail Component	1997
• Low Income Program - Site Visit	1997
• Student Self-Audit - Schools Environmental	1997
• Heat Pump Water Heater Initiative	1997
Commercial and Industrial	
Full Scale Programs	Launch 1996–97
• Commercial and Industrial Energy Services	1996–97
- Comprehensive Measures Financing	1996–97
- Commercial New Construction	1996–97
- Commercial Lighting	1996–97
- Commercial Appliances	1996–97
- Industrial Process Energy Efficiency	1996–97
- Industrial High Efficiency Motors	1996–97
• Commercial Cool Storage	1996–97
Flexible Commercial and Industrial Programs	Launch Phase 1
• Commercial Group Load Curtailment	1997
• Commercial Rooftop Cool Storage Program	1997
BENEFICIAL ELECTRIFICATION	
Residential	
• HVAC and Water Heating applications to improve consumer value	1996–97
• Initiate Flexible Security Lighting and Lawn Mower Programs	Launch 1997
Commercial and Industrial	
• Commercial Space Conditioning and Water Heating	Launch 1996–97
• Commercial Cooking and Security Lighting	Launch 1996–97
• Industrial Electrification Programs for Processing Heating, Food Processing, and Environmental Technologies	Launch 1996–97
• Flexible Industrial Electrification Options for Curing & Drying applications and Textile processes	Launch Phase 1 - 1997
General Research and Development	
• Develop telecommunication supported demand-side management programs	Launch 1996
• End-use renewables, market transformation, load management new technologies, targeted distributed generation, photovoltaics, electric vehicles	Launch 1996–97

The beneficial electrification options are designed to increase customer value, enhance economic development, and improve the environment. Such activities include industrial electrotechnologies and electric transportation.

In the longer term, the short-term action plan emphasizes research and development of renewable resource options in addition to clean coal technologies. Renewables research will include evaluation of biomass cofiring, wind resource investigations, investigation of landfill and coalbed methane potential, end-use photovoltaics, and distributed generation technologies including fuels cells and targeted demand-side management. Of course, in the long term, after 2002, there is sufficient time and flexibility to make any decisions, and no commitments are being made for resources after 2002 in the short-term action plan.

Description of the Plan

The short-term action plan is organized into two areas:
- Implementation of Resource Options
- Investigation/Research and Development (R&D).

Supply-side and customer service options are identified for each area. The short-term action plan is illustrated in *Figure 10-1*.

Implementation of Resource Options

To supply power, the short-term action plan identifies the following actions:
- Buying call options, including base load in 2001–2002 and peaking for winter and summer in 1998–2002.
- Converting the Bellefonte Nuclear Plant to a combined cycle plant utilizing natural gas or gasified coal as the primary fuel has been identified as one of the most viable alternatives. Such an alternative provides the opportunity to utilize a substantial portion of the Bellefonte non-nuclear plant equipment. However, there is a degree of uncertainty and market risk associated with such an alternative which requires further in-depth engineering and financial examination. Accordingly, TVA will use an outside, independent team of technical and financial experts to assess and develop the Bellefonte conversion strategy more fully over the next 18 to 24 months. During the course of the study, TVA will also pursue the evaluation and development of a demonstration gasification plant developed with the Department of Energy. In the meantime, the Bellefonte plant and Watts Bar Nuclear Plant Unit 2 will continue in a deferred status. TVA will continue to be receptive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities in partnership with TVA.
- Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.
- Investing in siting and pre-engineering for a coproduction facility, a com-

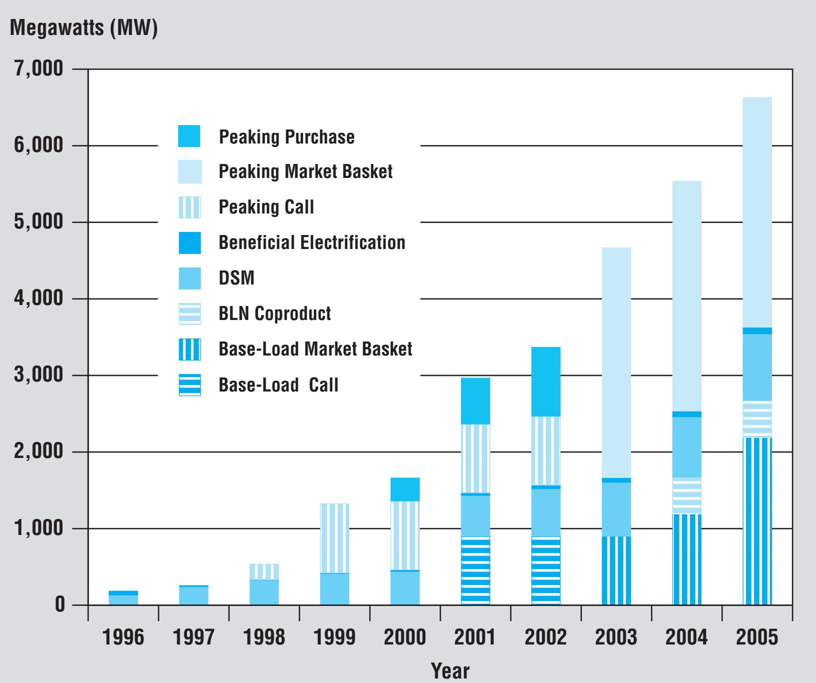
bined cycle facility, combustion turbines, cascaded humidified advanced turbines and compressed air energy storage systems. Three sites, in the western part of the TVA system, will be developed for this generation.
- Modernizing TVA's hydro plants.
- Perform cost-effective biomass cofiring.
- Implement a flexible plan for Phase II acid rain compliance.

A summary of the annual resource additions that meet customer needs from 1996-2005 are shown in *Figure 10-2*.

In the short-term action plan, TVA will implement three types of customer service options—demand-side management, beneficial electrification, and off-system sales. The demand-side management options to be implemented immediately are:

- A Heat Pump/Ground Source Heat Pump program that promotes quality installations of higher efficiency heat pumps by offering customers financing or leasing options and maintenance contracts.
- A Residential New Construction program that promotes higher efficiency standards and quality construction in new homes through incentives for homebuilders.
- A Manufactured Housing program that transforms the market by promoting installation of efficient heating, ventilation, air conditioning, and water heating equipment, proper duct design, and improved duct insulation by manufacturers during construction.
- A Residential Self-Audit program that provides homeowners a method to conduct their own home survey and receive a detailed computerized analysis identifying energy efficiency opportunities.
- A Residential Air Conditioner and Water Heater Load Management program that uses a radio control system to cycle water heaters and air conditioning load to reduce power system demand during times of peak electrical usage.
- A Commercial Cool Storage program that promotes thermal energy storage technologies to shift energy use from on-peak periods to off-peak periods.
- The Comprehensive Measures Financing option was expanded to over twice its original level to form the Commercial and Industrial Energy Services option. This option

FIGURE 10-2. **Short-Term Actions**



Short-term actions for both supply and customer services are indicated annually from 1996 to 2005.

provides project management services, technical assistance, and financing. The original option was targeted to building retrofits. The expanded option combines parts of the technology replacement options (Lighting, Appliances, High-Efficiency Motors), the Commercial New Construction option, and the Industrial Process Energy Efficiency options in a financing program. This allows TVA to capture much of the commercial and industrial energy efficiency potential in Block 2. This program includes targeted incentives directed to lost opportunity projects such as new construction or chiller replacements. The program will promote market transformation by providing trade ally incentives for architects and engineers to design energy-efficient buildings and to equipment dealers (e.g., motor dealers) to stock and sell high-efficiency equipment.

The plan calls for eight flexible customer service programs: six demand-side management programs and two beneficial electrification programs. The demand-side management programs include:

- A Residential Heat Pump Water Heating program that offsets the up-front cost of high-efficiency water heating technologies by offering residential customers financing or leasing options.
- A Residential Student Audit program that presents the self-audit package to students to conduct a home audit and to create greater understanding of the benefits of energy efficiency.
- A Low Income program that works with government agencies and community action agencies to directly install low-cost efficiency measures for participants in their homes.
- A Catalog and Retail Sales program that is designed to transform the market for high-efficiency lighting products, security lighting, and other efficient electric appliances through a catalog and in cooperation with participating retail outlets.
- A Commercial Rooftop Cool Storage program that promotes an emerging thermal storage technology that reduces customer equipment costs and shifts energy use from on-peak periods to off-peak periods. Initially, the program will focus on the development and commercialization of the rooftop cool storage technology. TVA is currently demonstrating this technology within the Valley.
- A Commercial Group Load Curtailment program that provides bill credits to commercial customers, or groups of customers, who are able to reduce demand for electricity by 100 kilowatts or more during peak demand hours.

In the short term, the demand-side management activities were grouped into four areas:

- Expansion of existing programs (Heat Pump/Ground Source Heat Pump program)
- Peak clipping or reduction (Residential Air Conditioner and Water Heater Load Management and Commercial Cool Storage programs)
- Energy efficiency improvements for lost opportunities (Residential New

Construction, and Commercial and Industrial Comprehensive Financing programs)

- Market transformation opportunities (Manufactured Housing program, Residential Self-Audit program, and the Commercial and Industrial Comprehensive Financing program)

A primary objective common to all programs is to increase public awareness of the benefits of energy efficiency and to provide consumers and trade allies with information on energy-efficient building equipment and practices. All programs will include promotional activities and educational components which support this important objective.

The long-term plan contains demand-side management options largely from demand-side management Blocks 1 and 2. The short-term plan contains almost all of the demand-side management programs identified in Blocks 1 and 2 with two options identified in Block 3. The specific programs included in the short-term plan compared to the demand-side management blocks are shown in *Figure 10-3.*

FIGURE 10-3. **Demand-Side Management in Short-Term Action Plan**

	OPTIONS CONSIDERED MW in 2010	SHORT-TERM ACTION PLAN MW in 2010	SHORT-TERM ACTION PLAN Recommended Action
Block 1			
Commercial Cool Storage	120	120	Flexible DSM
Rooftop Cool Storage	93	93	Flexible DSM
Commercial Group Load Curtailment	242	242	Flexible DSM
Residential Load Management - Air Conditioning	53	53	Immediate Implementation
Residential Existing Load Management - Air Conditioning	0	0	Immediate Implementation
Residential Existing Load Management - Water Heating	0	0	Immediate Implementation
Residential Heat Pump Leasing Program	518	518	Immediate Implementation
Residential Efficiency Products Catalog	107	107	Flexible DSM
Industrial Technology - High Efficiency Motors	14	14	Implemented w/C&I Energy Services
Residential Lighting Products - Retail Component	103	103	Flexible DSM
Comprehensive Measure Financing	170	170	Implemented w/C&I Energy Services
Residential Ground Source Heat Pump Leasing	62	62	Immediate Implementation
Total MW - Block 1	**1,482**		
Block 2			
Residential Self-Audit	19	19	Immediate Implementation
Residential New Homes	184	184	Immediate Implementation
Commercial Technology Rebates - Lighting	511	75	Implemented w/C&I Energy Services
Residential Low Income Program	75	75	Flexible DSM
Residential Load Management - Water Heaters	84	84	Immediate Implementation
Commercial New Construction	188	40	Implemented w/C&I Energy Services
Commercial Technology Rebates - Appliances	69	22	Implemented w/C&I Energy Services
Refrigerator Turn-In	13		
Residential Student Self-Audit	23	23	Flexible DSM
Small Commercial Retrofit	98		
Total MW - Block 2	**1,264**		

FIGURE 10-3. **Demand-Side Management in Short-Term Action Plan** *CONTINUED*

	OPTIONS CONSIDERED	SHORT-TERM ACTION PLAN	
	MW in 2010	MW in 2010	Recommended Action
Block 3			
Residential Load Management - SCADA	0		
Comprehensive Measure Rebates	311		
Industrial Energy Efficiency - Distributor Served	190	20	Implemented w/C&I Energy Services
Industrial Energy Efficiency - Direct Served	169	20	Implemented w/C&I Energy Services
Industrial Technology Rebates - Adj. Speed Drives	6		
Energy Efficient Pricing (opt-out)	56		
Residential Heat Pump Water Heating Leasing	103	103	Flexible DSM
Residential Direct Install	386		
Commercial Technology Rebates - HVAC	223		
Residential Manufactured Housing Program	53	53	Immediate Implementation
Total MW - Block 3	**1,497**		
Block 4			
Residential Load Management - New Technology	0		
Commercial HVAC Maintenance Program	26		
Residential Heat Pump Loans	469		
Residential Efficient Air Conditioning	133		
Residential Heat Pump Rebates	527		
Residential Load Management - Storage Water Heaters	39		
Industrial Technology Rebates - Comp. Air Eff.	4		
Residential Appliance Rebates Program	41		
Residential Low Income Weatherization Program	6		
Residential Solar Water Heater Program	4		
Commercial New Construction - Renewables	40		
Total MW - Block 4	**1,289**		
Total DSM Impact - 2010	**5,532**	**2,200**	

The demand-side management programs included in the short-term plan are of two types: First, those that are to be immediately implemented or are expansions of existing programs. These programs will result in a demand savings of 600 megawatts by 2002 and 1,450 megawatts by 2010. Second, flexible demand-side management programs have been identified. The programs are similar to the flexible supply-side options. These flexible demand-side programs have two phases of development. In the first phase, the programs are tested in the marketplace as experiments or pilot programs. The second phase would be full implementation and would occur if the first phase proves cost-effective and there is a need for the demand savings on the power system. The flexible demand-side management programs would add 50 megawatts by 2002 and potentially 750 megawatts by 2010. In the short-term action plan the total demand savings is expected to be 650 megawatts by 2002 and 2,200 megawatts by 2010 if all flexible demand-side management programs are implemented.

Beneficial electrification options are included in the short-term action plan to encourage energy efficiency and reduce peak demands on the power system, but at the same time minimize the impact on electric rates.

The four beneficial electrification options to be implemented immediately are:

- A Residential Heating and Air Conditioning program that promotes high-efficiency heat pumps as an alternative to equipment using other fuels.
- An Industrial Electrotechnologies program that promotes selected electrotechnologies to industrial customers to enhance competitiveness and address environmental concerns. This program will target the food process industry and will also promote electrotechnologies to improve process heating and to provide environmental solutions.
- A Commercial Heating and Air Conditioning program that promotes high-efficiency electric heating, ventilation, and air conditioning equipment as an alternative to equipment using other fuels.
- A Commercial Cooking program that promotes high-efficiency electric cooking equipment to commercial customers in cooperation with trade allies and equipment dealers.

The flexible beneficial electrification programs include:

- An Industrial Electrotechnologies program that promotes selected electrotechnologies to industrial customers to enhance competitiveness and address environmental concerns. This option will assess the applicability of electrotechnologies for the textile and chemical/metal industries and for industrial curing and drying.
- A Residential Security Lighting program that promotes security lighting products through a catalog and in participating retail outlets.

The beneficial electrification options are designed to increase consumer value, as are the demand-side management programs.

Off-system sales will better utilize existing assets from 1996-2002.

Investigation/Research and Development (R&D)

The short-term action plan calls for research and development programs covering supply-side and customer service options. TVA will pursue research or demonstration projects in the following supply-side areas:

1. Investigate cogeneration and other unique energy supply arrangements.
2. Developing new capacity using such technologies as cascaded humidified advanced turbines, distributed generation, and fuel cells. An explanation of these technologies is given below.
   - A cascaded humidified advanced turbine is a gas turbine with a unique configuration that allows the unit to have efficiencies similar to a conventional combined cycle plant (a type of plant that generates electricity first from

the heat produced by burning gas and then again from heat extracted from-exhaust steam), but without the addition of a steam turbine and associated equipment. The cascaded humidified advanced turbine should have a capital cost somewhat less than for a combined cycle installation of similar generating capacity.

- Distributed generation refers to the location of smaller-scale power generating units near the power consumer. Examples would be gas turbines or diesel generators located in power transmission substations or installed adjacent to large industrial or commercial power consumers. The close proximity of the power generator to the power user significantly reduces the losses associated with the transmission of power.
- Fuel cells are devices similar to batteries, except they are capable of generating power rather than simply storing power. A fuel and a form of air or oxygen are consumed in the cell by a chemical reaction that creates electricity.

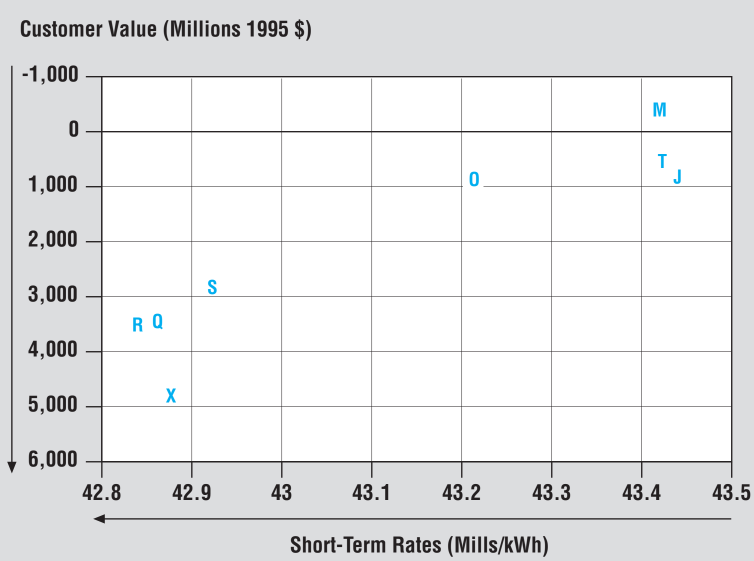
3. Developing renewable energy options to include investigations and research into the possibility of using wind resources, landfill methane, coalbed methane, end-use photovoltaics to produce power, and biomass energy projects.
   - Large wind turbines (windmills) have the potential to be a viable generation source, subject to the availability of wind at volumes and speeds capable of supporting this type of generating equipment. Short-term actions by TVA will include a flexible wind project at a selected site in the TVA service area. The first phase will determine the potential for this technology.
   - Methane (gas) from sanitary landfills offers another possible option as an innovative fuel source. Landfills are filled with organic waste material and sealed (covered) in such a way that air cannot gain admittance to the material. As the material decomposes, methane is produced. The methane can be collected by a series of wells drilled into the waste layers. Once collected, the methane can be used as a fuel by conventional power generation equipment such as internal combustion engines, gas turbines, or fuel cells.
   - Coalbed methane is produced in the same way as methane from a landfill. As the organic material in the coalbed decomposes to form coal, methane is produced as a byproduct. The methane can be collected from the coalbed prior to opening the coal seam for mining by a series of wells drilled into the seam. Like landfill methane, this gas can be used as a fuel in conventional power generation equipment.
   - Photovoltaics is a technology that converts solar energy into electricity. TVA will investigate the use of photovoltaics for end-use applications at remote sites where electricity is not readily available.
   - Investigate a biorefinery that uses refuse-derived fuel (garbage), wood waste, and energy crops to produce chemicals and boiler fuel.
   - Investigate a refuse-derived fuel/biomass energy facility that uses compost and biomass waste as a fuel.

Customer service research and development efforts during the short term for new demand-side management communications technologies and end-use renewables include:

- A market transformation research and development project that will explore alternative strategies for increasing the supply and demand for energy-efficient buildings and equipment. The project will be conducted in conjunction with distributors, trade allies, and state and local code officials.
- A communication technology research and development project that is proposed to demonstrate two-way communication technologies with a distributor of TVA power to enable TVA, distributors, and end-use customers to better manage electric load.
- An energy management/remote data acquisition project that is proposed to use two-way communication technologies for remote control of building energy management systems, and to allow TVA and distributors to collect customer energy use data remotely.
- Research on targeted applications of demand-side management, distributed renewable and non-renewable generation, and storage technologies to achieve transmission and distribution system benefits.
- An end-use photovoltaics research and development project that will examine how photovoltaics technologies can be used to reduce customers' energy costs and how these can be used in specific locations to reduce system generation, transmission, and distribution costs. The project will include TVA's membership in the Utility Photovoltaic Group (UPVG).
- Research and development activities for electric transportation that will focus on the development and demonstration of solutions to electric transportation limitations. TVA activities will concentrate on five areas of focus: vehicle evaluations, business impacts, stakeholder partnerships, awareness and education, and infrastructure development.

TVA compared the short-term action plan with seven previously identified long-term strategies across key evaluation criteria. Long-term actions identified in Strategy Q (see Chapter 9) were combined with the recommended short-term supply-side and customer service options to make an eighth strategy. The trade-off graphs illustrated in *Figures 10-4, 10-5, 10-6,* and *10-7* show how the short-term action plan, identified as (X), compares with the other long-term strategies. The

FIGURE 10-4. **Trade-Off for Customer Value vs. Short-Term Electric Rates**



The short-term plan, **(X)**, *has the highest customer value and approximately the same short-term rates as Strategies Q, R, and S.*

FIGURE 10-5. **Trade-Off for Short-Term Rates vs. Total Resource Costs (TRC)**

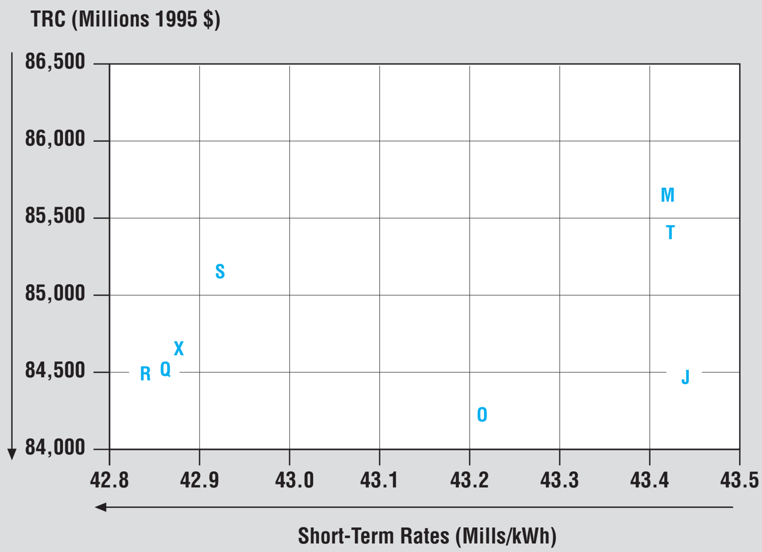
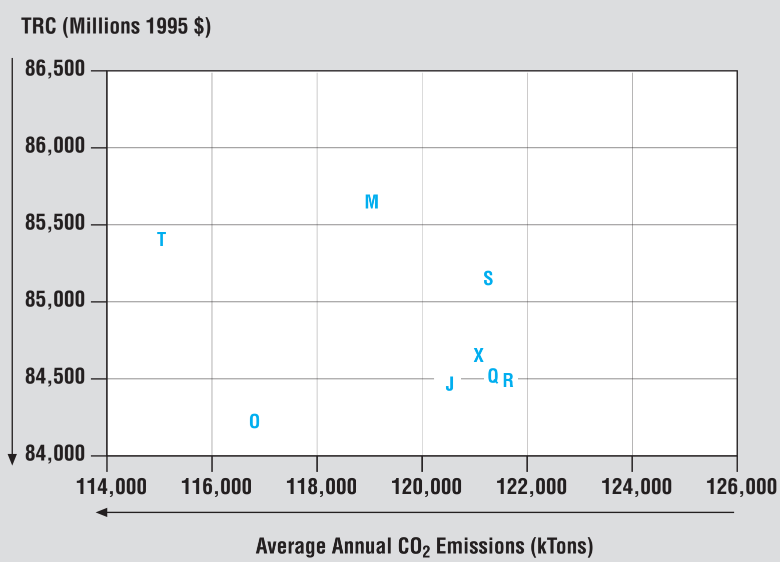


FIGURE 10-6. **Trade-Off for Carbon Dioxide Emissions vs. Total Resource Costs (TRC)**



trade-off graphs that show the short-term action plan are not designed to identify additional trade-offs between the short-term action plan (X) and the other strategies. The trade-off graphs are included to show that the short-term action plan is consistent with the seven best strategies, particularly Strategy Q.

The short-term strategy increases customer value and increases short-term rates slightly, compared to Strategy Q. Debt remains at the same level, total resource cost is slightly higher, and carbon dioxide emissions are reduced.

The short-term action plan, just as the long-term plan, provides for low cost, low debt, low electric rates, improved environmental emissions, high customer value, a high impact on economic development, and risk management.

Throughout Energy Vision 2020, three key concerns have been competitively priced electricity for customers, TVA's debt, and concern for the environment.

The projected electric rates, debt, and carbon dioxide emissions resulting from the short-term action plan for the period 1996-2005 are shown in *Figures 10-8, 10-9,* and *10-10*, respectively.

As indicated in *Figure 10-8*, electric rates adjusted for inflation decline from 1996 to 2005. As indicated in *Figure 10-7*, total debt in 2001 remains below the $30 billion statutory limit. In *Figure 10-9* the ratio of total debt to total assets declines from 0.85 to 0.73. This decline reflects less reliance on debt to finance capital expenditures. As shown in *Figure 10-10*, carbon dioxide emissions remain below 110 million tons per year from 1996-2000

and below 120 million tons per year from 2001-2005.

As previously explained, the recommended short-term action plan is derived from the portfolio of options presented in the long-term plan. Although the short-term action plan provides flexibility, even the near-term future usually does not turn out as expected. The plan, therefore, will be reviewed on an ongoing basis and revised as necessary. The long-term plan provides TVA with guidance on making changes to the short-term action plan.

FIGURE 10-7. **Trade-Off for Debt in the Year 2001 vs. Total Resource Costs (TRC)**

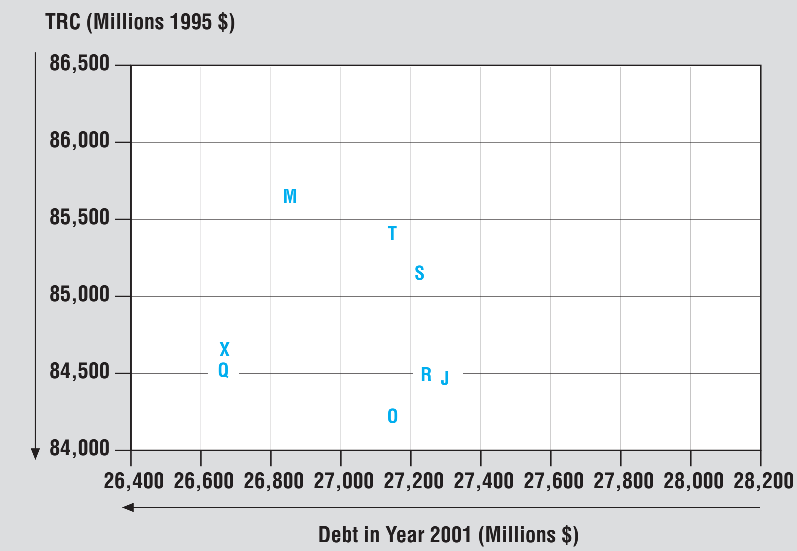
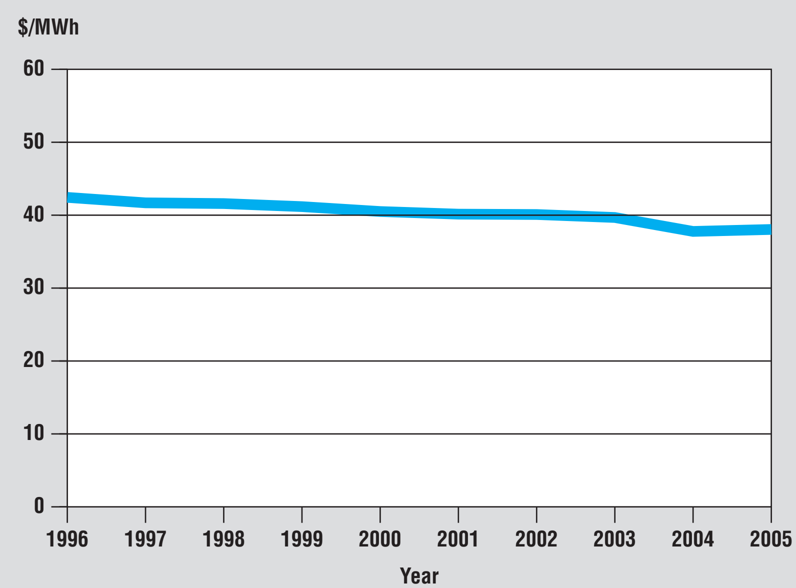


FIGURE 10-8. **Average System Rates Adjusted for Inflation Short-Term Strategy** *(1996-2005)*



TVA's Compliance with Environmental Regulations Will Provide a Safety Net

A number of environmental consultation, review, and permit requirements would apply to energy resource options that are put in place. The nature of these requirements varies depending on the kind of option. More extensive requirements would apply to those actions having more substantial environmental impacts.

These reviews or requirements include:

- National Environmental Policy Act (NEPA): Actual implementation of options identified in the plan would be "tiered" off the Energy Vision 2020 Integrated Resource Plan/ Environmental Impact Statement, and as appropriate, will be preceded by more specific NEPA reviews.
- Reviews, laws, or permits governing air pollution, wastewater discharge, solid and hazardous waste management, protection of wetlands and floodplains, endangered species, cultural resources, and farmland protection. The

FIGURE 10-9. **Ratio of Total Debt to Total Assets Short-Term Strategy** *(1996-2005)*

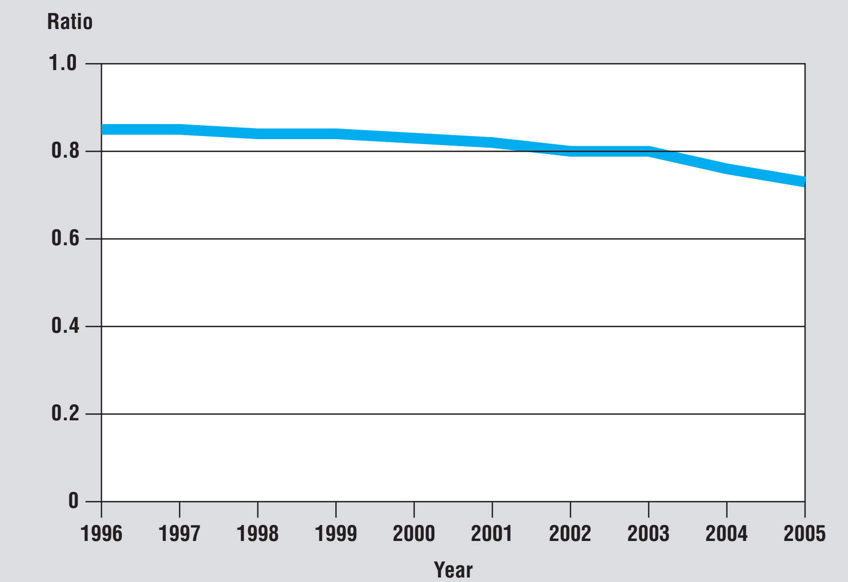
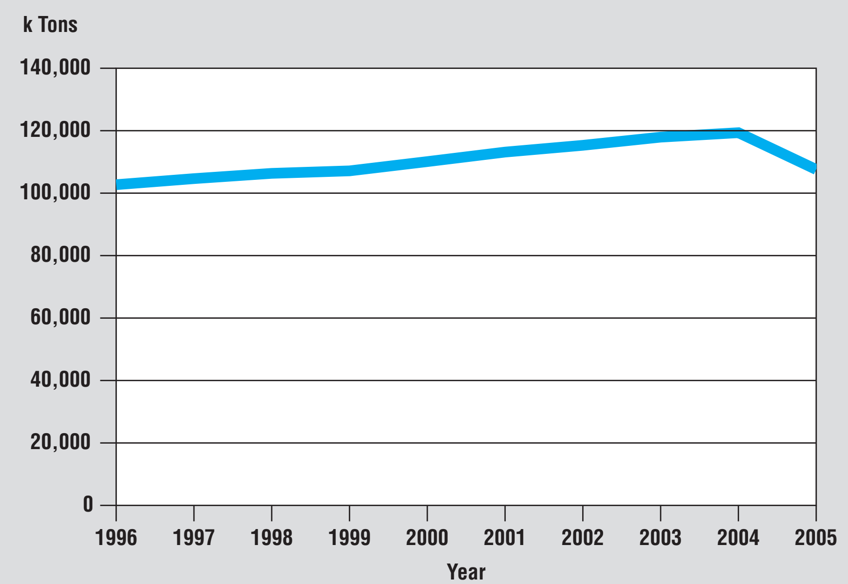


FIGURE 10-10. **Annual Carbon Dioxide Emissions Short-Term Strategy** *(1996-2005)*



Clean Air Act, the Clean Water Act, the Endangered Species Act, the Surface Mining Reclamation and Control Act, and the Resource Conservation and Recovery Act are just a few of the major laws in this country that are formulated to prevent or lessen various kinds of environmental impacts.

No major energy resource can be put in place without complying with a substantial number of federal, state, and local environmental requirements. These regulatory processes typically have multiple opportunities for public comment and participation. Most federal environmental laws allow citizens to bring suit to enforce compliance with requirements. Also, various federal, state, and local environmental regulatory agencies exist to police compliance.

Although these environmental laws and their implementing regulations do not eliminate all risk of environmental impacts, they substantially reduce those risks, especially the risk of significant impacts. Consequently, the risk of significant impacts associated with the implementation of any of the final strategies identified in Energy Vision 2020 is substantially lessened because of TVA's mindfulness of environmental regulations as each alternative was studied. Moreover, such impacts will be identified in the subsequent environmental reviews that TVA will conduct before it decides to put specific options in place.

Glossary

Glossary

The development and understanding of Energy Vision 2020 requires the careful, consistent use of certain key terms and phrases. Here are definitions of terms that are used often in the process. (Terms in definitions which are themselves defined in the Glossary are printed in *italics*.)

A

A&I Costs—Those expenses anticipated over the life of a facility for additions and improvements. These costs are typically capitalized.

Abatement—Reducing the degree of intensity of, or eliminating, pollution.

A/C—Air Conditioning.

Acid Gas—The gas product from a coal gasification unit that has not had the sulfur compounds removed.

Acid Deposition—The wet or dry deposition of acidic chemical compounds from the atmosphere.

Acid Rain—A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur dioxide and nitrogen oxides and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on Earth in either a wet or dry form. The wet forms, popularly called "acid rain," can fall as rain, snow, or fog. The dry forms are acidic gases or *particulates*.

Add-Ons—Purchases of new or additional equipment of a type previously not present in an existing facility, such as the purchase of a food freezer for a home that previously had none or the purchase of a second room air-conditioner.

Administrative Costs—Expenses incurred by the utility for program planning, design, management, and administration. They include labor, office supplies, data processing, and other such costs. They exclude the costs of marketing, purchase of equipment for programs, incentives, and monitoring and evaluation.

Advanced Batteries—An advanced technology battery that has more storage capacity than a lead acid battery.

Aesthetics—The visual perception of appearance of features in relation to one's sense of beauty.

AFUE—Annual fuel utilization efficiency (AFUE) is an efficiency rating used for natural gas appliances based on average usage including on and off cycling described in a standardized Department of Energy test procedure. These ratings are listed in publications from the Gas Appliance Manufacturers Association (GAMA).

Agricultural Sector—The group of nonresidential customers engaged in the production of crops or livestock, forestry, fishing, hunting, or trapping.

Air Separation Plant—A facility that produces nitrogen and oxygen from air.

Air Toxins—Various man-made and naturally occurring materials that are known or suspected of causing serious public health impacts, but for which no *National Ambient Air Quality Standards* exist.

Allowance—*Emissions Trading Options.*

Alluvial—Sediment deposited by flowing water.

Ambient—Surrounding.

Ambient Air Quality Standards—See National Air Quality Standards.

Anaerobic—Life in the absence of air or free oxygen.

Annual Participation—The number of customers enrolled in a particular utility sponsored customer service program for a given year.

Annual Participation Rate—The ratio of the number of participating units in a particular year to the number of eligible units.

Aquatic—Characteristic of or pertaining to water.

Aquifer—A water-bearing rock, rock formation, or group of rock formations.

Archaeological Resources—Material remains of past human activity.

ASD—An adjustable speed drive (ASD) may be used to control the speed of an electric motor.

ASHRAE—American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

Attainment Areas—Those areas that meet all *National Ambient Air Quality Standards* as determined by monitoring air pollutant levels.

Attributes—A measure of a resource option's characteristics or a measure of evaluation results.

Availability—The percentage of time in a given year that a TVA power plant (or generating unit in a power plant) can be called on to produce power.

Avoided Cost—The incremental cost to TVA for *capacity* or *energy* or both which, TVA would have to pay for the next best alternative option.

B

Base Load—The minimum *load* over a given period of time.

Base Load Capacity—Large power plants, often coal- or nuclear-fueled, which are designed to operate around the clock at high *capacity factors*.

Base Load Unit—Units or plants which are designed for nearly continuous operation at or near full capacity to provide all or part of the base load. A generating unit which is normally operated to meet all, or part, of the minimum load demand of a utilities system over a given amount of time.

Baseline—A mid-range set of assumptions on all variables, reflecting a "business as usual" decision strategy.

Beneficial Electrification—Promoting the use of electricity and electrical technologies in processes that will improve a customers productivity, quality of life, or economy over existing energy sources or technologies.

Benefit/Cost Ratio—The ratio of benefits produced by a course of action to the costs incurred in undertaking the course of action.

Benthic Invertebrates—An animal living on sea or lake bottoms that lacks a backbone or spinal column.

Benthos—Aquatic invertebrates that live on or in the first few inches of mud, sand, gravel, or other materials that make up the bottom of streams and lakes, e.g., worms, snails, crayfish, mussels, clams.

Best Management Practice (BMP)—A practice, or combination of practices, that is determined to be the most effective, practical means of preventing or reducing non-point source pollution to a level compatible with maintaining water quality.

Biocide—A substance that is destructive to many different organisms.

Biodiversity—The diversity of life in all its forms and all its levels of organization. Also termed "biological diversity".

Biomagnification—The accumulation of chemicals in organisms beyond the concentration that would occur if the chemical were in equilibrium between the organism and its surroundings. Biomagnification can occur in both terrestrial and aquatic environments.

Biomass—A source of energy embodied in organic matter (mainly plants). Biomass-based energy systems use wood, agricultural and wood waste, municipal waste, and landfill gas as fuels.

Biomass Cofiring—The use of *biomass* as a secondary fuel supplement in a coal-fired plant.

Biota—The animal and plant life of a particular region considered as a total ecological entity.

BLN—Bellefonte Nuclear Plant

Boiler—A component that consumes a fuel for a heat source to produce steam from water.

Boiling Water Reactor—A nuclear power reactor cooled and moderated by ordinary water, which is allowed to boil in the core to generate steam that passes directly to the turbine.

Bottom Ash—A solid residue from combustion of a fuel, such as coal.

British Thermal Unit (Btu)—A commonly used unit of energy, especially for fuels or heat. A kilowatthour is equal to 3412 Btu.

Buffering Capacity—Ability of a stream to absorb acids and bases without altering the stream pH.

C

CAES—*Compressed Air Energy Storage.*

Call Option—A financial tool that provides TVA the right to buy future power from another utility, an independent power producer, or a cogenerator. TVA can buy the right to actually purchase power and decide at a later date whether to purchase it.

Canopy—Refers to a layer of foliage in a forest formed by the crowns of trees.

Capability—(1) With respect to *supply-side resources*, the amount of electric power that a generating unit or electric system can reliably deliver under specified conditions over a specified period of time; (2) with respect to *demand-side resources*, the ability and skills to perform *demand-side*

management activities such as market research, program design, evaluation, etc.

Capacity—The amount of electric power that can be delivered by a generating unit or electric system, as determined by manufacturer's nameplate ratings or by testing. (For example, the capacity of a combustion turbine power plant, based on its nameplate rating, would be stated as 225 *MW*.)

Capacity Factor—A universal standard for measuring power plant performance. The ratio a plant's actual output to its maximum potential output, expressed as a percentage.

Capacity Margin—The total installed capacity of TVA's system in excess of peak load, divided by total installed capacity. Stated another way, Capacity Margin = (*Reserve Margin*) / (1 + *Reserve Margin*).

Carbon Dioxide (CO_2)—A colorless, odorless, nonpoisonous gas that results from fossil fuel combustion and is normally a part of the *ambient* air.

Carbon Monoxide (CO)—A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

Cascaded Humidified Advanced Turbine (CHAT)—An advanced Ericson cycle that employs intercooling, recuperation, reheat, and humidification of a *combustion turbine* with a cascaded topping turbine.

Cedar Glades—Distinctive plant communities occurring where certain types of limestone weather to produce bare rock outcrops or thin layers of soil.

CHAT—*Cascaded Humidified Advanced Turbine.*

Chemical Coproduction—The production of a chemical product while simultaneously producing electricity.

Chlorofluoro-Carbons (CFCs)—A family of inert, nontoxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging, and insulation or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere, they drift into the upper atmosphere, where their chlorine components destroy ozone.

Class I Areas—National parks and wilderness areas given protective air quality standards, as designated by the *Clean Air Act Amendment of 1977.*

Clean Air Act Amendment of 1970—Enabling legislation, which instructs the Environmental Protection Agency (EPA), to set air quality standards for pollutants of concern.

Clean Air Act Amendment of 1977—Legislation which provides greater regulatory authority to the EPA to set specific provisions to protect national parks and wilderness areas designated as *Class I areas.*

Clean Air Act Amendment of 1990—Legislation which added additional regulatory authority to enforce compliance with air quality standards in *non-attainment areas*. It also set new requirements for *acid rain*, hazardous air pollutants, and for the monitoring and reporting on air emissions.

Climate Challenge—The principle utility industry component of President Clinton's Climate Change Action Plan, which provides for voluntary limiting *greenhouse gases* emissions (primarily CO_2).

CO—*Carbon Monoxide.*

CO_2—*Carbon Dioxide.*

Coal Gasification—The process of converting coal into gas.

Coal Plant—An electric generation plant that uses coal as its main source of fuel.

Coalbed Methane—A gas that is present in coal seams.

Cogeneration—The sequential production of electricity and useful thermal energy (generally steam or hot water) from a single fuel source.

Coincident Peak—The *demand* of a TVA customer or group of customers at the time TVA's entire system is at its *peak load*.

Coincident Peak Demand—The load (in *kW*) of an end use, customer, or group of customers at the time the utility experiences its greatest demand for electricity.

Combined-Cycle Generating Unit—A generating unit that combines a simple cycle *combustion turbine* and a heat recovery steam generator, which uses the exhaust heat from the *combustion turbine* to generate steam which in turn drives a steam turbine. (Electricity is generated by both *turbines.*)

Combustion Technology—*Combustion turbines—combined cycles* and simple cycles.

Combustion Turbine (CT)—A gas *turbine* that burns natural gas, fuel oil, or other similar fuels and drives a turbine and generator to produce electricity. Typically used as the primary generator of electricity in a combined cycle installation.

Commercial Sector—The group of non-residential and non-industrial customers that provides services, including retail, wholesale, finance, insurance, and public administration.

Commodity—Products that, in the eyes of the buyers, are identical regardless of who produced it. An example is coal that meets a particular standard.

Commodity Industry—An industry that produces a *commodity*. For example, most agriculture and mining industries are commodity industries.

Community—An assemblage of plants, animals, bacteria, and fungi that live in an environment and interact with one another, forming a distinctive living system with its own composition, structure, environmental relations, development, and functions.

Compressed Air Energy Storage (CAES)—Compressed Air Energy Storage (CAES) combines features from conventional *combustion turbines* and *pumped hydro storage*. During periods of relatively low electric loads, and therefore low power generation costs, air is compressed and stored in an underground reservoir. During periods of high electric loads, the compressed air is released to drive turbine generators to produced electricity. The equipment is analogous to the compressor used in a combustion turbine, and the process is similar to the pumping and storing of water at a higher elevation in pumped hydro generation.

Configuration Control—The process of maintaining consistency between the physical condition of a nuclear plant and its associated design and engineering records.

Conservation—A reduction in either *energy* usage or *peak demand* so as to provide the prior end-use service levels at a lower cost.

Constraint—A qualification of the minimum and / or maximum amount of an output or cost that could or should be produced or incurred in a given time period.

Contingency—A plan or reserve capacity to handle an unplanned outage of a generator, transmission line, transformer, or other piece of electrical equipment on a transmission system.

Conversion—The modification of a power plant (either fully or partially constructed) to enable the plant to use a fuel that is different than the fuel originally intended. For example, a partially constructed nuclear plant might be modified so that it would use pulverized coal as a fuel source.

COP—The Coefficient of Performance (COP) is the ratio of useful energy output (e.g., but of space or water heating value) to the energy input (btu value of natural gas or electricity).

Coproduct—A secondary product that is produced usually in an industrial process in addition to the primary product.

Cost-Effectiveness—A measure of the degree to which a course of action provides benefits in excess of its cost.

Cradle-To-Grave—A term used to describe the generation (e.g., mining), transportation, storage, treatment, and disposal of a fuel or waste product.

Criteria—Units of measure used in integrated resource planning. They are derived from issues or concerns. For example, an evaluation criteria for concern over future rates can be short-term rate impact.

Cultural Resources—The physical remains (artifacts, ruins, burial grounds, petroglyphs, etc.) and conceptual contents or contexts (such as a setting for legendary, historic, or prehistoric events for native people) of an area which are useful in gaining knowledge about man's past.

Cumulative Effects—The net/total changes in electricity use or demand caused by all of the program's participants from the time of a program's inception through the current year.

Cumulative Participation—The net/total number of participating units from the start of a program through the current year.

Cumulative Participation Rate—The ratio of the total number of participating units from the start of a program through the current year to the total number of eligible units.

Cumulative Probability Distribution—A table or graph that shows the chance that an unknown value will turn out to be less than each of a series of given values. For example, if a random July day in the year 2000 is picked, one might estimate that there is a 10 percent probability that the high temperature will be below 70 degrees, 25 percent probability of it being below 80 degrees, 50 percent chance of below 90 degrees, 90 percent chance of below 100 degrees, and 99.9 percent chance of below 110 degrees.

Customer Class—A group of customers with similar characteristics, such as economic activity or level of electricity use. Standard electric utility customer classes include residential, commercial, and industrial.

Customer Service Options—Actions taken to influence the nature of loads on the customer side of the meter.

D

DBH—*Diameter at Breast Height.*

Decision Analysis—A decision-making process that provides a mathematical framework by which a large set of resource *strategies* can be evaluated for a number of uncertain parameters. For example, an ultimate decision might include five sub-decisions, each with five key uncertain parameters, for which there are three values representing the range of likely outcomes. Under this example, 1,115 scenarios would be evaluated in making the decision.

Decommissioning—The process of closing down and putting a facility into a safe state after its useful life has come to an end.

DECON—A nuclear decommissioning option, where all radioactive and contaminated materials are removed from the plant. The reactor site may then be released for unrestricted use with no further licensing requirements. Under this option, it is assumed that the entire reactor facility will be dismantled and disposed.

Declining Block Rates—An electric rate structure that assesses a lower average unit charge as usage increases.

Delivery Point—A physical location on TVA's transmission system that is the contractual point at which a customer takes delivery of electricity from TVA.

Delta—In load forecasting, the increase or decrease in the forecast sales caused by the high or low levels of any of the assumptions in the forecast.

Demand—The amount of electric energy used at a specific point in time, measured in watts (or multiples thereof, such as *kilowatt*, *megawatt*, or *gigawatt*). Demand is measured for individual customers, for groups or classes of customers, and for TVA's system as a whole.

Demand-Side Management (DSM)—Activities which influence electricity use on the customer's side of the meter. Examples include home weatherization, use of compact fluorescent lighting, etc.

Demand-Side Management Measure—A single technology, such as a compact fluorescent light bulb, which can be used to alter customer *load*.

Demand-Side Management Programs—Organized utility activities that are intended to affect the amount and timing of customer electricity use.

Demand-Side Resource—Bundles or packages of DSM activities which can be used to reduce customer energy demands, and thus be viewed in many respects like a generating source.

Derating—Lowering the capacity rating of a generating unit due to factors such as age, loss of efficiency in equipment, loss of availability, or loss of reliability of the unit.

Derivatives—Financial instruments for a commodity whose value is tied to something else, such as fuel costs or interest rates. Derivatives do not call for immediate delivery of the commodity from seller to buyer. *Call options* and futures are examples of these instruments.

Design Capacity—The generating capability of a plant that sets the sizing of all plant components. This is usually close to the full load capability of a plant.

Diameter at Breast Height (DBH)—Tree diameter (outside bark) at breast height (4.5 feet above the ground).

Diesel Generators—An electrical generator powered by a traditional diesel engine.

Direct-Installation Programs—Activities in which the utility (or its contractor) installs *DSM measures* in the facilities of participating customers; such programs generally cover low-cost measures, such as water heater wraps and compact fluorescent lamps.

Direct Served Customers—A group of approximately 60 ultimate consumers with large or unusual power requirements that are served directly by TVA.

Dispatchable—Capable of being connected or disconnected from a utility's system as necessary for cost-effective and efficient operation of the system. Generally applies to generating facilities, but could also apply to a load which is interruptible when necessary.

Dispersed Load Center—Distribution of electricity from a point at which the load of a given area is assumed to be concentrated.

Distributed Generation—Power generation facilities located close to energy users. These are normally small size units (i.e., less than 50 MW) and may include both generation and energy storage technologies.

Distributor—A company that usually buys wholesale electricity from a provider and delivers it to individual commercial, industrial, and household customers.

Diversified Coincident Peak Demand Effect—The change caused by a utility's DSM program in the demand for electricity at the time the utility experiences its system peak.

Diversified Demand—The average load (in kW) across a group of customers or end uses during a given time period.

DOE 2—A public domain building energy analysis software program developed with funding from the Department of Energy.

DSM—*Demand-Side Management.*

DX—Direct expansion (DX) refers to cooling equipment with a refrigerant to air coil and no chilled water system.

E

Early Replacement—The removal of equipment before it reaches its normal retirement age and the substitution of new, typically more efficient equipment for the old.

Econometric Models—Models that use statistical relationships between past electricity sales and actual major historical factors, such as economic activity and prices, to forecast future electricity sales.

Economic Dispatch—The hour-by-hour operation of TVA's system of generating units to meet hourly and daily load swings in a way that minimizes the cost of producing electricity.

Economic Potential—An estimate of the possible energy savings assuming that all energy-efficient options will be adopted and all existing equipment will be replaced with the most efficient whenever it is cost-effective to do so, without regard to market acceptance.

Economy Surplus Power (ESP)—A form of interruptible power sold by TVA. The price for ESP changes hourly and is based on a markup over the incremental cost of the power. There are several variations of ESP with different markups and interruption provisions.

Ecosystem—Any unit that includes all organisms (i.e., the community) in a given area interacting with the physical environment.

EER—Energy efficiency ratio (EER) is a ratio calculated by dividing the cooling capacity of a cooling unit in *Btus* per hour (Btuh) by the power input in watts at any given set of rating conditions, expressed in Btuh per watt (Btuh/watt). These ratings are listed in publications by the Air-Conditioning & Refrigeration Institute (ARI).

EF—Energy Factor (EF) is a measure of the overall efficiency rating of a water heater certified by the Gas Appliance Manufacturers Association (GAMA).

Effects—These include: (a) direct effects caused by an action and occur at the same time and place; (b) indirect effects caused by an action and occur later in time or farther removed in distance, but still reasonably foreseeable. Effects and impacts as used in this document are synonymous.

Effluent—Wastewater—treated or untreated—that flows out of a treatment plant, sewer, or industrial out fall. Generally refers to wastes discharged into surface waters.

EIS—Environmental Impact Statement.

Electric and Magnetic Fields (EMF)—Two types of energy fields which are emitted from any device that generates, transmits, or uses electricity.

Eligible Market—The subset of the total market that is qualified to participate in a customer service program based on the program's participation criteria.

Embayment—A body of water forming a bay.

Embedded Costs—Costs already incurred or committed to. Usually applies to an investment such as a generating plant or transmission line.

EMF—*Electric and Magnetic Fields.*

Emission—Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Emissions Offsets—Reductions in emissions from existing facilities used to offset the emission produced from a new facility.

Emissions Trading Options—An Environmental Protection Agency policy that allows an electric plant complex with several facilities to decrease air pollution from some facilities while increasing it from others, so long as total results are equal to or better than those required by previous limits. Facilities where this is done are treated as if they exist in a bubble in which total air pollutant emissions are averaged out. Complexes that reduce emissions substantially may be able to "bank" their "credits/*allowances*" or sell them to other industries.

EMS—Energy management system is a term used for automated control of *HVAC* and lighting systems in buildings.

Endangered Species—Any biotic species formally listed as in danger of extinction throughout all or a significant portion of its range of habitat.

Endemic—Native to and limited to only a particular region.

End Use—The ultimate benefits provided by electricity. For example, commercial electric energy uses can be segmented into several end uses, such as lighting, air conditioning, ventilation, heating, cooking, refrigerating, etc.

End Use Model—An energy demand forecasting approach which is based on the end uses of electricity and the factors that influence such end uses, such as electricity consumption, end-use efficiencies, turn-over of appliance stock, etc.

Energy—The amount of power consumed over a period of time, measured in watt hours, *kWh*, *MWh*, or *GWh*.

Energy Efficiency—(1) With regard to *supply-side resources*, reducing the amount of fuel required to produce a given amount of electric energy; (2) with regard to *demand-side management resources*, reducing the amount of electric energy used without reducing the functionality of that use—for example, by replacing a 74-watt incandescent light bulb with an 18-watt compact fluorescent light bulb delivering the same amount of lumens.

Energy Efficiency Programs—Programs (sometimes called energy conservation programs) that are aimed at reducing the amount of energy used by specific end-use devices and systems without degrading the services provided, thereby reducing overall electricity consumption (*kWh*), often without regard for the (e.g., peak or of-peak) timing of program-induced savings. Such savings are generally achieved by substituting technically more advanced equipment to produce the same level of end-use services (e.g., lighting or warmth) with less electricity.

Energy Storage—A mechanism for retaining energy during light load periods, when energy production costs are relatively low, and releasing the energy during high peak periods. The duration of an energy storage cycle rarely exceeds one week.

ENTOMB (Entombment)—A nuclear decommissioning option that consists of sealing residual radioactive or contaminated materials and components within a structure that prevents access by unauthorized personnel. The entombment boundary would normally consist of those portions of the reactor building above certain levels of radioactivity. If necessary, additional reinforced concrete is poured to close up these areas, integral access hatches, and manways. Non-radioactive systems and structures are drained and de-energized, then secured throughout the dormancy period until final disposition.

Environmental Externalities—Externalities are activities which result from the production and consumption of goods and services that impose costs or benefits on society that are not reflected in the prices of those goods or services. For example, negative externalities such as pollution and sonic booms can impose costs on a society that are not reflected in the prices of those goods associated with the pollution or sonic boom. Discussions of externalities in the utility industry have generally dealt with environmental externalities arising from various forms of pollution.

Environmental Mitigation—Reducing the potential degree of environmental impact.

Environmental Protection Agency (EPA)—A federal agency charged with implementing a number of environmental statutes.

EPACT of 1992—The Energy Policy Act of 1992 introduced many topics such as *energy efficiency , DSM, IRP*, *renewable* energy sources, transmission access, research on EMF, and energy independence.

Equipment Cost—The price of components that the utility purchases directly for a DSM program, including the cost of DSM measures distributed free to participants.

Erosion—The process by which soil particles are detached and transported by water and gravity to some downslope or downstream point.

ESP—*Economy Surplus Power.*

Evaluation Criteria—Measures to evaluate the contribution of resource options to stated objectives and values.

Evaluation and Measurement—The phase of a DSM program which focuses on determining the effectiveness and actual field results of the program.

Existing Buildings—Structures that are in use as of the beginning of the current year.

Externalities—Consequences or impacts of resource development and consumption that are not directly accounted for in the price paid for the resource developed and consumed.

Federally Listed—Animals or plants that have been officially added to the Federal lists of endangered or threatened wildlife or plants by the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service.

F

Feedstock—The raw materials utilized by a chemical production facility to make the final product.

FERC—Federal Energy Regulatory Commission

Firm Capacity—(1) With regard to *supply-side resources*, a binding commitment to purchase or sell *capacity*. Purchases increase the capability of TVA's system; sales decrease TVA's *capability*; (2) with regard to *demand-side management resources*, the amount of capability that must be provided to a customer under normal conditions.

Firm Power—Power sales which do not have arrangements in the contract for interruptions. (See *Interruptible Power)*

Firm Power Supply Contracts—Contracted power supply that is available 100 percent of the time except under conditions such as Force Majure (circumstances that are normally beyond the control of the contracting parties, e.g., "Acts of God").

Fixed Costs—Costs associated with constructing and maintaining resources in an operable condition, including capitalized construction costs, fixed operating and maintenance costs and fuel inventory costs. These costs are recovered whether or not the resource is actually operated.

Flexible Option—A resource option that can be altered or modified in accordance with TVA needs.

Flexible Strategy—A combination of options that can be easily altered over time to meet TVA's power needs.

Flexibility—The degree to which resource decisions can be changed over time as events unfold and near-term futures become more clearly known.

Fluidized Bed—A Fluidized Bed Combustion Boiler burns solid fuel with a mixture of limestone to reduce sodium dioxide (SO_2)emissions without the addition of a flue gas desulfurization system.

Fly Ash—The small ash particles that are carried out of a combustor with the existing flue gas. These particles are collected by appropriate equipment prior to discharging the flue gas into the atmosphere.

Forced Outage—The occurrence of a component failure or other condition that requires removal of a generating unit from service immediately or up to and including the next weekend.

Forest Cover Type—A descriptive classification of forest land based on present occupancy of an area by tree species (also known as "forest type"), such as:

- Oak-hickory. Forests in which upland oaks or hickory, singly or in combination, constitute a plurality of stocking.
- Oak-pine or mixed. Forests in which hardwoods (usually upland oaks) constitute a plurality of stocking but in which pines account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow-poplar.)

Forward Contract—A transaction in which two parties agree to the purchase or the sale of a commodity at some future time under such conditions as the two agree upon.

Fossil Fuel Plant—A plant using coal, oil, natural gas or other fossil fuel as its source of energy.

Free Drivers—Customers who take *DSM* program recommended actions because of the program, but who do not participate directly in the program (e.g., they do not claim rebates).

Free Riders—Customers who would have adopted program recommended actions even without the program, but who participate directly in the program (e.g., they claim rebates).

Fuel Cells—A device capable of converting a fuel and an oxidizer directly to electricity.

Fuel Switching Programs—Programs that encourage customers to change from one fuel to another for a particular end-use.

Full-Scale Programs—Mature, system wide programs that are available to all of the eligible customers in the utility's service area.

Future—A combination of discrete values for key uncertainties that TVA is treated explicitly in Energy Vision 2020. For example, a *future* might assume a high rate of load growth, low oil prices, low coal prices, high interest rates, and no new carbon dioxide (CO_2) emission regulations.

Futures (Financial Market)—The sale of a product for delivery at some time in the future for a specified price. Most major commodity markets have well-organized active futures markets. For example, farmers will sometimes sell part of their crops for fall delivery before the crop is even planted.

G

Gas-Fired Combined Cycle—A generating unit consisting of a combustion turbine generator and a steam turbine generator. The primary fuel is natural gas.

Gasifier—A collection of equipment that produces a fuel gas from a typically solid fuel. This fuel gas is suitable for use as a fuel in a combustion turbine or as a feedstock for a chemical processing plant.

General Information Programs—Customer Service programs that inform customers about DSM options through such mechanisms as brochures, bill stuffers, TV and radio ads, and workshops.

Geographic—Belonging to or characteristic of a particular region.

Gigawatt—GW, an amount of electric power equal to 1,000 *MW* or 1 billion watts.

Gigawatt hour—GWh, an amount of energy equal to 1,000 *MWh* or 1 billion watt -hours.

Global Warming—The theory that certain gases such as carbon dioxide (CO_2), methane (CH_4), and chlorofluorocarbon (CFC) in the earth's atmosphere effectively restrict radiation cooling, thus elevating the earth's ambient temperatures.

Greenfield Site—A new site which has not previously been developed.

Greenhouse Effect—The build-up of carbon dioxide and other trace gases that allows light from the sun's rays to heat the Earth but prevents a counterbalancing loss of heat.

Greenhouse Gas Emissions—A gas whose presence in the upper atmosphere contributes to the greenhouse effect by allowing visible light to pass through the atmosphere while preventing heat radiating back from the Earth from escaping. Greenhouse gases from *anthropogenic sources* include *carbon dioxide, nitrous oxide, methane,* and *chlorofluoro-carbons (CFCs)*. There also are even larger quantities of naturally occurring greenhouse gases, notably ozone and water vapor, whose concentrations may be affected by interactions with atmospheric pollutants.

Groundwater—Water within the earth or geologic stratum that supplies wells and springs.

GW—Gigawatt, an amount of electric power equal to 1,000 MW, or 1 billion watts.

GWh—Gigawatt hour, an amount of energy equal to 1,000 MWh, or 1 billion watt-hours.

H

Habitat—The total environmental conditions on a unit of land including food, cover, and water within the home range.

Habitat Diversity—The variety and variability of habitat types, as well as their interrelationships on a given area and scale.

HAP—*Hazardous Air Pollutants.*

Hardwoods—Angiosperms, usually broadleaf and deciduous. Soft hardwoods are soft-textured hardwoods such as boxelder, red and silver maples, hackberry, sweetgum, yellow poplar, blackgum, sycamore, black cherry, and elm. Hard hardwoods are hard-textured hardwoods such as sugar maple, hickory, dogwood, persimmon, black locust, beech, ash, black walnut, and all commercial oaks.

Hazardous Air Pollutants (HAP)—Air pollutants that are not covered by ambient air quality standards but that present, or may present, a threat of adverse health or environmental effects. These include an initial list of 189 chemicals designated by Congress that is subject to revision by the Environmental Protection Agency.

Hazardous Waste—A byproduct of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special *Environmental Protection Agency* lists.

Haze—Atmospheric moisture, dust, smoke, and vapor suspended to form a partly opaque condition.

Heat Rate—A measure of efficiency for electric generating units, based on the amount of thermal energy (measured in BTUs) needed to produce a *kWh* of elec tricity. The lower the heat rate, the more efficiently the generating plant turns fuel into electricity.

Heat Recovery Steam Generator—Heat Recovery Steam Generator recovers heat from combustion turbine exhaust gases to raise steam to power a steam turbine, which can be used to generate additional electricity.

Heavy Metals—Natural elements such as lead, mercury, cadmium, and nickel. They are mined from the earth and used in numerous manufacturing processes and countless products.

Herbicide—Any substance or mixture of substances intended to prevent the growth of, or destroy, unwanted plants or vegetation.

High-Level Waste—Material that is highly radioactive. In a nuclear power plant, high-level waste is spent fuel.

Historic Site—See Archeological Resources.

HSPF—Heating Season Performance Factor (HSPF) is the total heating output of a heat pump during its normal annual usage period for heating divided by the total electric power input in watt-hours during the same period. This rating is listed in publications by the American Refrigeration Institute (ARI).

Hydro Electric Power Generation—A dam creates an upper and a lower water reservoir. The height difference between the two reservoirs establishes potential energy that is used to generate electricity by allowing water from the upper reservoir to flow through a hydro *turbine* to the lower reservoir.

I

IGCC—*Integrated Gasification Combined Cycle.*

Impacts—*Effects.*

Impoundment—A body of water or sludge confined by a dam, dike, floodgate, or other barrier.

Incentive—An award offered to encourage participation in a *DSM* program or adoption of recommended measures.

Incentive Programs—Programs that offer cash or noncash awards to customers, trade allies, or employees to encourage participation in a *DSM* program and adoption of recommended measures.

Incremental Cost—The additional cost incurred because of an activity. For example, a plant sitting idle has costs associated with it such as interest on funds used to build it and basic maintenance. When started up, the plant has additional costs such as fuel, additional maintenance, and other costs. These latter costs are the incremental costs of producing the product. Similar terms are *avoided cost*, variable cost, and marginal cost.

Incremental Fuel Cost—The cost of replacing a unit of fuel in today's market.

Incremental Participation—The cumulative number of program participants in the current year minus the cumulative number of participants in the previous year.

Independent Power Producer (IPP)—Any person or entity who owns or operates, in whole or in part, one or more new independent power production facilities.

Industrial Customer—In the context of Energy Vision 2020, a business engaged in industrial activities, which buys electrical energy either from TVA directly or a distributor, depending upon its electrical energy requirements.

Industrial Sector—The group of non-residential or commercial customers that provides products, including agriculture, construction, mining, and manufacturing.

Inflexible Option—A resource option that cannot be changed once construction or implementation begins (e.g., construction of a combustion turbine).

Integrated Gasification Combined Cycle (IGCC)—Integration of a coal gasification plant with a combined cycle plant. A coal gasification plant is a facility that converts coal into a synthetic fuel gas.

Integrated Resource Planning (IRP)—A utility planning process that evaluates *supply-side resources* and *DSM* resources on a level playing field to reliably and cost effectively meet the future energy needs of customers.

Integration—The process of combining resource options to become strategies, and uncertainties to become futures. Strategies are combined with futures to create scenarios.

Interactive Planning—A process whereby the assumptions, supporting data and information, and preliminary results of planning are subject to open and systematic discussion with *stakeholders* to discover the interactive and interdependent effects of planning factors.

Interconnection—An electrical connection on TVA's transmission system between TVA and a neighboring utility which allows the transfer of electrical energy between TVA's transmission system and the neighboring utility's transmission system.

Intermediate Unit—A generating plant that operates between 15 percent and 60 percent of the time. An intermediate plant normally runs more hours than a peaking plant, but less than a base-load plant.

Internalized Costs—Costs which result from the production and consumption of goods and services that are reflected in the price of those goods and services.

Interruptible Power—A type of *demand-side management* activity in which the power contract allows TVA limited rights to turn off the power when overall demand is high in return for a lower electricity price to the customer (*See Firm Power*).

Interruptible Power Contracts—Power supply contracts under which the consumer agrees to temporarily reduce its electric usage when the utility so requests. In return, the consumer is charged a reduced electric rate.

IPP—*Independent Power Producer.*

IRP—*Integrated Resource Planning*.

Issue—An expressed concern regarding TVA's energy resource plan or its implementation. For example, an industrial customer may see low electricity rates as vital to its continued operation.

K

Karst (Topography)—The relief of an area underlaid by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins.

Karst Region—A particular geographic region of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns.

Kilowatt—kW, which is the amount of power equal to 1,000 watts.

Kilowatt hour—kWh, which is the amount of energy equal to 1,000 watt-hours.

KM—Kilometer, unit of length equal to 1,000 meters.

kW—Kilowatt, which is the amount of power equal to 1,000 watts.

kWh—Kilowatt-hour, which is the amount of energy equal to 1,000 watt-hours.

L

Lacustrine—Living or growing in lakes; of or related to lakes.

LAER—Lowest Achievable Emission Rate

Lead (Pb)—A heavy metal that is hazardous to health if breathed or swallowed. Its use in gasoline, paints, and plumbing compounds has been sharply restricted by federal regulations, but enormous quantities of lead already released into the environment are causing significant problems.

Levelized Cost—A stream of equal periodic costs or revenues that has the same present value as a given unequal stream of costs or revenues.

Licensing Basis—Those engineering, design, and analysis records and other documents that ensure conformance of a nuclear unit with applicable regulations.

Life-Cycle Costs—The total costs associated with the production and consumption of a resource during its use.

Lignite—An imperfectly formed coal, usually dark brown and often having woody texture.

Limited Interruptible Power (LIP)—A form of interruptible power sold by TVA. LIP customers get discounts from firm power rates in exchange for granting TVA limited rights to interrupt the power if necessary when the power supply situation is very tight. TVA's right to interrupt may be limited by serveral contract terms, such as the amount of power TVA may curtail, the period of interruption, or the duration between interruption.

Load—The amount of electric power that is drawn from TVA's electric system at a given point in time.

Load-Building Programs—Programs that aim to increase electricity consumption, generally without regard to the timing of the increased usage (e.g., peak or off-peak).

Load Factor—A measure of the variability in electric usage, defined as the ratio of energy actually consumed to the potential consumption at peak load for the period of time of interest. Load factor is usually calculated over a one year (8,760 hours) time period.

Load Forecast—A projection of future electricity sales measured in *kilowatt hours* and *peak loads* measured in *megawatts*. Depending on its intended use, a load forecast can cover a period as short as one hour or as long as 25 years or more.

Load Management—The control of customer demand during peak periods or during periods when supplies of electricity are short. Control can occur through the rescheduling or the direct curtailment of power demand. Unlike energy conservation, load management may not conserve energy.

Load Not Served—A measure of the reliability of a power system.

Load Profile—A curve or chart showing electrical power supplied or required plotted against time of occurrence; this illustrates the varying magnitude of the electric power load over time.

Load Shape—The time-of-use pattern of customer electricity use, generally a 24-hour pattern or an annual (8,760-hour) pattern.

Load Shifting Programs—Programs that aim to move or reschedule electricity consumption from one time to another (usually from the on-peak to off-peak periods during a single day).

Loop Flow—A flow of electricity from one place to another that follows a path other than the one specified in a contract or otherwise intended. A loop flow may pass through the transmission system of a utility not involved in the original transaction.

Loss of Load Expectation—The expected time that capacity is not sufficient to meet the system demand.

Loss of Load Probability—A measure of the expected number of hours per year that system demand will exceed system capacity.

Low-Level Waste—Radioactive material that is only slightly or moderately radioactively contaminated. Low-level radioactive waste consists largely of ordinary trash and other items that have come into contact with radioactive materials.

M

Mainstream Reservoirs—Reservoirs on large rivers such as the Tennessee River.

Maintenance Outage—The removal of a generating unit from service to perform work on specific components that could have been postponed past the next weekend, but which could not be postponed from season to season . This is work done to prevent a potential *forced outage*.

Market Potential—An estimate of the possible energy savings that would occur because of normal market forces (i.e., likely customer adoption over time of various actions without a *DSM* program).

Mature Trees—Trees that have grown into the sawtimber class but have not yet begun to decline and die from natural processes.

Megawatt—MW, the amount of power equal to 1,000 KW or 1,000,000 watts.

Methane (CH_4)—A greenhouse gas that is colorless, nonpoisonous, and flammable and is created by anaerobic decomposition of organic compounds.

mg/m^3—Micrograms per cubic meter.

micro-ACCESS—A building energy analysis software program available through EPRI.

microns—A unit of length equal to one millionth of a meter.

Milepost 160—Marker on the Tennessee River that is considered to be a central location of the Tennessee Valley service area.

Mitigation—Measures taken to reduce adverse impacts.

Mn—Manganese, a hard and brittle metallic element that resembles iron but is not magnetic.

Mobile Sources—Transportation air pollution sources, primarily automobiles and trucks.

Monitored Retrievable Storage (MRS)—A temporary (40 years) collection and storage facility for spent nuclear fuel rods until a permanent waste repository is available.

Monitoring and Evaluation Costs—Expenditures associated with the collection and analysis of data used to assess DSM program operations and effects.

Multi-Attribute Tradeoff Analysis—An approach designed for interactive participation by a group to make tradeoff comparisons among different attributes for many strategies and futures.

MW—Megawatt, the amount of power equal to 1,000 KW or 1,000,000 watts.

MWh—Megawatt hour, the amount of power equal to 1,000 kWh or 1,000,000 watt hours.

N

NAPAP—*National Acid Precipitation Assessment Program*.

National Acid Precipitation Assessment Program (NAPAP)—A 10-year scientific study of the effects of, and sources contributing to, *acid deposition* that was conducted by the federal government from 1980 to 1990.

National Ambient Air Quality Standards (NAAQS)—Uniform, national air quality standards established by the *Environmental Protection Agency* that restrict ambient levels of certain pollutants to protect public health (primary standards) or public welfare (secondary standards). Standards have been set for *ozone*, *carbon monoxide*, *particulates PM (10)*, *sulfur dioxide*, *nitrogen dioxide,* and *lead*.

Native Species—Species normally indigenous to an area; not introduced by man.

Natural Resources—The elements of the natural environment that are evaluated as resources (i.e. water resources, forests).

NEPA—National Environmental Policy Act.

Net Effect—The change in electricity use or demand for a participating customer that can be attributed to the utility *DSM* program, expressed in *MWh*/year and *MW*.

New Construction—Buildings and facilities that are constructed during the current year; it may also include major renovations of existing facilities.

New Construction Programs—Customer service programs that affect the design and construction of residential and commercial buildings and manufacturing facilities; such programs may also include major renovations of existing facilities.

New Participants—Customers who take part in a customer service program during the current year and did not participate in the program during the previous year.

NIMBY—An acronym for "Not In My Backyard", used to characterize a person or group resisting development of a project within their neighborhood or another geographic area of concern.

Nitrogen Dioxide (NO_2)—The result of nitric oxide combining with oxygen in the atmosphere. A major component of photochemical smog.

Nitrogen or Nitrous Oxides (NO_X)—A product of combustion by mobile and stationary sources and a major contributor to the formation of ozone in the troposphere and acid deposition.

Non-attainment Area—A geographic area that does not meet one or more of the *National Ambient Air Quality Standards*

for the criteria pollutants designated in the Clean Air Act.

Non-coincident Peak—The absolute peak demand imposed on TVA by a customer, group of customers or all the customers as a whole, but not necessarily at the same time.

Non-point Sources—Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm water runoff.

Normal Replacement—The removal of worn-out (and perhaps obsolete) equipment and the installation of new equipment.

NO_X—Nitrogen Oxide or Nitrous Oxide.

O

Off-Peak—The periods of time during which energy is being delivered far below the maximum demands that could be placed on a utility system.

Off System Sales—Sales of electricity by TVA to utilities outside the TVA service area.

On-Peak—The periods of time during which energy is being delivered near, or at, the maximum coincident peak load.

OPEC—Organization for Petroleum Exporting Companies.

Operating and Maintenance (O&M) Costs—Noncapital, equipment-related expenses that continue over the life of the equipment; they include fuel costs as well as costs for maintaining and servicing equipment. There are both fixed and variable O&M costs.

Options—Actions TVA can take to resolve an issue. For example, if TVA forecasts an energy deficit, it has the option to meet it with *DSM* programs or with other resources.

Option (Financial Market)—In financial markets, the right to buy or sell something at some time in the future at a specified price. For example, a utility that is unsure about whether it will need an additional 100 *MW* of power next winter may buy an option from a neighboring utility today. The neighboring utility is then obligated to deliver the power at the agreed-upon price if the other utility requests it. However, the utility that bought the option is under no obligation to buy the power.

Option Purchase Agreement—A proposal, in the form of *call options, put options*, or *forward contracts*, by marketers, brokers, and others in the electric industry to sell TVA electricity.

Outage—The operating condition of a generating unit when it is unavailable for service.

Ozone (O_3)—A substance found in the stratosphere and the *troposphere*. In the stratosphere (the atmospheric layer beginning 7 to 10 miles above the Earth's surface) ozone is a form of oxygen found naturally that provides a protective layer shielding the Earth from ultraviolet radiation. In the troposphere (the layer extending up 7 to 10 miles from the Earth's surface), ozone is a chemical oxidant and a major component of photochemical smog. Depending on its concentration, ozone can seriously affect the human respiratory system and is one of the most widespread of all the criteria pollutants. Ozone in the troposphere is produced through complex chemical reactions of *nitrogen oxides* and sunlight.

P

Palustrine—Relating to marshes or wetlands.

Participant Costs—Those expenses associated with taking part in a *DSM* program paid by the customer and not reimbursed by the utility.

Participants—Units used by a utility to measure participation in its DSM programs; such units of measurement include customers or households for residential programs and customers, floor area, or kW-connected for commercial and industrial customers.

Participation Rate—The ratio of the number of *participants* in a program to the number eligible for the program, with both the numerator and denominator defined in the same units.

Particulate—Minute separate particles.

Particulate Collection Devices—Environmental control systems (i.e., *electrostatic precipitators*, baghouses) designed to remove suspended *particulate* matter (i.e., *fly ash*) from coal-fired boiler flue gas.

Pathogens—An agent that causes disease, especially a microorganism such as a bacterium or fungus.

PCBs—*Polychlorinated byphenals*.

Peak Demand—The maximum rate of electricity use, expressed in *kW*.

Peak Load—The maximum load experienced by TVA's electric system over a given period of time.

Peak-Clipping Programs—Load reduction programs that aim to reduce electricity demand (*kW*) at certain critical times, typically when the utility experiences system peak demand.

Peaking Capacity—Capacity that is available for use and used to meet peak load. Such capacity, usually represented by *combustion turbines*, often has low capital costs and high fuel costs, and is designed to operate for relatively short periods of time.

Peaking Units—A generating unit available to assist in meeting that portion of peak load which is above base and intermediate loads.

Penetration—The ratio of the number of new units of a specific type (e.g., DSM measures) installed to the total number of new units installed during a given time (e.g., the fraction of new air-conditioner sales that exceeds an energy-efficiency ratio of 10).

Pesticide—Chemical materials used to control undesirable insects, animals, diseases, vegetation, or other forms of life.

pH—A measure of the acidity or alkalinity of a solution. pH is represented on a scale of 0 to 14, with 7 being a neutral state, 0 most acid, and 14 most alkaline.

Phase l and Phase II Acid Rain Control—The 1990 Clean Air Act Amendments require fossil-fuel fired generation units to reduce their SO_2 and NO_x emissions in two phases in order to control acid rain. The Phase I compliance period commences on January 1, 1995; the Phase 2 compliance period commences on January 1, 2000.

Photovoltaics—Solar-photovoltaic (PV) power plants convert solar energy to electricity using a semiconductor material, usually silicon doped with phosphorus and boron, to generate direct current.

Physiographic Provinces—Systematic description of areas with some point of physical geology in common.

Pilot Program—A program designed and implemented to test a technology, process, or product on a limited basis in order to evaluate its effectiveness and identify potential problem areas.

Planned Outage—The removal of a generating unit from service for inspection and/or general overhaul of one or more major equipment groups. This is work which is usually scheduled well in advance of the planned outage period (e.g., annual boiler overhaul, five-year turbine overhaul).

Plume—A flowing, often somewhat conical, trail of emissions from a continuous point source.

PM 10—Minute separate particles equal to 10 microns or less.

Point Sources—A stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, for example, a pipe, ditch, ship, ore pit, or factory smokestack.

Parts per million (PPM)—The number of parts of a given substance or pollutant in a million parts of a base material; a measure of concentration.

Present Value—The value of future dollars in terms of what they are worth today. The loan amount one could borrow today and pay back with the future dollars.

Pressurized Water Reactor (PWR)—A light water reactor in which the water used as a moderator is kept under pressure, preventing it from boiling at normal temperatures.

Prevention of Significant Deterioration (PSD)—A program in which state or federal permits for new or modified sources in places where air quality is already better than required to meet primary and *secondary ambient air quality standards*.

Price Taker—In any market, a buyer or seller with no individual control over the price of the product.

Primary Particulates—Particles emitted directly from a source.

Private Costs—Cost borne by those producing a good (e.g., fuel, operation and maintenance, and capital costs). Also referred to as “utility cost.

PSCs or **PUCs**—Public Service Commissions or Public Utility Commissions; state authorities that regulate utilities.

Pulverized Coal—The pulverized coal (PC) fired boiler with *steam turbine* power generation is currently the principal electricity generation technology in the United States.

Pumped Storage Hydro Plant—A hydro plant that continuously recycles water through two reservoirs, one upper and one lower. When demand for electricity is high, water held in the upper reservoir is released through a long underground power tunnel. Electricity is generated by the force of falling water driving hydraulic turbines connected to large generators. When demand is low, the generators reverse and function as electric motors to pump water from the lower reservoir back to the upper, where it is stored for reuse during peak demand periods.

Put Option—An option granting the holder the right to sell the underlying security or commodity at a certain price at a specified period of time.

Q

Qualitative Evaluation—An assessment using qualities or rankings rather than a measurement or estimate of quantity.

Quantitative Evaluation—An assessment based on a measurement or estimate of quantity.

R

Radionuclides—Radioactive nuclides.

Rate Impact Measure Test—A test which measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the utility implementing a resource option.

Real Prices—(Or constant dollar prices, prices excluding inflation) As applied to price changes, the rate of change in a price over time adjusted for the overall inflation rate. For example, if the price of a widget goes up 1 percent while the average price of all goods sold in the economy goes up 2 percent, the real price of the widget is said to have declined 1 percent.

Rebate—Money given to customers, contractors, homebuilders, or other trade allies who make equipment choices to help the purchaser defray the incremental cost of DSM measures.

Reburn—A process that reduces emissions of NO_X by staging of the combustion process. A secondary fuel (either pulverized coal or natural gas) is introduced into the furnace after primary combustion and chemically reduces the previously formed NO_X.

Reference Case—One given set of circumstances used to compare all other sets of circumstances. This is TVA's "No Action" alternative.

Regional Haze—A type of visibility impairment which is the result of dispersed and intermixed pollutants from many sources.

Reliability—The ability of TVA's electric system to deliver uninterrupted power to its customers.

Renewable Resources—Power plants or other generating devices whose fuel source is generally considered to be renewable. These include generators fueled by biomass, water, photovoltaics, solar, wave, or wind energy.

Renewables—See *Renewable Resources*.

Repowering—Replacing or adding to the source of power of an existing electric generating station.

Request for Proposal (RFP)—Formal action by TVA to request competitive bids from developers, marketers, brokers, electric utilities, and other entities that can potentially supply low cost power to TVA.

Rerating—Changing the nameplate capacity of a generating unit.

Reserve Margin—The difference between the capability of TVA's electric system and expected *peak load*, expressed as a percentage of expected peak load.

Residential Sector—The group of customers to whom electricity is sold for household purposes, including space heating, water heating, air conditioning, lighting, and appliances in single-family, multifamily, and mobile homes.

Resources—*Supply-side* or *Customer Service Options* which can be used by TVA to meet future customer energy needs.

Resource Option—*Supply-side* or Customer Service actions TVA can take to meet future customer energy needs.

Resource Strategy—A combination of *resource options* used to fulfill a particular *future*.

Retail Competition—Competition for the business of ultimate consumers.

Retrofit—Replacement or upgrading of equipment before it reaches normal retirement age.

Retrofit Programs—Programs that upgrade existing facilities and equipment before they reach their normal retirement age.

Revenue Requirements—The amount or money that must be recovered from customers to cover a utility's fixed and variable costs.

River Substrate—A layer of material or substance in a river.

Robustness—The degree to which an energy resource strategy meets an objective for most or all futures.

S

SAFSTOR—With the Safstor option, fuel assemblies, nuclear source material, and radioactive liquid and solid wastes will be removed from the plant. The external doors and hatches of the buildings will be secured to prevent unauthorized entry. Buildings will be accessible only to fulfill periodic inspections and surveillance requirements. Systems needed for these functions will be maintained throughout the dormancy period in accordance with the requirements of a possession-only license issued by NRC. A full-time security force will also be provided to ensure prevention of unauthorized entry.

Saturation—On the demand side, the percentage of a group of customers that have a particular end use. For example,

the residential saturation of heat pumps is 50 percent if half of residential customers have them. In the commercial sector, saturations (also know as fuel shares) are generally measured on a percentage of square footage basis.

SCADA—*Supervisory Control and Data Acquisition*.

Scenario—In the context of Energy Vision 2020, the combining of one *strategy* with one *future*.

Scoping—The procedure in Energy Vision 2020 by which TVA identified important issues and determined the extent of analysis necessary for an informed decision on a proposed action. Scoping is an integral part of any environmental analysis.

Scrubber—A device that removes sulfur dioxide from flue gas using lime or limestone.

Scrubber Sludge—The *effluent* from a scrubber that is discharged and is stored in a landfill, principally as a calcium sulfate.

Secondary Particulates—Particles formed in the atmosphere from emitted gases.

Sedimentation—The action or process of depositing sediment.

Seedling—Live trees of a species less than 1.0 inch in *diameter at breast height* that are expected to survive and develop.

SEER—Seasonal Energy Efficiency Ratio (SEER) is the total cooling of a central unitary air conditioner or unitary heat pump in Btu's during its normal annual usage period for cooling divided by the total electric energy input in watt-hours during the same period. This rating is listed in publications by the American Refrigeration Institute (ARI).

Sensitive Species—Species that are listed with states as needing special management.

Sensitivity Analysis—The process of changing a characteristic of or assumption about a resource or a streategy in to determine the impact this change has on a set of *evaluation criteria*.

Sheet Erosion—*Erosion* of a uniform layer of surface soil from a large area caused by runoff water.

Short Rotation Woody Crops—A species of trees grown (on a relatively short rotation schedule) for the explicit purpose of harvesting for use in power production.

Soil—A dynamic natural medium composed of mineral and organic materials in which plants grow.

Sorbent—A substance that takes up and holds.

Species—A class of individuals having common attributes and designated by a common name.

Spent Fuel—Nuclear fuel that can no longer economically sustain a chain reaction.

Stakeholder—For the purposes of Energy Vision 2020, an individual, a group of individuals, or an organization that may be affected by or have a vested interest in a TVA decision or action. TVA's stakeholders include its customers, residents of the Tennessee Valley, etc.

State Implementation Plan (SIP)—*Environmental Protection Agency* approved state plans for the establishment, regulation, and enforcement of air pollution standards.

Steam Generator—In pressurized water reactors, a huge "radiator" where heat from the primary (reactor coolant) loop is transferred to the secondary (steam) loop without mixing of the two streams of water.

Storage Units—Facilities that are able to store low cost, off-peak generated energy and discharge this energy during high demand peak periods.

Stranded Costs—Costs that a utility faces because of *stranded investments*. For example, a utility may owe money on a closed plant that is generating no income. If an investment can operate and cover part of its cost, only the portion of the cost not covered would be stranded.

Stranded Investment—An investment in plant or equipment that loses its value because of competition that forces down the price of the product. In the electric utility industry, firms may have been allowed or directed by regulators to build high cost capacity to meet the obligation to serve their customers. If the market is open to competition, lower cost producers may capture these customers, causing the high cost capacity to close and become a stranded investment.

Strategy—In the context of Energy Vision 2020, a combination of options intended to fulfill a particular resource goal. For example, an energy deficiency in 2007 might be met with a combination of *supply-side resources* and *DSM resources*.

Streams—A continually, frequently, or infrequently flowing body of water that follows a defined course. The three classes of streams are:

- Ephemeral: A channel that carries water only during and immediately following rainstorms. Also known as a "dry wash."
- Intermittent: A watercourse that flows in a well-defined channel during the wet seasons of the year, but not the entire year.
- Perennial: A watercourse that flows throughout the year or nearly so (90 per

cent of the time) in a well-defined channel.

Substation—An assemblage of equipment for the purposes of switching and/or changing or regulating the voltage of electricity.

Succession—A process of biotic community development that involves changes in species, structure and community processes over time.

Sulfur Dioxide (SO_2)—A heavy, colorless, gaseous air pollutant formed primarily by the combustion of fossil plants.

Sunk Cost—The sum of previous investments; monies that have already been spent.

Supercritical Pulverized Coal-Fired Plant—A supply-side option that is technically similar to the subcritical pulverized coal (PC) fired plant, except that the supercritical boiler operates at supercritical pressures of greater than 3,200 pounds per square inch.

Supervisory Control and Data Acquisition (SCADA)—A real-time system that gathers information on an electrical system and also can be used to perform real-time control actions to modify the electrical system. These actions can include switching transmission lines in and out of service, switching capacitors in and out of service, starting and stopping generators, etc.. A SCADA system usually has centralized computer controls with communications equipment to gather and transmit real-time information between the central control center and the electric system.

Supply-Side Resource—Resources that meet customer needs by increasing production of electricity (e.g. hydro, fossil, nuclear, combustion turbines, etc.).

Surface Water—Streams, rivers, ponds, lakes, and manmade reservoirs.

Surrogate Measure—A measure that can be used to represent one or more other measures in an analysis. For example, sulfur dioxide can be an effective surrogate for other air pollution emissions elements when analyzing certain air pollution characteristics.

System Energy Requirements—The total energy the generating system needs to produce to meet customer needs over some time period, generally a year. System energy requirements include all sales and *system losses*. Customer needs are measured before *demand-side management* measures are applied.

System Losses—Difference between the energy metered at the generator and the energy recorded at the customers' meters.

System Reliability—The guarantee of system performance at all times and under all reasonable conditions to ensure constancy, quality, adequacy, and economy of electricity. It is also the assurance of a continuous supply of electricity for customers at the proper voltage and frequency.

T

Tailwater—Water downstream from a dam, including those waters released from the dam.

Takeback—Changes in customer behavior resulting in greater energy use stimulated by participation in a *DSM* program.

Target Market—The group of customers (a subset of the eligible market) that is the focus of utility marketing efforts.

Thermal Stratification—Layering of water with different temperatures, where it is warmer near the surface and colder near the bottom.

Threatened Species—Species formally listed as threatened with extinction.

Topography—The physical features of a place or region. Commonly refers to land forms and variation in elevation.

Total Program Costs—All expenses associated with a *DSM* program regardless of whether borne by the utility, participating customer, or trade allies. The costs paid by customers and trade allies are first adjusted for incentives from the utility to avoid double-counting costs.

Total Resource Cost (TRC) Test—A benefit-cost test which measures the net costs of a demand-side program as a resource option based on the total cost of the program, including both the participants' and the utility's costs. The costs in this test are the program costs paid by both the utility and the participants plus the increase in supply costs for any period in which load has been increased. All equipment costs are included in this test.

Total Value Test—Extends the *Total Resource Costs* test to not only include the total cost of an option, but also the effects upon the benefits or "value" that participants and ratepayers receive.

Trade Allies—Organizations (e.g., architect and engineer firms, building contractors, appliance manufacturers and dealers, and banks) that affect the energy-related decisions of customers who might participate in *DSM* programs.

Trade Off—When satisfying more of one need means satisfying less of another.

Transmission System—That portion of a utility that is used for the purpose of transmitting electric energy in bulk to other principal parts of the system or to other utility systems.

Troposphere—Lower atmosphere.

TSP – Total suspended particulate matter.

Turbine—A machine for directly converting the kinetic and/or thermal energy of a flowing fluid (air, hot gas, steam, or water) into useful rotational energy.

U

Unbundling of Services—To give separate prices for transmission services such as delivery of active power, regulation of system frequency, sag and surge control, waveform quality services, etc.) and power generation.

Utility Costs—All the expenses (administrative, equipment, incentives, marketing, monitoring and evaluation, and other) incurred by a utility in a given year for operation of a DSM program regardless of whether the costs are capitalized or expensed.

Uncertainties—In the context of Energy Vision 2020, issues or concerns that are generally beyond TVA's control that may affect the cost or performance of its energy resources in the future.

Utility-Grade Installations—Designs that typically provide greater reliability, particularly under adverse conditions, than *Independent Power Producer* (IPP) installations using similar technologies.

V

Valley-Filling Programs—Programs that typically seek to increase off-peak electricity consumption (without necessarily reducing on-peak demands).

Variable Costs—Costs associated with the generation of electricity that vary with the utilization of the generating station, such as fuel, consumable supplies, etc.

Variable Frequency Drive (VFD)—A variable frequency drive is a type of *ASD* that varies the frequency of the electricity to an electric motor to control it's speed.

Visibility Impairment or Degradation—Visibility Impairment or degradation is usually defined as aesthetic damage where the ability to discern form, color or texture is reduced and therefore the scenic value is also diminished. Or, as stated in 40 CFR 51.30(x), visibility impairment is "…any humanly perceptible change in visibility (visual range, contrast, coloration) from that which would have existed under natural conditions."

Visual Quality Zones (VQZs)—Areas of the landscape denoted by specified distances from the observer. Used as a frame of reference in which to discuss landscape characteristics or activities of man sometimes referred to as "distance zones".

Volatile Organic Compounds—Any organic compound that participates in atmospheric photochemical reactions except for those designated by the *Environmental Protection Agency* administrator as having negligible photochemical reactivity.

Volt—The unit of electromotive force or electric pressure analogous to water pressure in pounds per square inch. It is the electromotive force which, if steadily applied to a circuit having a resistance of one ohm, will produce a current of one ampere.

W

Water Quality—A term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose.

Watershed—The entire area that contributes to a drainage or stream.

Weather Adjusted (Or Weather Normalized)—Having the effects of the difference between actual and expected normal weather removed. For example, TVA forecasts summer peaks for a normally expected valley-wide average temperature of 96 degrees. If the peak one year occurs at 100 degrees, a weather adjusted peak will be estimated by applying a per degree adjustment factor to the four degree difference.

Wheeling—Transferring electrical energy produced by another utility or an *independent power producer (IPP)* to a customer in one's own service area or through one's own transmission system to a neighboring utility.

Wholesale Electric Competition—Competition for the business of *wholesale power customers*.

Wholesale Customer—An organization that purchases bulk electric power for distribution and resale to ultimate retail consumers. There are 160 municipal and cooperative power distributors that are wholesale customers to TVA.

Wholesale Power—Power sold to other utilities or local power *distributors* for resale to ultimate consumers of electricity.

Wind Farm—Groups of Wind Turbines.

Z

Zebra Mussel—An imported mussel which fouls, among other things, water intake structures.

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Note: A detailed table of contents is found in each technical document

These technical documents support Volume 1 of TVA's Energy Vision 2020 Integrated Resource Plan/Environmental Impact Statement:

- Chapter One: Overview and Objectives
- Chapter Two: Integrated Resource Planning
- Chapter Three: Affected Environment
- Chapter Four: Existing Power System
- Chapter Five: Evaluation Criteria
- Chapter Six: Load Forecast and Need for Power
- Chapter Seven: Supply-Side Options
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- Chapter Ten: Short-Term Action Plan

Responses to public comments on the draft Energy Vision 2020 published on July 26, 1995, are found in Volume 3 of this set.

Energy Vision 2020

1

Volume 2, Technical Document

Comprehensive Affected Environment

Summary

This document provides detailed information about the natural and socioeconomic resources in the region that may be influenced by TVA's Energy Vision 2020 decisions about future energy resources. It helps provide a baseline for assessing the potential environmental consequences of alternative energy strategies for the future.

The Energy Vision 2020 assessment is made at a macro, or regional, scale rather than at a micro, or site-specific, scale.

The primary study area for Energy Vision 2020 includes the TVA power service area and the Tennessee River watershed. This area contains 201 counties within a 58- million acre area. It also covers appropriate areas of the Green and Ohio Rivers in Kentucky and the Cumberland and Mississippi Rivers in Tennessee because they contain TVA coal-fired plants and, in the case of the Cumberland River, one hydro-electric power plant.

Similarly, there are potential effects on other resources outside the primary study area. As appropriate, the study contains information about them.

Volume 2, Technical Document 1

Comprehensive Affected Environment

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SECTION 4: WATER RESOURCES

Comprehensive Affected Environment

SECTION 1: OVERVIEW

Energy Vision 2020 evaluates the affected environment to help provide a baseline for assessing the environmental consequences of alternative energy strategies. Because Energy Vision 2020 is also an environmental impact statement, special emphasis is being given to the environment. A regional perspective takes in both natural conditions and those resulting from human development. It considers socioeconomic, air, water, and land resources.

The Study Area

The primary study area for Energy Vision 2020, shown in the maps in *Figures T1-1* and *T1-2*, includes the TVA power service area and the Tennessee River watershed. This area contains 201 counties within a 58-million acre area. This study also covers appropriate areas of the Green and Ohio Rivers in Kentucky and the Cumberland and Mississippi Rivers in Tennessee because they contain TVA coal-fired plants and, in the case of the Cumberland River, one hydroelectric power plant. Similarly, there are potential effects on other resources outside the primary study area. As appropriate, the study contains information about them. For example, the assessment region for air quality is not limited to the TVA service area because of pollutant emissions originating outside the region, pollutants leaving the region, and because of some air pollution effects such as haze and ozone. These are recognized as regional issues.

Fuel Cycles

Fuel cycles have a wide range of impacts in the environment. They include mining, drilling, fuel transportation, power generation and waste assimilation or disposal impacts that involve air, land, and water resources. As a result, the affected environment also encompasses potentially impacted areas that may be remote from power plants. A fuel cycle consists of all the actions and outcomes of using any fuel for energy conversion, including both direct and indirect effects of the fuel cycle.

Figure T1-3 shows the relationships between fuel cycles and their resulting environmental impacts. Fuel energy choices, conversion technology, and environmental controls determine potential environmental impacts. For most impacts, site selection determines to what degree potential impacts are realized.

Environmental Quality and Trends

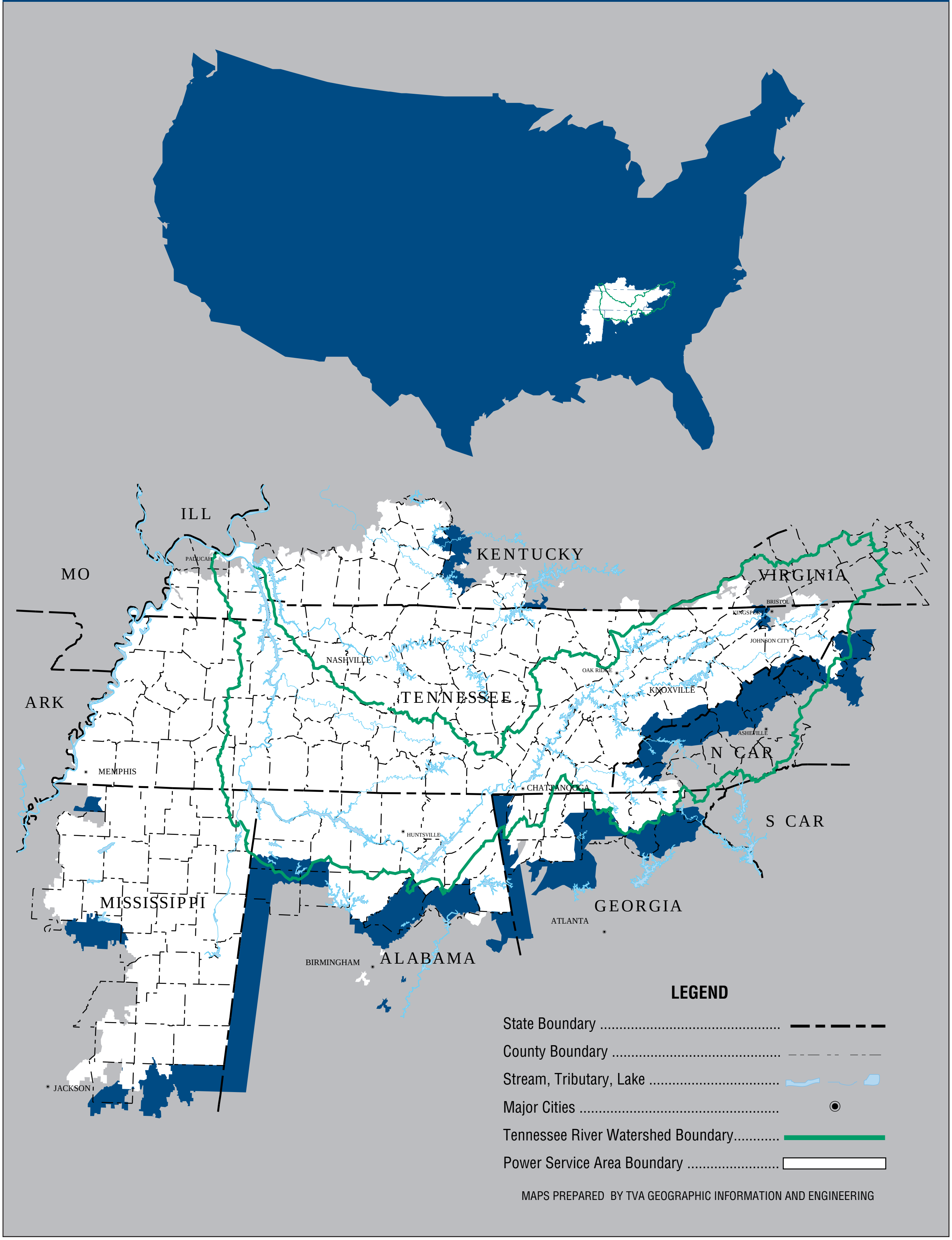
Natural resources include the air, water, and land resources of the region. This document, Technical Document 1, discusses the present quality of these resources, as well as recent and current trends in environmental quality. The socioeconomic environment, also discussed here, encompasses both the regional economy and the TVA power system.

Most direct land, water, and socioeconomic impacts are localized and depend on site selection. Proper environmental screening and selection can avoid many potentially significant impacts such as:

- Loss of wetlands, habitats, prime farmland, and cultural and historic resources
- Alteration of sensitive aquatic habitats due to heat releases, wastewater discharge, water withdrawal, or stream flow alteration
- Danger to threatened or endangered species
- Aesthetics and noise
- Socioeconomic implications

Although some air quality impacts are localized, such as plume impacts on elevated terrain, most are not. Air pollutant transport

FIGURE T1-1. **The Energy Vision 2020 Study Area is in the Southeastern United States**



and conversion processes are complex and depend greatly on meteorological conditions. TVA considers air quality impacts distant from the site when selecting plant locations. Considerations include the "down wind" spatial distribution of sensitive receptors (humans, natural resources), prevailing ambient air quality, dominant meteorological conditions, and characteristics of the air pollutant emissions. Some air quality conditions, however, are regional in scale, and some level of direct impacts may occur regardless of the location of emissions in the TVA region. Visibility impairment due to haze, ozone formation, and acid deposition are examples of potential regional effects.

Some indirect impacts, such as those from fuel sourcing and transportation, function independently of site selection. For example, coal mining impacts are generally unaffected by a power plant's location. Most potential land and water impacts depend on site selection. These are assessed in a general manner, with emphasis on the range of impacts that may be encountered. Some strategies are inherently more likely than others to result in significant environmental impacts because of an emphasis on a particular fuel or energy conversion technology. These inherent differences are discussed. Detailed environmental reviews will be conducted under National Environmental Policy Act guidelines as specific sites are selected.

SOCIOECONOMIC ENVIRONMENT

The socioeconomic environment is an integral portion of the region's total environment. Potential socioeconomic effects include impacts to social services and the local or regional economies. Energy Vision 2020 focuses on the region's economy and its components, since social services impacts are largely site-specific.

AIR RESOURCES

Air quality is important to the protection of human health and natural resources. Regional compliance with the Federal National Ambient Air Quality Standards (NAAQS) serves as a key indicator of how well human health is protected. This document presents trends in regional compliance and analyzes present air quality. Federal standards are reviewed periodically by the U.S. Environmental Protection Agency to determine if changes in standards are necessary to ensure continued adequate protection for human health and natural resources. Section 3, Air Resources, in this document examines the implications of stricter standards on compliance.

Natural resources such as soils, forests, crops, other vegetation, surface waters, aquatic ecosystems, and aquatic life may be sensitive to air quality impacts of acidic deposition (including acid rain), ozone exposure, and heavy metals deposition. Concerns in these areas are discussed in terms of present air quality and regional emissions, including those emissions contributed by TVA.

WATER RESOURCES

Water quality is critical to protecting, preserving, and restoring finite water resources. These resources include aquatic ecosystems and aquatic life, recreation, and domestic and industrial water supplies. Section 4, Water Resources, in this document discusses in detail the water quality necessary to support these uses. The sources and reasons for impaired water quality are presented, including TVA operations.

LAND RESOURCES

A broad range of land uses takes in management of the natural ecosystem, agriculture, forestry, urban and industrial use, and recreational use. Factors such as soils, groundwater, wildlife, sensitive or threatened ecosystems, threatened and endangered species, cultural resources, and terrestrial environments, such as wetlands and forests, are critically important in supporting and preserving these uses.

TVA affects land resources through site selection for power plants, reservoirs, and transmission lines; fuel procurement; air emissions; radioactive waste management; and solid waste management. Most land resource impacts are site-specific in nature and thus are not addressed in detail in this document because Energy Vision 2020 is intended to serve as a broader program-level review. Appropriate National Environmental Policy Act environmental reviews will evaluate site-specific effects associated with the actual deployment of future energy resource options.

FIGURE T1-2. **The Energy Vision 2020 Study Area Includes the TVA Service Area and the Tennessee River Watershed**

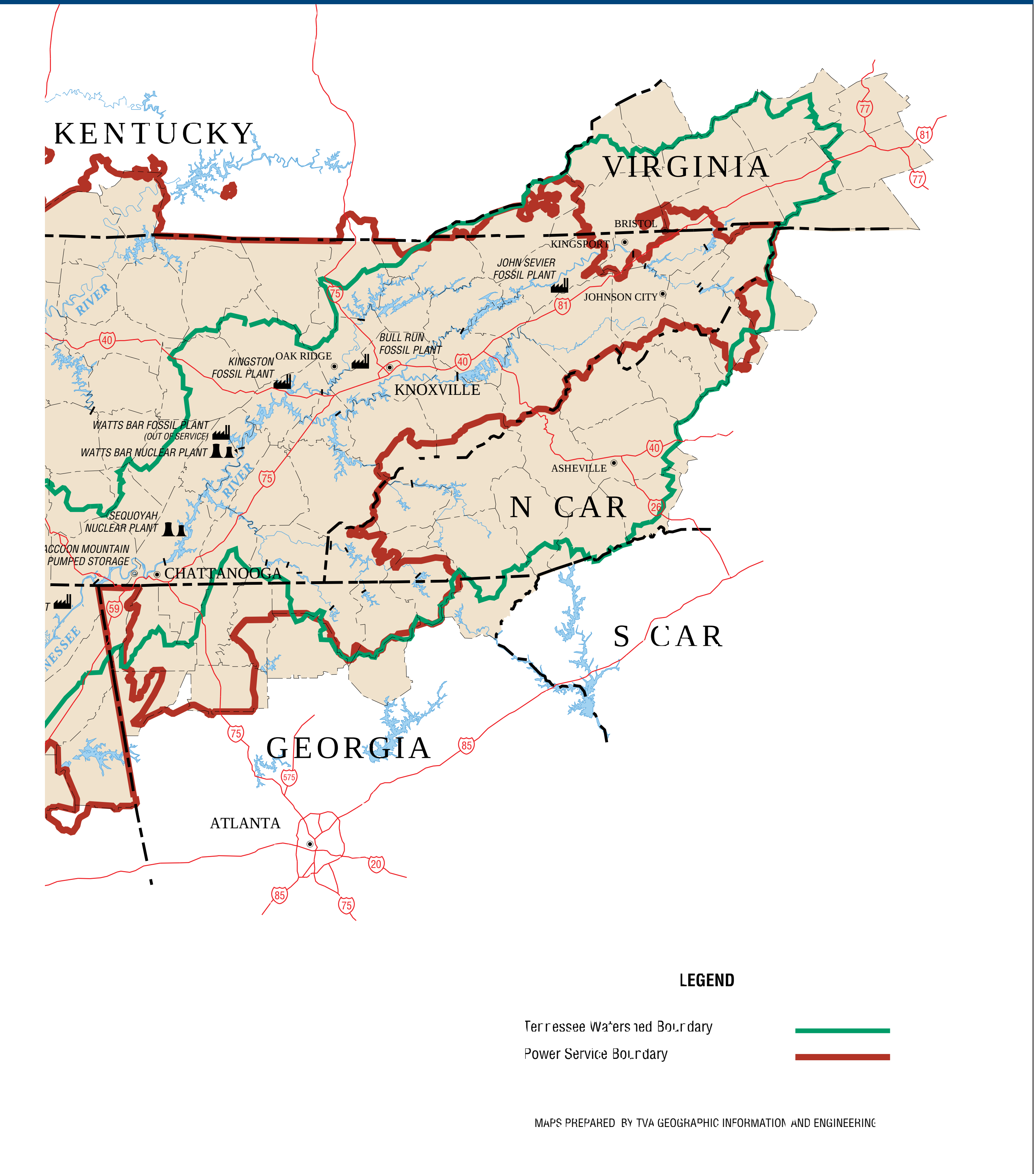
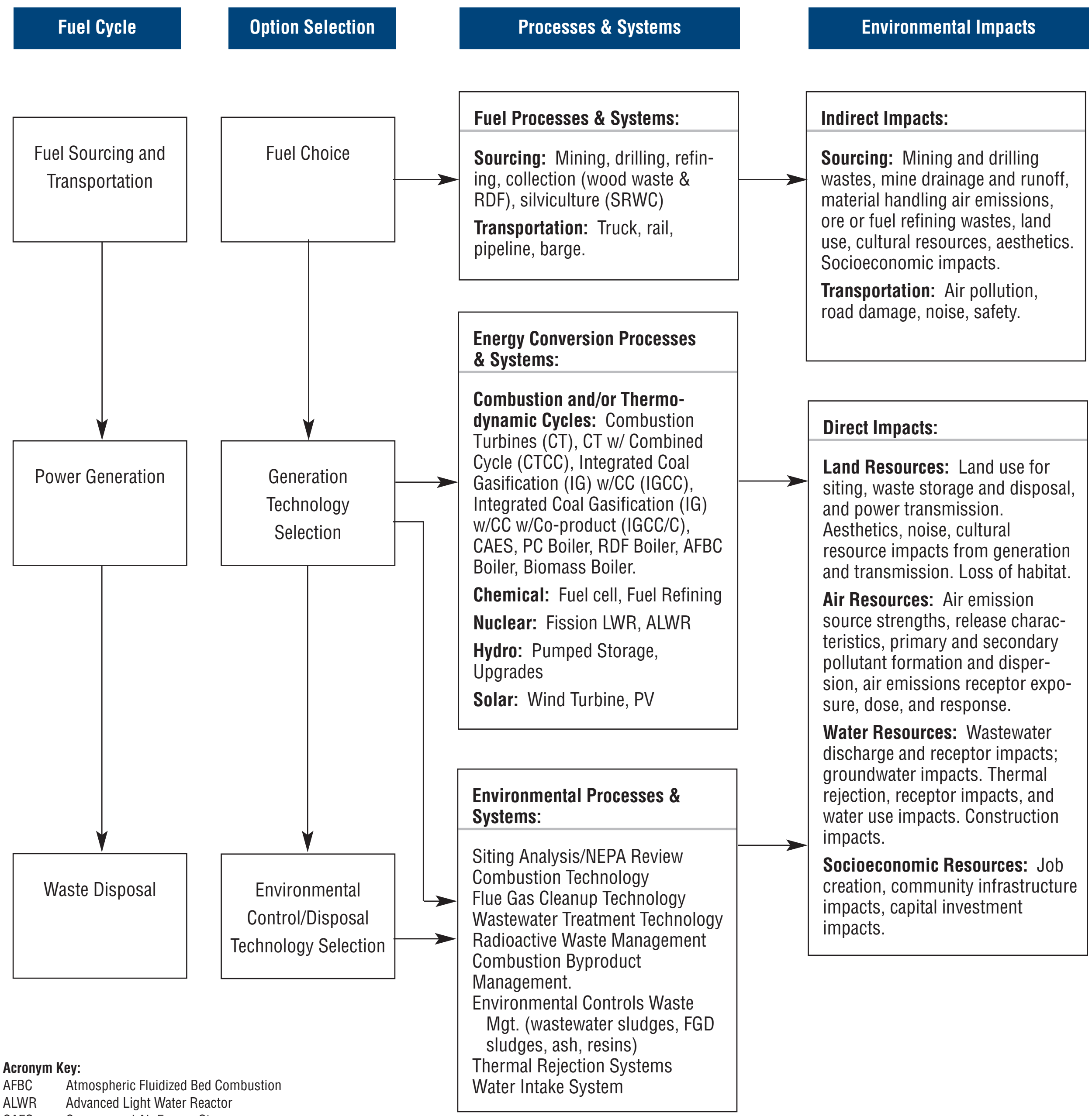

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
RIVER
BULL RUN FOSSIL PLANT
KINGSTON FOSSIL PLANT
OAK RIDGE
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
RIVER
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
NESSEE
S CAR
GEORGIA
ATLANTA
LEGEND
Tennessee Watershed Boundary
Power Service Boundary
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-3. **Relationships Between Fuel Cycles and Their Resultant Environmental Impacts**



Acronym Key:

AFBC	Atmospheric Fluidized Bed Combustion
ALWR	Advanced Light Water Reactor
CAES	Compressed Air Energy Storage
CT	Combustion Turbine
FGD	Flue Gas Desulfurization
IG	Integrated Gasification
IGCC	Integrated Gasification Combined Cycle
LWR	Light Water Reactor
NEPA	National Environmental Policy Act
RDF	Refuse Derived Fuel
PV	Photovoltiacs
SRWC	Short Rotation Woody Crops

SECTION 2: SOCIOECONOMIC ENVIRONMENT

Introduction

The TVA region consists of the 170 counties in which TVA provides electric power. It also includes 31 additional counties that are within the Tennessee River watershed, most of Tennessee, and parts of the surrounding states of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia, to comprise a 201-county area. In terms of economic development impacts, the study area is the power service area, since this is the area that is directly affected by TVA plant locations, electric rates, and bills. In 1994, the power service area had an economy of $146 billion in total personal income, 3.6 million people in total non-farm payroll employment, and $175 billion in gross product. The population was 7.7 million in 1994. Per capita income in the power service area was about $19 thousand the same year, or about 86 percent of the national average.

The 201-county area constitutes an economy that is about 13 percent larger than the power service area. In 1994, the 201-county region had an economy of $165 billion in total personal income and 4 million non-farm jobs. (Gross product is not available for this area.) The population was 8.7 million, and per capita income was about the same as for the power service area. The general economic situation and trends are identical for the power service area and the 201-county region.

The region is considerably more rural and the economy depends much more on manufacturing than the nation as a whole. Close to half of the region's population lives in non-metropolitan counties, compared to less than one-fourth in the nation. In 1994, about 26 percent of total non-farm payroll employment in the region was in manufacturing. This compares to 16 percent for the entire United States Manufacturing's predominance in the region is due to several advantages that have previously benefited the area and should continue to do so in the future. They include:

- A location in the South, with good access to the markets of the Northeast, the Midwest, the Southwest, and Florida
- Good transportation for shipping commodities via interstate highway, rail, and barge
- A low-wage (for the U.S.) workforce with good work habits
- Abundant, relatively low-cost resources including water, electricity, and land.

Economy

A large manufacturing base has helped this area outperform the U.S. economy and is expected to continue to do so. Strong manufacturing gains since 1985, as evidenced in manufacturing employment shown in *Figure T1-4*, have stimulated the region's growth. Three critical factors hampered manufacturing in the early to mid-1980s: exceptionally high oil and energy prices, high interest rates, and high foreign exchange rates. These have returned to relatively lower levels and are expected to remain there, setting up favorable conditions for growth in the region's manufacturing.

FIGURE T1-4. **Manufacturing Employment**

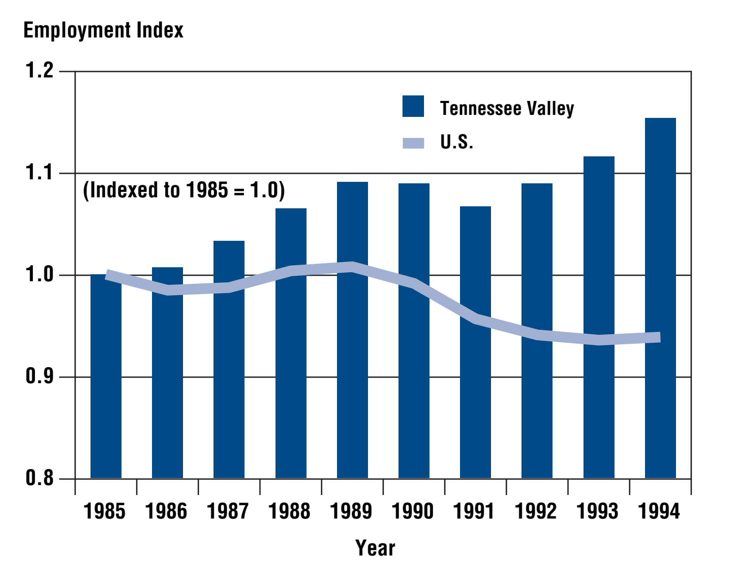


FIGURE T1-5. **Earnings, Employment, and Product in the Tennessee Valley**

	AVERAGE ANNUAL GROWTH RATES	
Earnings (1994 dollars)	**1979-1985**	**1985-1994**
Total	1.0%	3.4%
Manufacturing	0.3%	2.5%
Durables	1.1%	3.0%
Non-Durables	-0.6%	2.0%
Service Sector	2.5%	4.4%
Employment		
Total	0.9%	3.0%
Manufacturing	-0.4%	1.6%
Durables	0.1%	2.2%
Non-Durables	-0.9%	1.1%
Service Sector	2.8%	4.2%
Product (1987 dollars)		
Total	2.1%	3.9%
Manufacturing	2.4%	5.3%
Durables	3.4%	6.5%
Non-Durables	1.7%	4.2%
Service Sector	3.1%	4.0%

The cost of electricity significantly affects production costs for many of the region's manufacturing industries. Manufacturing has been helped by relatively low, stable TVA electric rates since 1988. In the future, TVA rates are expected to become even more competitive with the U.S. average. This will aid the region in maintaining manufacturing's competitive edge.

The region's manufacturing industry mix has been changing. The manufacture of durable goods, those which generally last three or more years, has expanded rapidly in the region. This has been due to newer durables industries, such as motor vehicles, coming to the region. At the same time, nondurable goods industries, such as textiles and apparel, have been losing jobs to foreign markets despite outperforming the national market.

Although manufacturing is the core of the region's economic base, non-manufacturing industries accounted for some two-thirds of total regional product in 1994. The service sector, which makes up the bulk of the non-manufacturing side of the economy, has provided, and is expected to continue to provide, the great majority of all new jobs created in the region. This follows the national trend. However, the region does not have particular comparative advantages in the service sector, as it does in manufacturing. Thus, compared with the national service sector, the service sector in the Energy Vision 2020 study area remains highly dependent on the income generated in manufacturing.

Figure T1-5 shows these historical trends for earnings, employment, and product in the manufacturing and service sectors of the TVA power service area.

Future Trends

For the balance of the decade, the region's performance is expected to continue the trend of the 1985 to 1994 period. Relatively favorable national conditions and TVA's favorable electric rates for regional manufacturing are both expected to continue. TVA expects the region's newer manufacturing industries to continue further expansion. However, worldwide economic competition is likely to become more intense as some trade barriers are removed and regions of the world favor trading blocs. For this reason, businesses will continue to hold down labor costs as much as possible; downsizing and relatively slow wage growth in the TVA region will persist. Overall, manufacturing growth in the region is expected to exceed the national rate significantly. The strength in the region's service sector is expected to continue, following the growth in manufacturing.

After the year 2000, Energy Vision 2020 expects the region's growth will slow considerably as the area's newer manufacturing industries reach maturity. Nevertheless, manufacturing's intensiveness is expected to continue to provide enough impetus for the region to expand somewhat faster than the national rate. The region's service sector is expected to remain somewhat underdeveloped relative to the nation's. Thus, with the slowing of manufacturing growth, the whole regional economy is expected to proceed at a slower tempo.

The TVA region is not a uniform economic area, however. Manufacturing accounts for about twice the share of non-farm employment in the region's non-metropolitan areas compared to the metropolitan areas (42 percent compared to only 20 percent). Further, the region's non-metropolitan areas have shown faster growth in manufacturing during expansionary periods than its metropolitan areas. Thus, the non-metropolitan areas have been, and are more likely to continue to be, more affected by the fortunes of manufacturing.

Additional information on the economic forecast is available in Volume 2, Technical Document 5, "Load Forecast." Detailed information on the regional economic situation and trends is available from TVA in a report titled "Economic Outlook" (TVA 1994).

The Agricultural Sector

Agriculture directly represents a very small percentage of the Valley's economy. The terms "agriculture" and "agricultural" refer to industries grouped in Division A of the Office of Management and Budget's (OMB) Standard Industrial Classification of Establishments. Division A industries include those involved in crop and livestock production, agricultural services, forestry, fishing, hunting, and trapping.

In 1989, only 2.7 percent of the area's population lived on farms. These farms generated only 1.8 percent of the region's total earnings, produced only 1.6 percent of its total product, and employed only 5.1 percent of its labor force. These small percentages belie the importance of agriculture to the area, however, since they do not account for the strong linkages between the agricultural sector and most other Valley industrial sectors. Once the economy's most important sector, agriculture has been declining in importance in terms of earnings, product, and employment, as shown in *Figure T1-6*. It is expected to continue to wane in the future.

The table in *Figure T1-6* shows that the Valley's farm population in 1969 was almost three times larger than in 1989. Earnings, employment, and production also fell steeply over the period, both absolutely and relative to regional totals. By 2020, the Valley's agricultural sector is expected to account for only 0.5 percent of regional earnings, 0.9 percent of regional product, and 3.1 percent of regional employment.

FIGURE T1-6. **Population, Earnings, Employment, and Product in the Agricultural Sector in 1969, 1979, and 1989**

	1969	1979	1989
Farm Population	636,090	337,008	219,503
Earnings (millions of 1994 dollars)	$2,675	$2,176	$1,656
Employment	250,876	224,901	201,401
Product (millions of 1987 dollars)	$1,936	$1,769	$1,865
SHARE OF REGIONAL TOTAL:			
Farm Population	9.5%	4.3%	2.7%
Earnings	5.0%	2.9%	1.8%
Employment	9.7%	6.8%	5.1%
Product	3.3%	2.1%	1.6%

1 Population for the 201-County Valley Region from the 1970, 1980, and 1990 U.S. Censuses of Population.

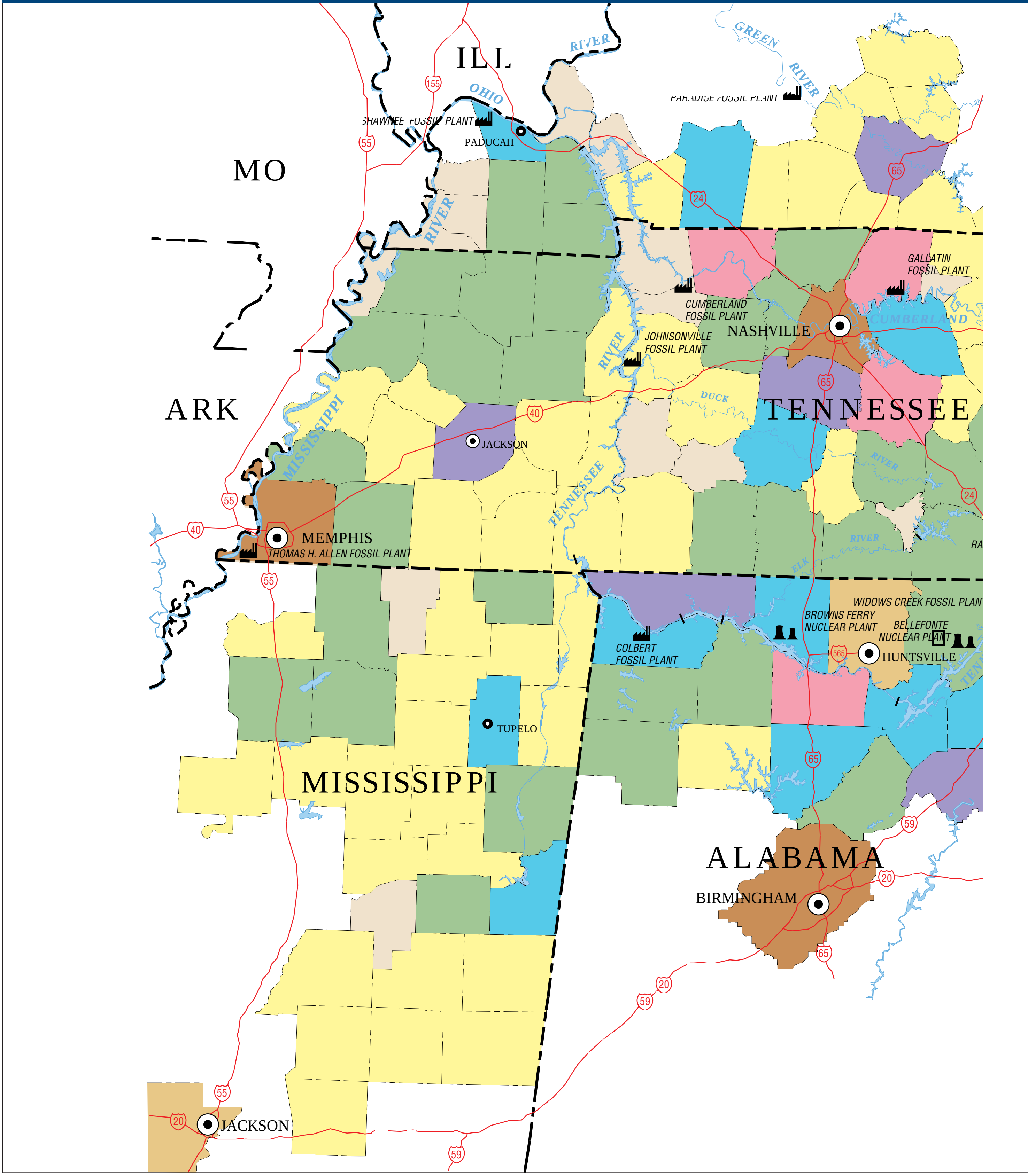
2 Earnings, employment, and product data are for the 170-County Power Service Area.

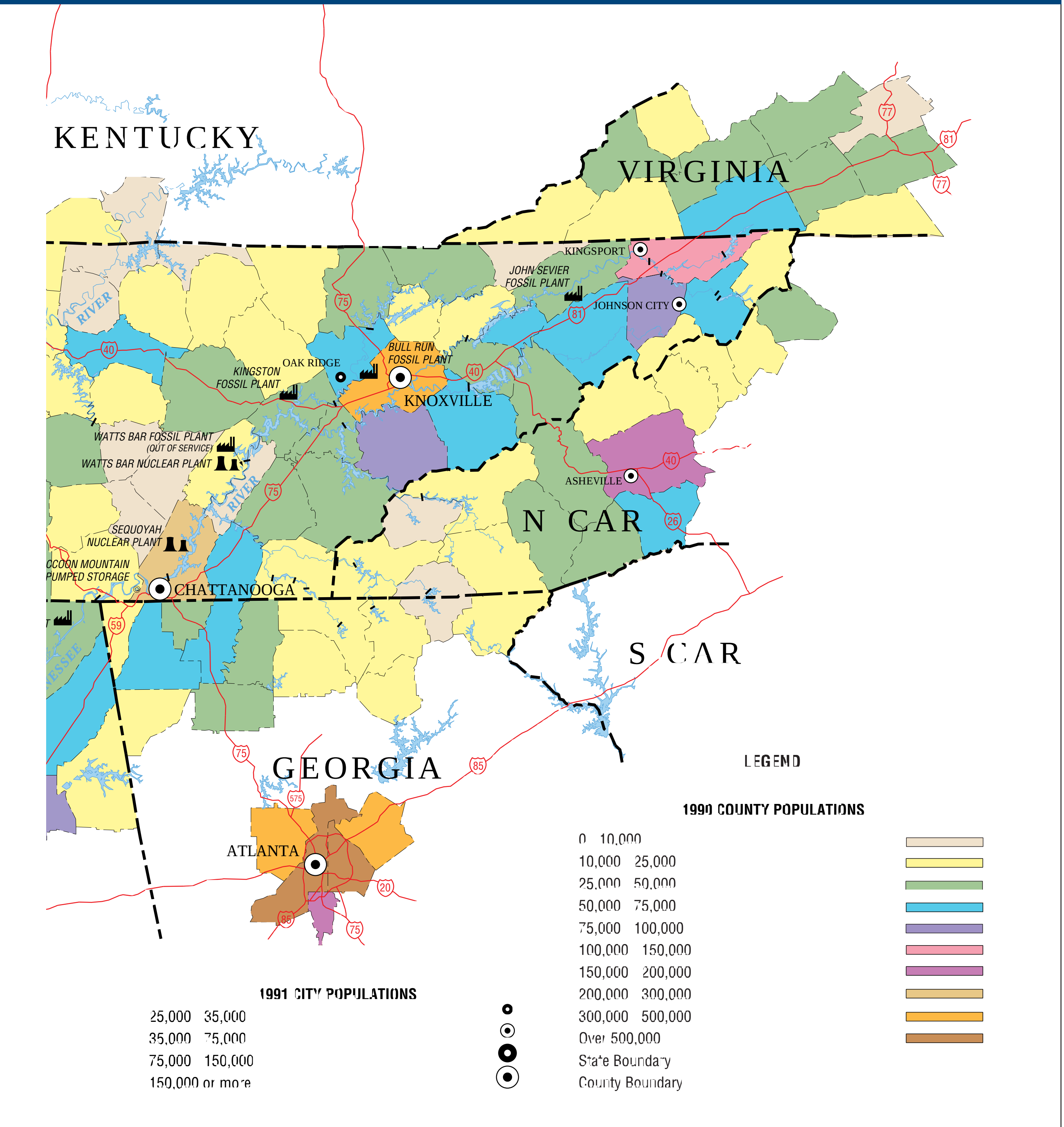
Population

About 8.7 million people live in the 201-county TVA region (about 7.7 million of these within the TVA power service area), with almost half residing in the major metropolitan areas of Nashville, Memphis, Knoxville, Chattanooga, and Tri-Cities, Tennessee, and Huntsville, Alabama. These metropolitan areas are all mid-sized, without any one large dominating area in the region, and are distributed fairly evenly throughout the region. Surrounding these metropolitan areas are a few smaller metropolitan areas and numerous satellite cities, along with the surrounding rural communities connected by both economic and transportation links. *Figure T1-7* shows the distribution of population in the TVA region. Thus, the region, while largely rural, is generally well served by centers of commerce and government, and the workforce is evenly distributed across the region, rather than focused in any particular central area.

Although only about 15 percent of the population is non-white, the distribution of the non-white population is very uneven across the region. There are greater concentrations in the central counties of metropolitan areas and in an area including most of the region's Mississippi counties, Memphis, and the counties north and east of Memphis. The region's African American households had a median income of $15,705 in 1990, about two-thirds of the region's median. Most of the region's non-metropolitan counties also had low median income levels. Similarly, regional poverty rates are generally much higher among the non-white population and in both rural and inner city areas. (Poverty rates are 34 percent for African American persons compared with 16 percent of the total population.)

FIGURE T1-7. **Population Distribution for Counties and Selected Cities**





MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

SECTION 3: AIR RESOURCES

Introduction

This section describes the ambient (surrounding) air quality of the TVA region, discusses TVA emission contributions to ambient air quality, and identifies air quality impacts to human health and welfare. Volume 2, Technical Document 2, Environmental Consequences, describes how changes in TVA emissions could affect regional air quality, human health, environmental resources, and materials.

The primary region of the affected environment is broadly defined as the state of Tennessee, as well as southwestern Kentucky, southwestern Virginia, western North Carolina, and northern Georgia, Alabama, and Mississippi. This area represents the watershed of the Tennessee River and the 201 counties of the greater TVA service area, as shown in *Figure T1-2*. Emissions from outside the Tennessee Valley region contribute to air quality in the Valley. Also, TVA emissions are transported outside the Valley and have some impact on air quality beyond the primary study area. Although the study area experiences a number of air quality problems, overall air quality is good.

Weather and Climate Patterns

Weather and climate patterns of the Tennessee Valley affect several aspects of TVA's energy strategy. Strategy considerations include:

- Ability to meet permitted thermal limits for cooling water discharges and nuclear safety intakes
- Available energy supply from hydroelectric power generation (a function of reservoir water levels)
- Energy demand for heating and air conditioning
- Dispersion of air emissions from TVA facilities and their impact on regional air quality

Much of the year the western extension of the Azores-Bermuda high pressure ridge dominates the TVA region. This circulation results in extended periods of fair weather and, at times, atmospheric stagnation. Its greatest influence is in the summer and fall. Warm, humid air masses dominate in the summer with occasional tropical disturbances from the Gulf or cold fronts from the northwest, north, or northeast. Light winds and considerable sunshine typify summer weather, often with afternoon cumulus clouds and scattered thunderstorms. The Bermuda high is much weaker in winter and spring. Stronger westerly flows dominate the weather pattern, bringing alternately low and high pressure systems. Storms come primarily from the Southwest and the Gulf Coast or from the Plains and the Midwest.

FIGURE T1-8. **Climatic Averages of Eight First-Order National Weather Service Stations in the TVA Region[1]**

	MEAN TEMPERATURE [2]		MEAN DEWPOINT [3]		PRECIPITATION [2]		Percent of	WIND SPEED [3]	
	Celsius	Fahrenheit	Celsius	Fahrenheit	Millimeters	Inches	Possible Sunshine [4]	Meters Per Second	Miles Per Hour
Annual	14.9	58.9	8.9	48.0	1,270	50.01	59	3.3	7.3
Winter	4.5	40.1	-0.8	30.5	334	13.13	47	3.8	8.4
Spring	14.9	58.8	7.9	46.2	360	14.19	61	3.7	8.3
Summer	24.7	76.5	18.8	65.9	301	11.87	64	2.6	5.8
Fall	15.7	60.3	9.6	49.3	275	10.82	61	2.9	6.5
Maximums and Month of Occurrence									
Month	JULY		JULY		MARCH		JUNE	MARCH	
Maximum	25.5	77.9	19.7	67.4	135	5.32	66	4.2	9.3
Minimums and Month of Occurrence									
Month	JANUARY		JANUARY		OCTOBER		JANUARY	AUGUST	
Minimum	3.0	37.4	-1.6	29.1	76	2.99	44	2.5	5.5

1 Cities include Asheville, North Carolina; Tri-Cities Airport, Knoxville Airport, Chattanooga, Nashville and Memphis, Tennessee; Birmingham and Huntsville, Alabama.

2 1961 – 1990 normals.

3 1951-1980 hourly data bases.

4 Excluding Tri-Cities Airport and Huntsville; data periods for the other six varying, but generally including 1951-1980.

FIGURE T1-9. **Annual Average Temperatures and Precipitation Averaged for 1961-1990 Across the TVA Region**

	TEMPERATURE		PRECIPITATION	
	Celsius	Fahrenheit	Millimeters	Inches
Southwest Virginia, Western North Carolina	12.0	53.6	1,268	49.9
Eastern Tennessee	13.7	56.7	1,271	50.0
Central Tennessee & Kentucky	13.7	56.7	1,358	53.5
Western Tennessee & Kentucky	14.5	58.0	1,302	51.3
North Georgia & Northeast Alabama	15.5	59.8	1,431	56.3
Northwest Alabama & North Mississippi	16.3	61.3	1,435	56.5

Two charts paint a picture of climate conditions in the TVA region. *Figure T1-8* gives 30-year average temperatures for the Tennessee Valley. Average summer temperatures are 24.7^{o} C (76.5^{o} F) and winter temperatures, 4.5^{o} C (40.1^{o} F). Heat waves with daily maximum temperatures above 35^{o} C (95^{o} F) occur in some summers, and cold waves with temperatures falling below -15^{o} C (5^{o} F), in some winters. The southern and western parts of the region are warmer than the northern and eastern parts *(Figure T1-9)*. *Figure T1-10* contrasts summer temperatures during 1988 and 1989. These are examples of temperatures for unusually dry and wet years. Summer 1988 was warmer than normal; summer 1989, cooler than normal.

Figure T1-8 indicates that precipitation is abundant and normally well distributed throughout the year, although winter and spring are somewhat wetter than summer and fall. Averages in this table are representative of lower elevations in the Tennessee Valley. Patterns of precipitation across the TVA region are indicated in *Figure T1-9*. *Figure T1-11* indicates regional patterns during the abnormally dry summer of 1988 and wet summer of 1989. The last in a series of five drier than normal years was 1988. The period from 1985 to 1988 marked the four driest consecutive years during the last 100 years in the Tennessee River Basin. This pattern is important in interpreting regional air quality impacts during the decade of the 1980s.

Wind speed and direction significantly determine weather patterns and dispersion of emissions. *Figure T1-8* shows that surface wind speeds are relatively light, with higher winds in winter and spring and lower winds in summer and fall. Wind speeds at higher elevations are generally stronger than averages shown in the table. The most frequent surface wind directions are from the south or southeast and from the north or northeast sectors. *Figure T1-12* gives the surface wind roses (direction patterns) for airports in the TVA region. At higher levels in the atmosphere, winds generally blow from the southwest, west, or northwest, as shown on the same map by the Nashville windsaloft wind rose for an altitude of 1,500 meters above ground level. A windrose is a diagram with spokes representing the sixteen cardinal directions (i.e., N, NNE, NE, etc.). The frequency with which the measured wind blows from a given direction is illustrated by the distance between the point where a heavy line, or edge of the rose, crosses a spoke and the center of the diagram. In *Figure T1-12*, the wind direction frequencies in all windroses have been normalized (i.e., divided by a common factor) using the frequency of the most frequent wind direction. Thus, the heavy line in each windrose crosses the outer end of the spoke representing the most frequent wind direction (a normalized frequency of one). A direction only half as frequent as the most frequent direction has a normalized frequency of 0.5, and the heavy line crosses the midpoint of the spoke.

Figure T1-8 indicates that solar radiation (shown as percent of possible sunshine) and dewpoint are higher in the summer than other seasons.

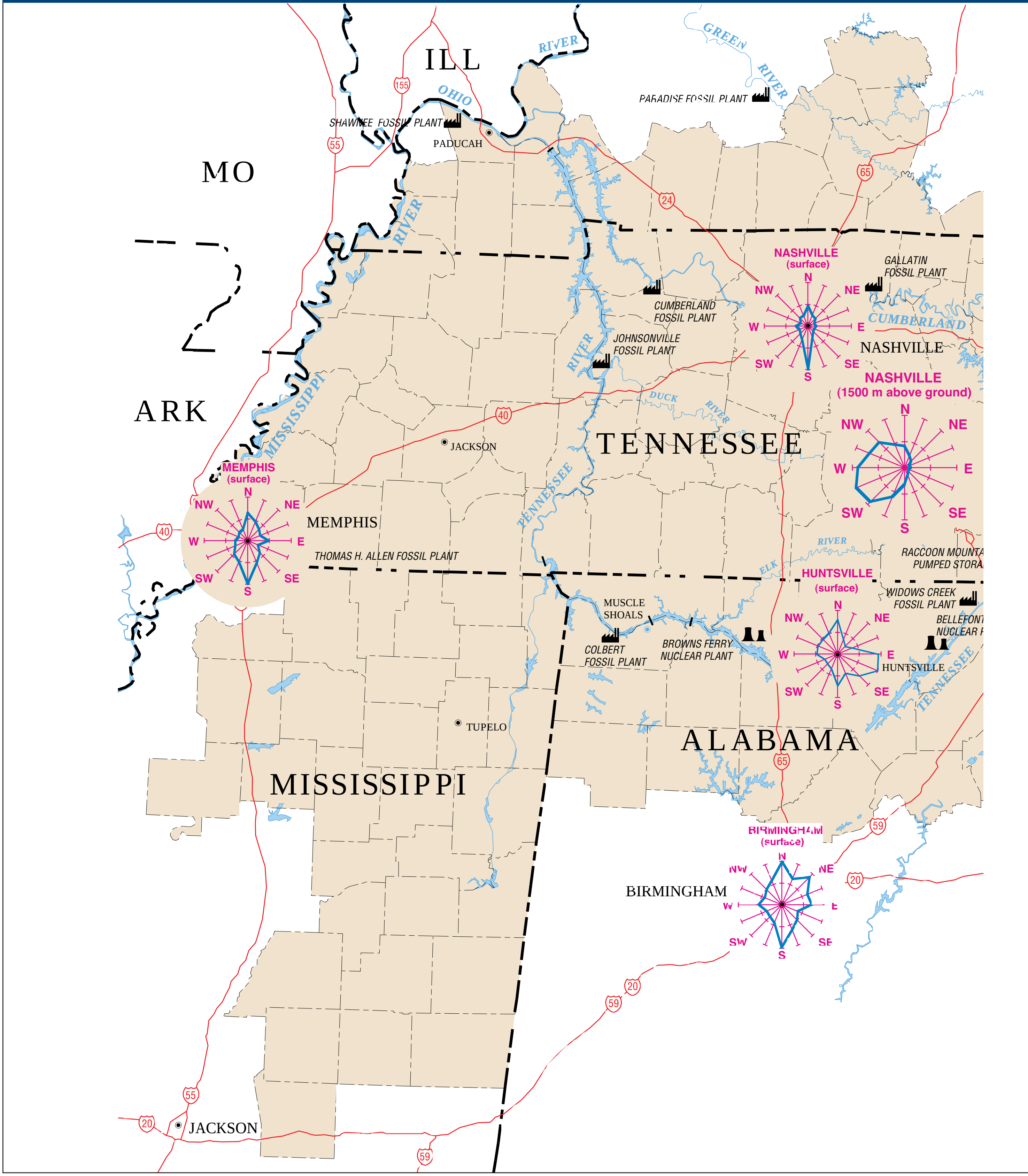
FIGURE T1-10. **Summer Temperature Across the TVA Region for 1988 and 1989**

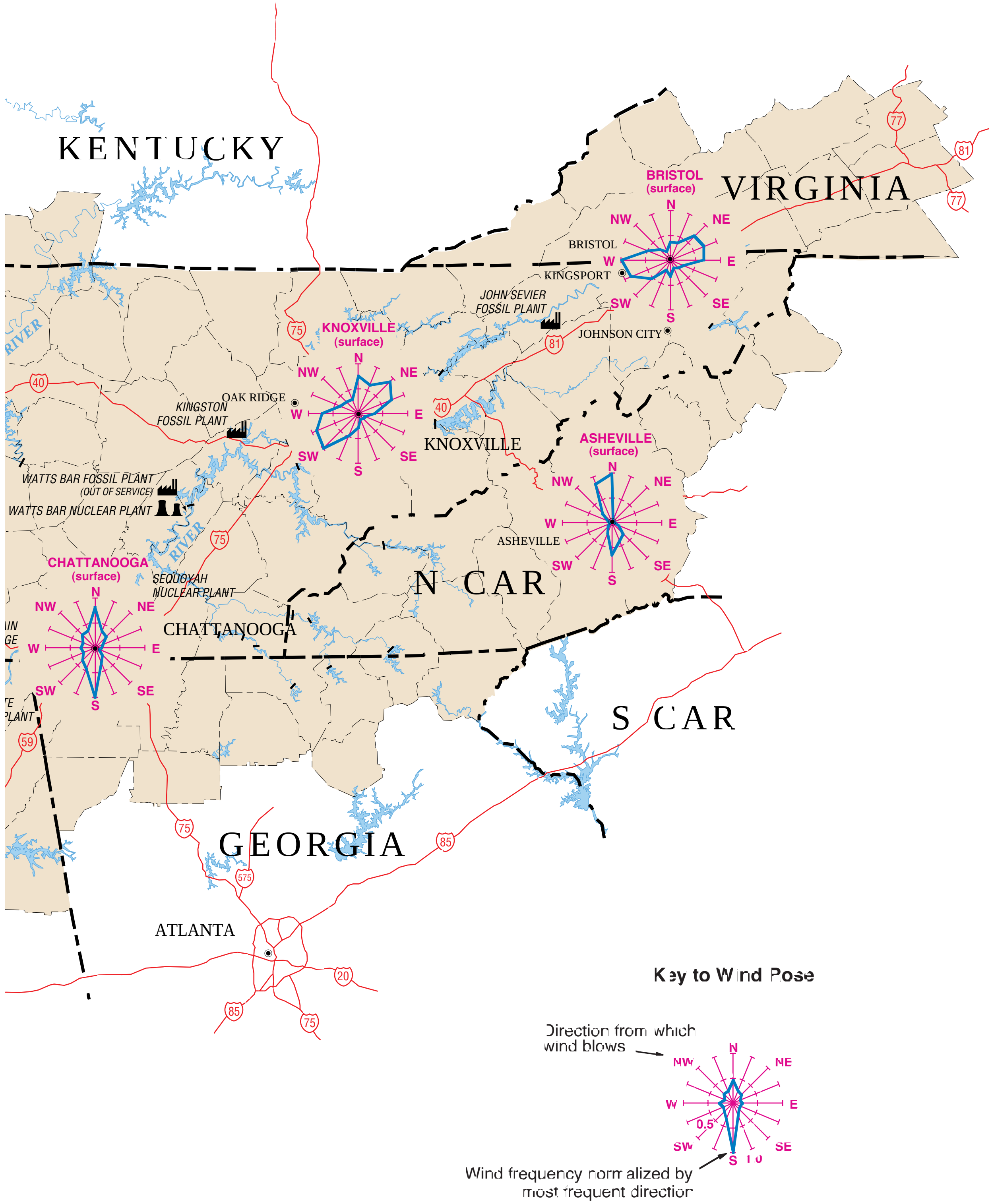
	Summer 1988 Fahrenheit	Summer 1989 Fahrenheit
Southwest Virginia, Western North Carolina	71.1	70.3
Eastern Tennessee	74.8	73.6
Central Tennessee & Kentucky	76.8	74.2
Western Tennessee & Kentucky	78.5	76.3
North Georgia & Northeast Alabama	77.5	75.8
Northwest Alabama & North Mississippi	79.3	77.5

FIGURE T1-11. **Summer Precipitation Across the TVA Region for 1988 and 1989**

	Summer 1988 Inches	Summer 1989 Inches
Southwest Virginia, Western North Carolina	10.5	20.5
Eastern Tennessee	10.0	17.9
Central Tennessee & Kentucky	10.1	18.3
Western Tennessee & Kentucky	9.3	15.9
North Georgia & Northeast Alabama	9.5	21.2
Northwest Alabama & North Mississippi	7.8	21.2

FIGURE T1-12. **Prevailing Wind Direction for Surface Winds at 8 Regional Airports and Winds Aloft at Nashville**





MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

Weather Patterns and Air Pollution

Weather and climate affect pollutant levels within the troposphere, or lowest layer of the atmosphere. Wind, temperature, humidity, atmospheric turbulence, clouds, and precipitation influence air pollution locally and regionally. These different scales interact with various meteorological factors to control air pollution through the transport, transformation, dilution, and removal of air pollutants.

WIND

The atmosphere is composed primarily of oxygen and nitrogen. Their relative abundance remains constant throughout the troposphere in a homogeneous mix. Pollutant concentrations are highly non-homogeneous, as are water vapor and clouds. Consequently, the relative mix of atmospheric constituents varies geographically and from one day to the next. However, the atmosphere does exhibit some persistent trends when examined over a period of a year or longer. Perhaps the most significant trend is a general tendency for westerly air flow across the United States. Individual weather systems, such as large-scale (horizontal dimensions greater than 1,000 kilometers) extra-tropical cyclones (low pressure areas) and anti-cyclones (high pressure areas), may move in varying directions. In addition, local (near surface) winds may tend to blow more frequently with a southerly or northerly component. However, when averaged over all areas for an entire year, the general direction of air flow is from west to east.

Wind direction holds implications for air pollution transport. Pollutant sources tend to have their greatest environmental impact east of their location. Local geography may modify this tendency somewhat, especially for pollutant emissions close to the ground. However, emissions from elevated stacks such as power plants are transported primarily toward the east. This does not mean that, on an individual episode basis, such sources cannot impact areas in other directions. Indeed, instances of episodic exposure are most likely to deviate from the standard west-to-east rule-of-thumb for the source of pollution to the receptor of pollution. Examples of these short-term exposures would involve high hourly ozone concentrations and high acidic deposition rates associated with individual precipitation events.

TEMPERATURE AND WATER VAPOR

Air temperature and water vapor levels are generally greater in summer than in winter, and are generally higher in the southern United States than in the North. This has important implications for some secondary pollutant formation. Chemical reactions in the atmosphere generally depend on the temperature: the higher the temperature, the faster the reaction rate. Some chemical reactions, especially those associated with ozone formation, also depend on water vapor. Higher humidity levels produce faster reactions. In addition, biogenic or natural sources (plants and soils) emit chemical byproducts most strongly when air temperatures are high. Thus, natural nitrogen oxide and isoprene (volatile organic compounds emitted by vegetation) emissions are most likely to be high when atmospheric conditions are also most conducive to photochemical production of ozone.

Atmospheric humidity also strongly influences the size of fine aerosols or particles suspended in the air. As humidity rises, more particles are able to attract greater amounts of water vapor. These particles then scatter light. When this happens, a haze forms that reduces incoming sunlight and obscures visibility. Thus, regional visibility impairment is strongly coupled not only with the proximity of pollution sources producing fine suspended particles, but also with air masses characterized by high moisture content.

ATMOSPHERIC INSTABILITY

Wind speed has a dilution effect on air pollutants, with stronger winds resulting in lower concentrations of pollutants. Atmospheric turbulence, defined as air motion over spatial scales of a few hundreds of meters down to a few centimeters, is even more important in determining how rapidly pollutant emissions are diluted upon entering the atmosphere. Turbulence is produced primarily by wind shear (wind speed and/or direction changes over small distances) and convective instability. The latter is especially important on sunny afternoons when solar heating of the ground produces local “thermals” or masses of heated air which rise and eventually mix with their surroundings. This process leads to a fairly rapid vertical exchange of mass (moisture and pollution), heat energy, and momentum. Thus, the vertical structure of the lower atmosphere, or boundary layer, is controlled by convective processes much of the time. Air pollutants emitted near the ground are immediately (i.e., within a few minutes) diluted vertically whenever strong vertical turbulence occurs. Pollutants from elevated points are often not diluted as rapidly, and may actually avoid much vertical dilution altogether if emitted from a sufficiently tall stack. Thus, pollutants emitted at night, when convective turbulence is uncommon, undergo only slow dilution, enabling plumes of pollutants from some sources to travel long distances intact.

CLOUDS AND PRECIPITATION

Few natural components of the atmosphere are more variable than clouds. They can be associated with the large-scale cyclones, medium-(or meso-) scale thunderstorm complexes, or small-scale afternoon thermals. Clouds form over elevated terrain, when warm and moist air passes over cold water or land,

and whenever conditions are conducive to fog. Except in the case of fog, clouds are produced when moist air rises and cools. This cooling can result in the air temperature falling below the dewpoint, or temperature at which the relative humidity is 100 percent. At this point air becomes slightly oversaturated, and water vapor condenses onto the available surfaces of fine suspended particles. These very small droplets (generally less than 100 micrometers) form clouds.

Clouds are important in air pollution formation for several reasons:

- Clouds scatter solar radiation, sending some of it back into space. This can reduce the amount reaching the lower troposphere, thereby minimizing photochemistry.
- Clouds can reduce the air temperature near the ground, which can also lead to reduced photochemistry.
- Clouds formed as the result of convective instability can puncture the stable layer that usually caps the surface-based mixing layer of the atmosphere. This can lead to the vertical exchange of pollutants between the mixing layer and the "free troposphere" above.

Clouds are especially important in promoting aqueous-phase chemical reactions that produce secondary pollutants, such as sulfate aerosols, from the sulfur dioxide emitted by human-produced sources. After a cloud evaporates, it leaves behind fine acidic particles. These particles eventually fall out of the atmosphere or are scavenged by precipitation. Precipitation cannot exist without clouds. Consequently, precipitating clouds have the following roles:

- Serve as efficient scavengers of some air pollutants
- Can deliver large amounts of acidic pollutants to the ground
- Play an important role in cleansing the atmosphere
- Over elevated terrain, surface vegetation can intercept clouds and scavenge droplets, thereby depositing pollutants directly to the surface as cloud or "occult" deposition.

Precipitation acts in a manner similar to clouds in scavenging airborne particles and gases. Rain can deliver large amounts of acidic materials in a relatively short period of time. Water from rainfall can cover leaf surfaces by depositing pollutants directly on vegetation, runoff into surface waters, or percolate into soils. Percolated water deposits pollutants in the soils or, in some cases, delivers pollutants into groundwater storage. Snowfall can enable pollutants to build up in accumulated snowpack, especially in mountainous terrain, and deliver large pulses of pollutants to surface waters during spring melt.

Air Regulations

CRITERIA AIR POLLUTANTS

The TVA region generally has good air quality. This conclusion is based primarily on widespread attainment of the National Ambient Air Quality Standards. These standards have been established by the U.S. Environmental Protection Agency (EPA) for pollution concentrations in the outdoor air. The Environmental Protection Agency has established standards for six "criteria" pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, lead, particulate matter, and ozone. Two levels for air quality were established. Primary standards are set at levels to protect public health; secondary standards are set to protect public welfare (e.g., visibility, aquatic ecosystems, crops and forests, soils, materials). Current National Ambient Air Quality Standards are shown in the table in *Figure T1-13*.

The terms "primary pollutants" and "secondary pollutants" are distinctly different from the terms " primary standards" and "secondary standards." Primary pollutants are emitted directly from the source into the atmosphere; secondary pollutants are formed in the atmosphere from primary emissions. Examples of

FIGURE T1-13. **The National Ambient Air Quality Standards Set Limits for Six Pollutants to Protect Human Health and the Environment**

Pollutant	Averaging Time	STANDARD Primary	STANDARD Secondary
Carbon Monoxide	8-hour 1-hour	9.0 35.0	none none
Lead	Quarter Year	1.5	1.5
Nitrogen Dioxide	Annual	0.053	0.053
Ozone	1-hour	0.12	0.12
Particulate Matter Less Than 10 Microns in Size (PM10)	24-hour Annual	150 μg/m3 50 μg/m3	150 μg/m3 50 μg/m3
Sulfur Dioxide	3-hour 24-hour Annual	none 0.14 0.03	0.50 none none

National standards, other than annual standards, are not to be exceeded more than once per year (except where noted in the figure). Units are parts per million by volume of air except for particulate matter with diameters less than or equal to 10 microns, which is expressed in micrograms per cubic meter. The ozone standard is attained when the expected number of days per calendar year in which the maximum hourly average concentration is above the standard is equal to or less than one day.

primary pollutants are sulfur dioxide, nitrogen dioxide, and particulate matter. Examples of secondary pollutants are ozone, acidic deposition, and fine-particulate matter.

Locales where pollutant concentrations do not exceed the level of the standards are in compliance with the National Ambient Air Quality Standards. They are designated "attainment areas." Where standards are not achieved, they are designated "nonattainment." Where insufficient information exists for designation, areas are unclassified. The maps in *Figures T1-14* through *T1-17* show areas of attainment and nonattainment in the TVA region for sulfur dioxide, ozone, total suspended particulates, and lead. The maps indicate that the National Ambient Air Quality Standards have been attained in most locations in the region.

Specific discussions of criteria pollutants, their sources, ambient trends, and future regulations follow the discussion of air quality concerns related to the Clean Air Act Amendments.

CLEAN AIR ACT AMENDMENTS OF 1977

The Clean Air Act Amendments of 1977 established timetables for periodically reviewing existing standards and adopting new standards if necessary at approximately five-year intervals. Standards are under review by the Environmental Protection Agency in 1995 for sulfur dioxide, particulate matter smaller than 10 microns, and ozone. The Environmental Protection Agency's 1994 review of the nitrogen dioxide standard recommended no changes. No action on the carbon monoxide or lead standards is being considered.

Prevention of Significant Deterioration

The Prevention of Significant Deterioration section of the 1977 Clean Air Act Amendments provides special protection for air quality and air quality-related values in national parks and wilderness areas, designated as Class I areas. Class I areas within the Energy Vision 2020 Study Area include the Great Smoky Mountains National Park, Mammoth Cave National Park, and the Joyce Kilmer/Slickrock, Shining Rock, Linville Gorge, Cohutta, Sipsey, and Mingo National Wilderness Areas. The map in *Figure T1-18* depicts these areas.

Federal land managers (including the National Park Service and U.S. Forest Service) have authority to review state permit requests for new or expanding sources whose air emissions might impact air quality and air quality-related values in a Class I area. Air quality-related values include visibility, flora, fauna, surface waters, ecosystems, and geological, cultural, and historical resources. A specific national goal was defined for visibility to prevent impairment by human-induced air pollutants. Action is required to mitigate any existing visibility impairment in a Class I area and to forestall any future impairment. Legislation requires reasonable progress toward this national goal (U.S. Code of Federal Regulations 1977). If federal land managers determine that emissions from the requesting source could cause an adverse impact to air quality-related values, they can recommend that the states deny or otherwise modify a permit application to restrict emissions or to offset impacts. The burden of proof to demonstrate source-specific impacts falls on the federal land manager.

Since 1990 the National Park Service and the U.S. Forest Service have cited adverse impacts from acid deposition, ozone, and visibility impairment in Class I areas in southern Appalachia. These agencies have recommended emission offsets as a permit condition for several new applicants in Virginia, Tennessee, and North Carolina. In the February 1992 Federal Register (U.S. Code of Federal Regulations 1992), the National Park Service announced a preliminary finding of adverse air quality impacts in the Great Smoky Mountains National Park and recommended that the states disallow any net increase in emissions in a 200-kilometer exclusion zone surrounding the Park. In a 1994 publication "Clearing the Air at Great Smoky Mountains National Park," the National Park Service discusses adverse impacts documented in the Great Smoky Mountains National Park and their actions to protect the park's natural resources (Shaver et al. 1994).

Air quality in southern Appalachia meets all current federal standards. Voluntary and cooperative action is required to effectively mitigate present and prevent future adverse impacts. Contributions from existing industries and communities, as well as new or expanding sources, must be considered. The Southern Appalachian Mountain Initiative, a regional air quality assessment program, includes the eight states surrounding the southern Appalachians, the Environmental Protection Agency, the National Park Service, the U.S. Forest Service, TVA, industries, the community, environmental groups, academia, and the general public. The Southern Appalachian Mountain Initiative intends to evaluate and recommend options to remedy existing and prevent future adverse air quality impacts. The Southern Appalachian Mountain Initiative and other research and assessment programs in which TVA is cooperating are described later in this section.

AIR QUALITY CONCERNS SINCE THE 1977 CLEAN AIR ACT AMENDMENTS

Several air quality concerns have emerged in the past two decades. Acid deposition, regional visibility impairment, hazardous air pollutants, and greenhouse gases are now either regulated or are being considered for regulation. The 1990 Clean Air Act Amendments:

- Strengthened regulatory authority to address areas that were not in attainment with the National Ambient Air Quality Standards
- Legislated emission reductions to reduce acid deposition

- Required reductions of hazardous air pollutants from known industrial sources
- Provided for studies to characterize the extent of utility emissions of hazardous air pollutants
- Set up additional monitoring and reporting requirements for major sources of pollutants

Discussions of acid deposition, visibility impairment, hazardous air pollutants, and greenhouse gases follow discussions of criteria pollutants below.

Air Pollutants

SULFUR DIOXIDE

Health and Welfare Concerns

Depending on the concentration, sulfur dioxide can impact human health. As a respiratory irritant, it was one of the first air pollutants to be regulated because of its association with industrial pollution episodes in the 1940s and 1950s that resulted in a number of deaths in England. *Figure T1-19* shows that ambient exposures of sulfur dioxide in the Tennessee Valley have been reduced by more than 40 percent since 1979. Current ambient levels of sulfur dioxide are now well below the national standards and the thresholds for damage to vegetation and materials. Despite success in reducing ambient concentrations, the Environmental Protection Agency is evaluating whether short-term exposures to elevated sulfur dioxide concentrations may pose a health risk to a small population of exercising, nonmedicated asthmatics. The Agency is considering a new short-term standard that could require further sulfur dioxide emission reductions. Sulfur dioxide is also a precursor for sulfate, a secondary pollutant that contributes to acidic deposition and fine-particulate matter that can impact human health and impair visibility.

Sources of Contribution

At ambient outdoor levels, sulfur dioxide is an odorless, colorless gas. Biological decay, volcanic activity, and other natural sources contribute about half the total global emissions of atmospheric sulfur. In industrialized countries human-produced sources far exceed natural sources. Fossil-fuel power plants, industrial boilers, ore processing facilities, and petroleum refineries are sources of major human-produced emissions. The Environmental Protection Agency's 1990 Interim Emissions Inventory was used to project total sulfur dioxide emissions from point, area, and mobile sources in the general source area for the Tennessee Valley. This is shown on the map in *Figure T1-20*.

FIGURE T1-19. **Concentrations of Sulfur Dioxide in the Energy Vision 2020 Study Area Are 40 Percent Below 1979 Levels**

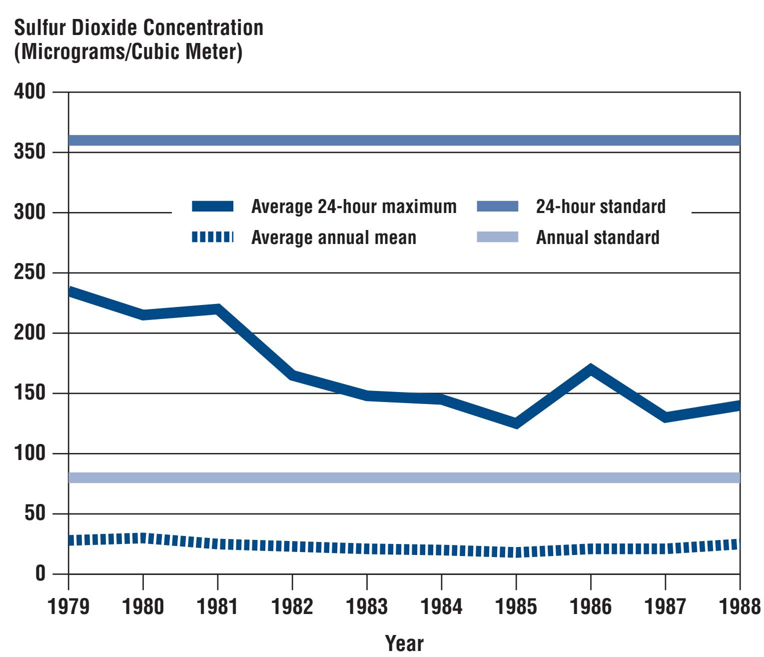
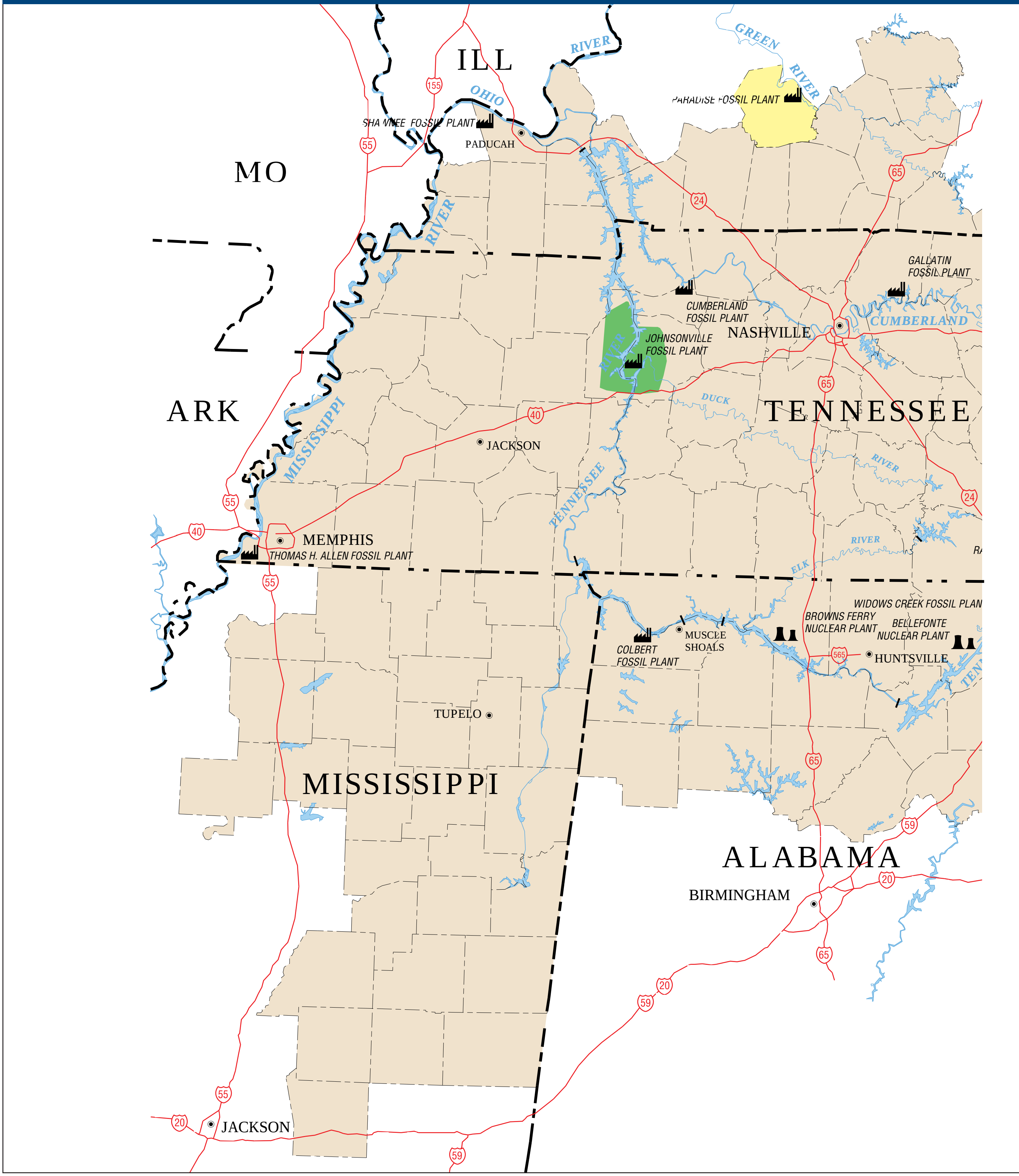


FIGURE T1-14. **Areas in Nonattainment for Sulfur Dioxide Under the National Ambient Air Quality Standards**



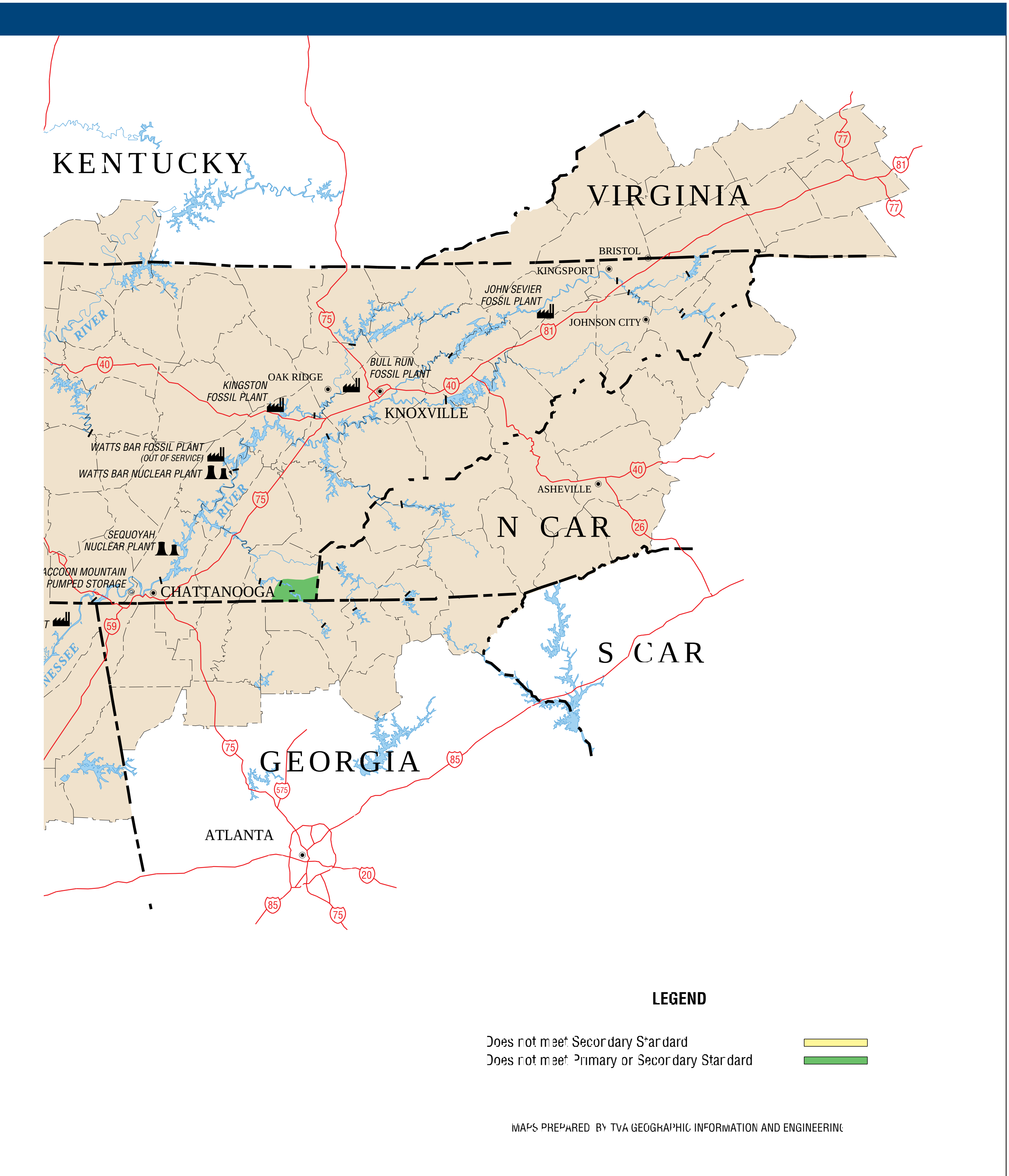
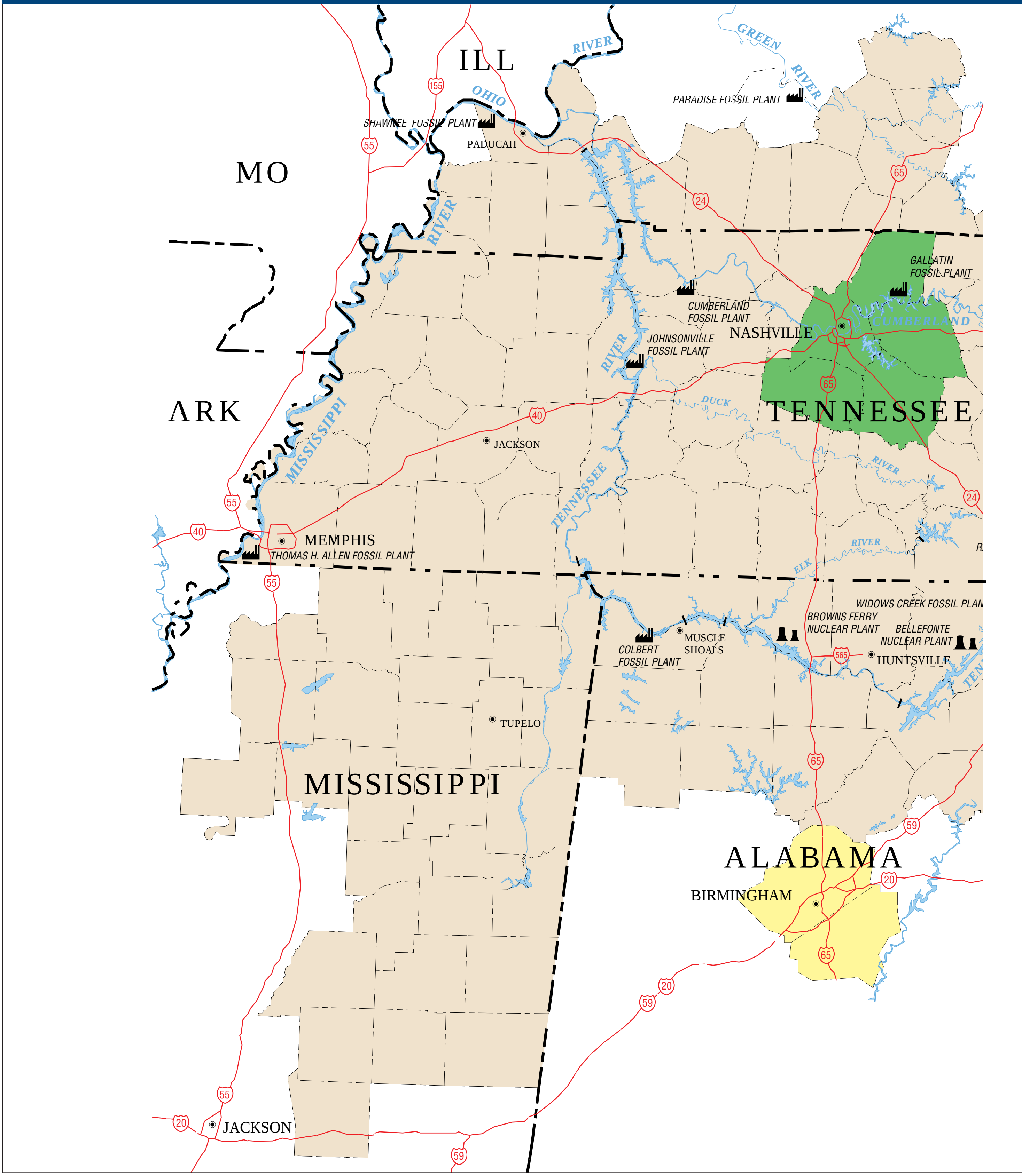
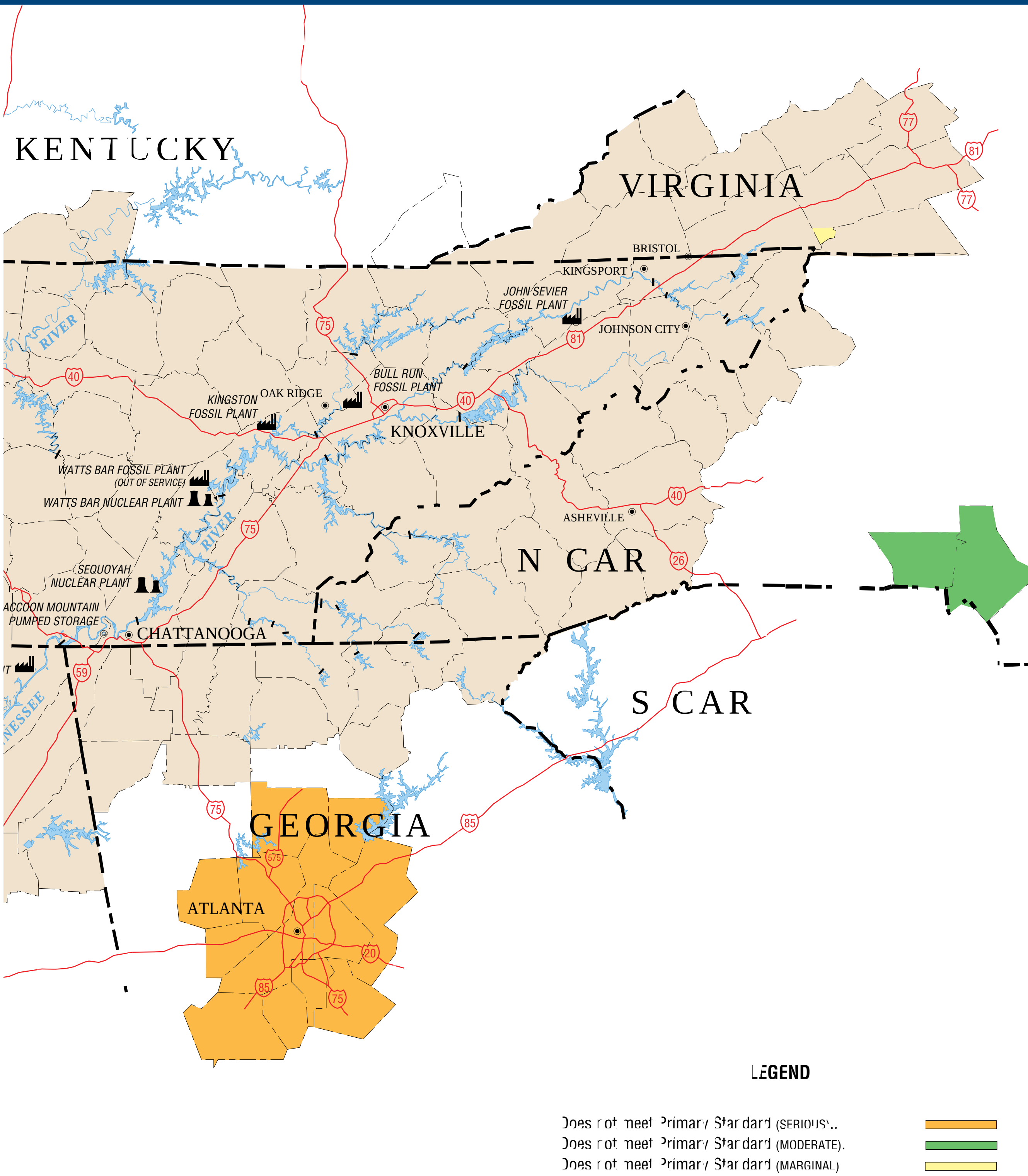

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
RIVER
OAK RIDGE
BULL RUN FOSSIL PLANT
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
RIVER
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
NESSEE
S CAR
GEORGIA
ATLANTA
LEGEND
Does not meet Secondary Standard
Does not meet Primary or Secondary Standard
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

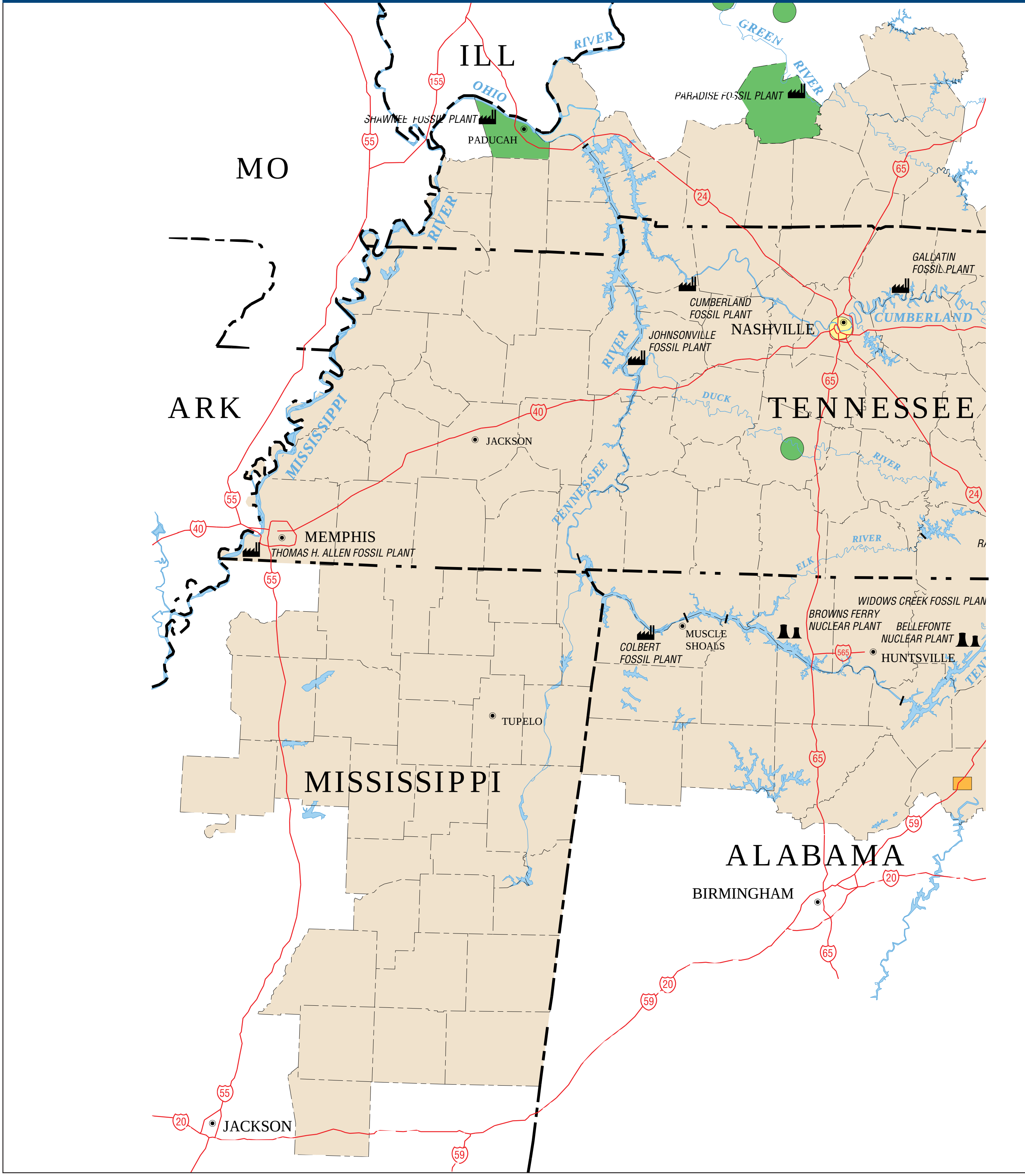
FIGURE T1-15. **Areas in Nonattainment for Ozone Under the National Ambient Air Quality Standards**

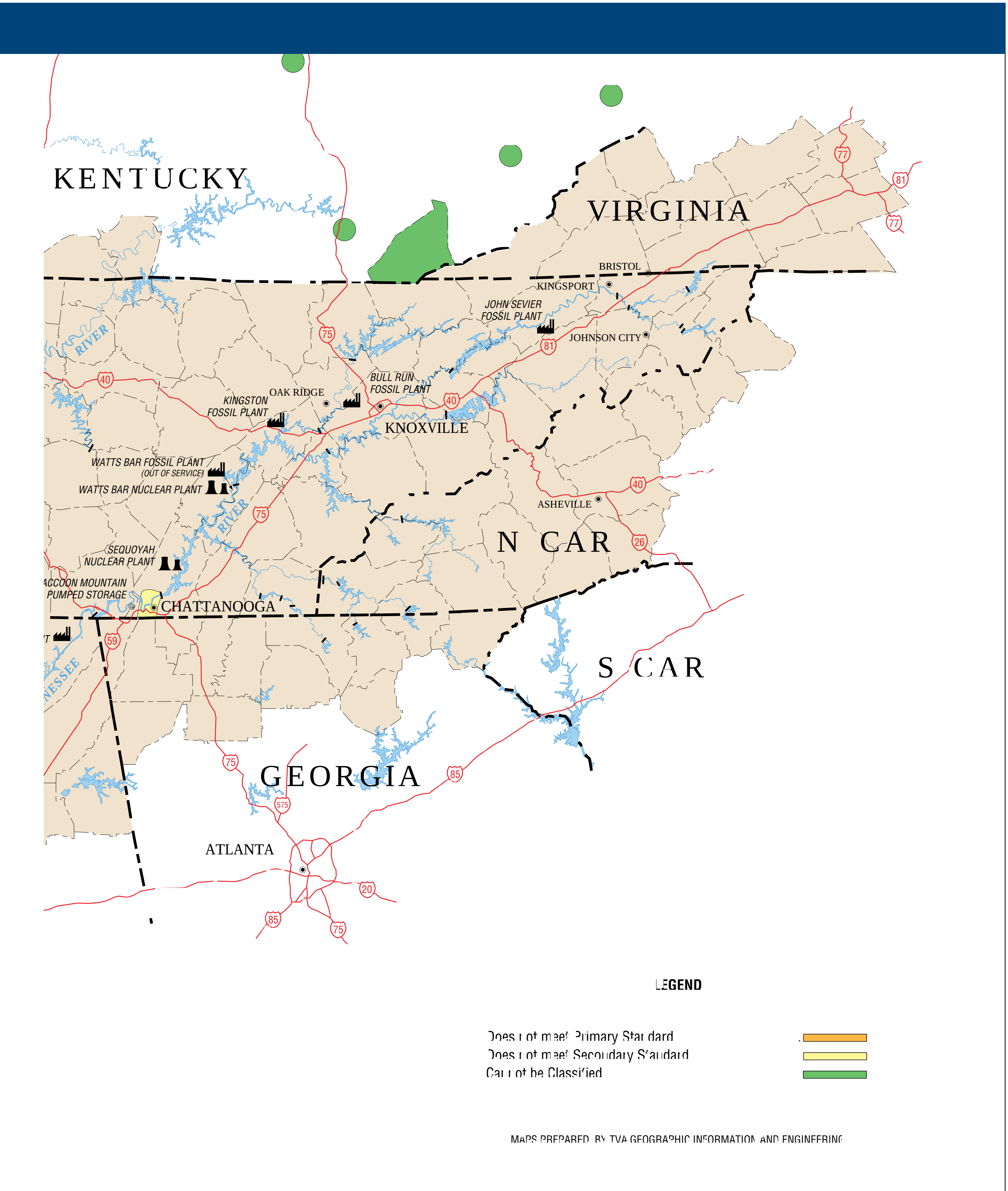




MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-16. **Areas in Nonattainment for Total Suspended Particulate Matter Under the National Ambient Air Quality Standards**




KENTUCKY
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KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
RIVER
OAK RIDGE
BULL RUN FOSSIL PLANT
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
RIVER
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
NESSEE
S CAR
GEORGIA
ATLANTA
LEGEND
Does not meet Primary Standard
Does not meet Secondary Standard
Cannot be Classified
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-17. **Areas in Nonattainment for Lead Under the National Ambient Air Quality Standards**

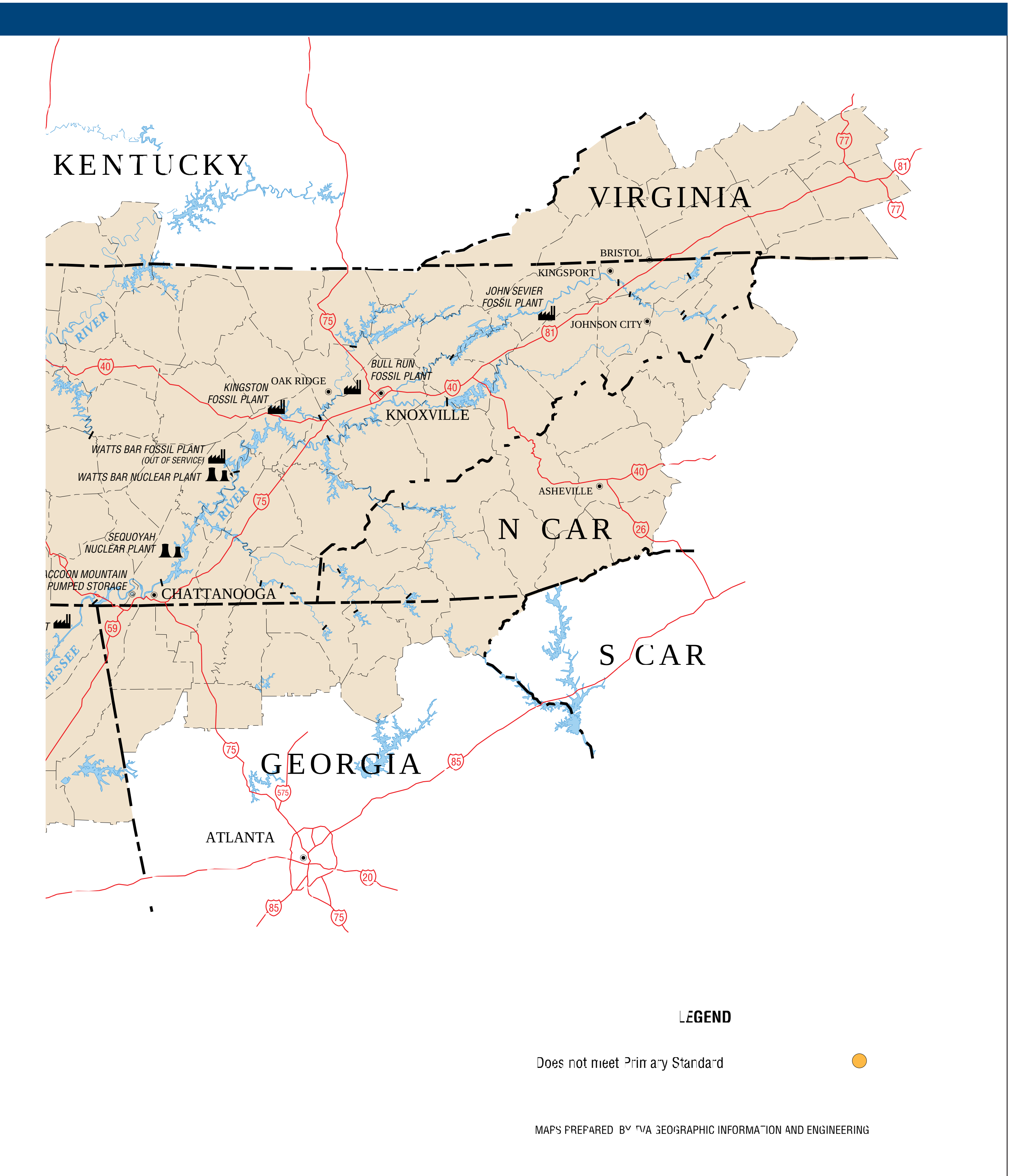
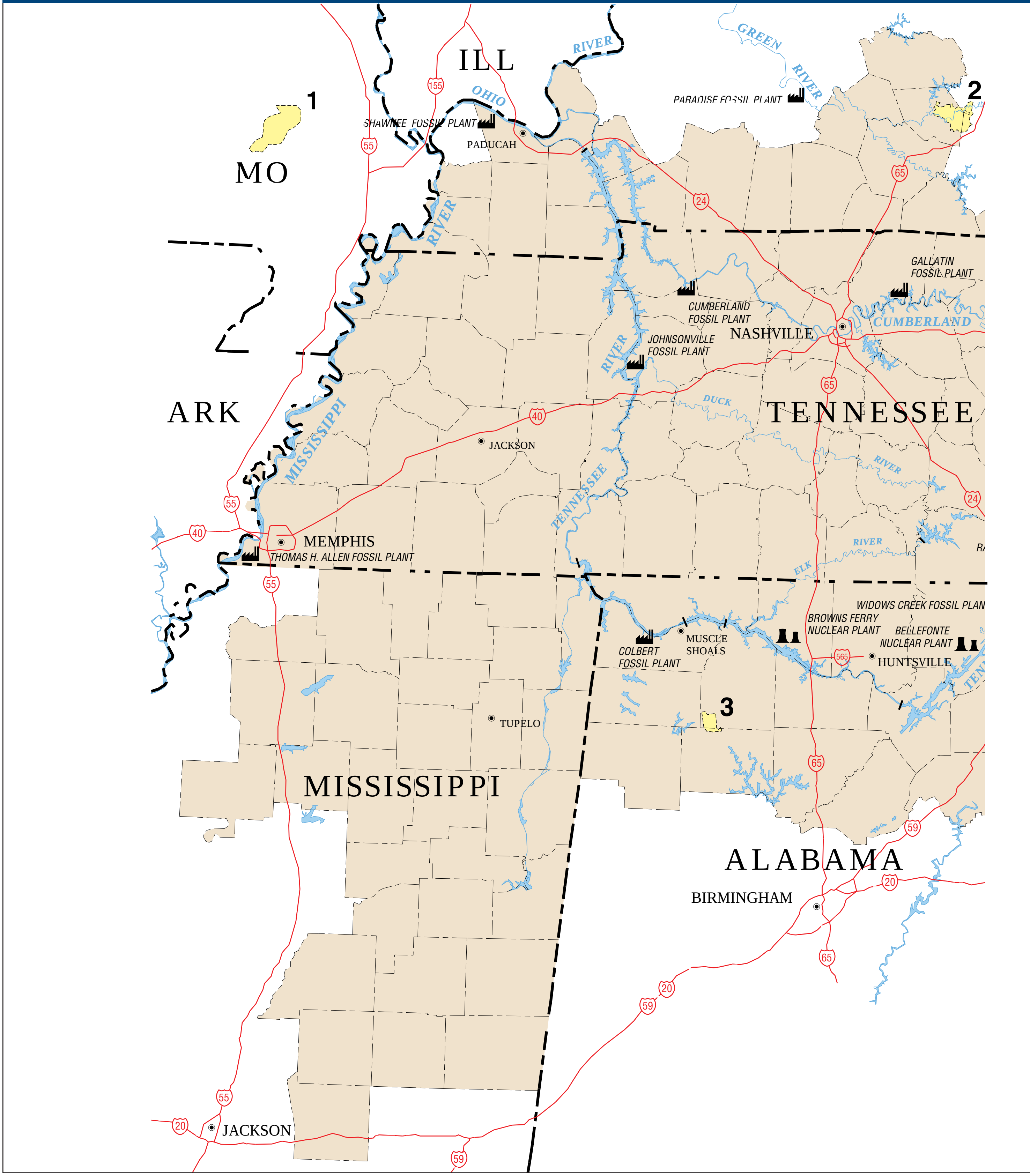
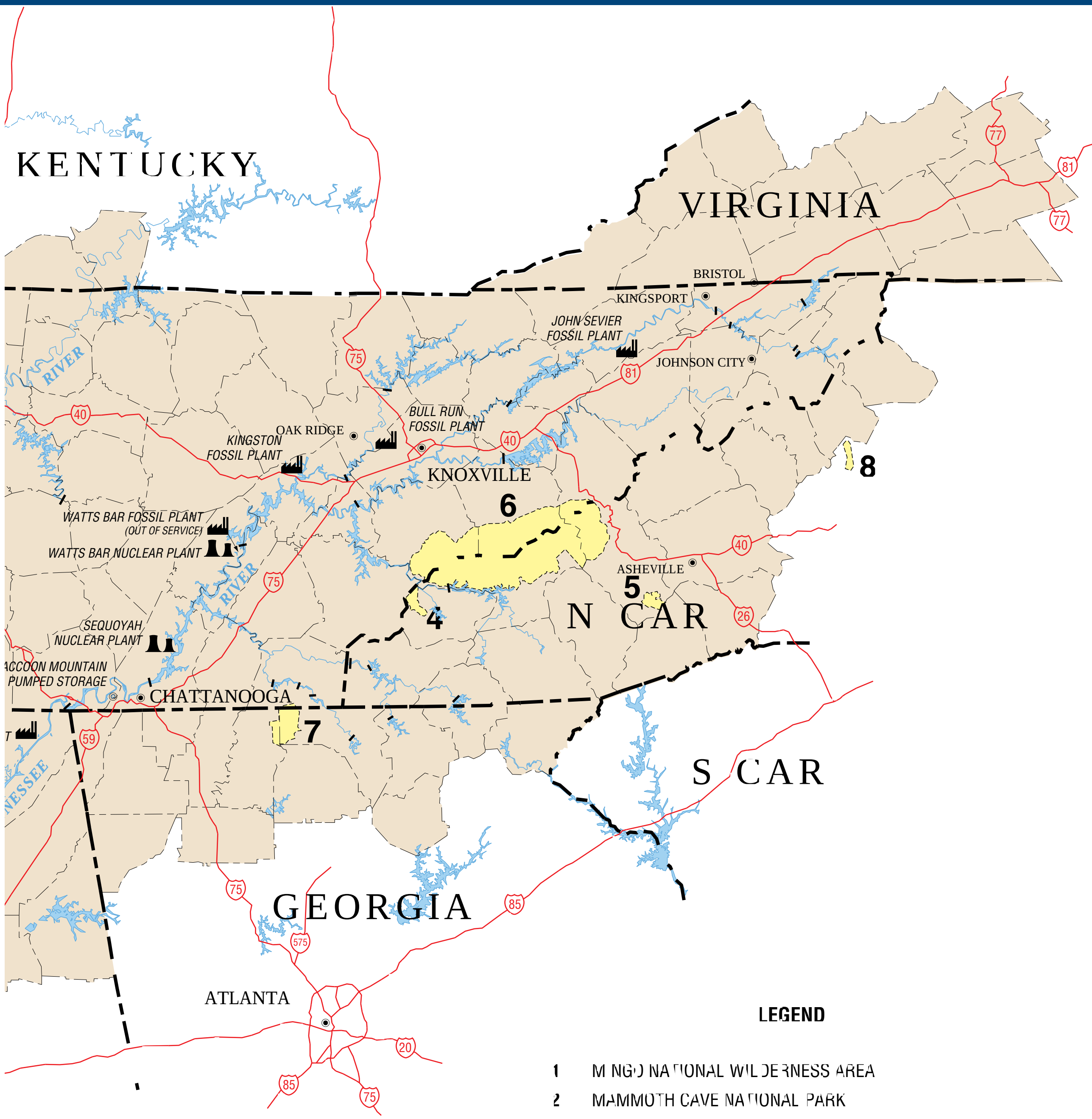

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
RIVER
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
RIVER
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
75
40
81
77
26
59
85
575
20
LEGEND
Does not meet Primary Standard
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-18. **National Park and National Wilderness Areas in the Energy Vision 2020 Study Area Designated as Air Quality Class I Areas for the Prevention of Significant Deterioration**



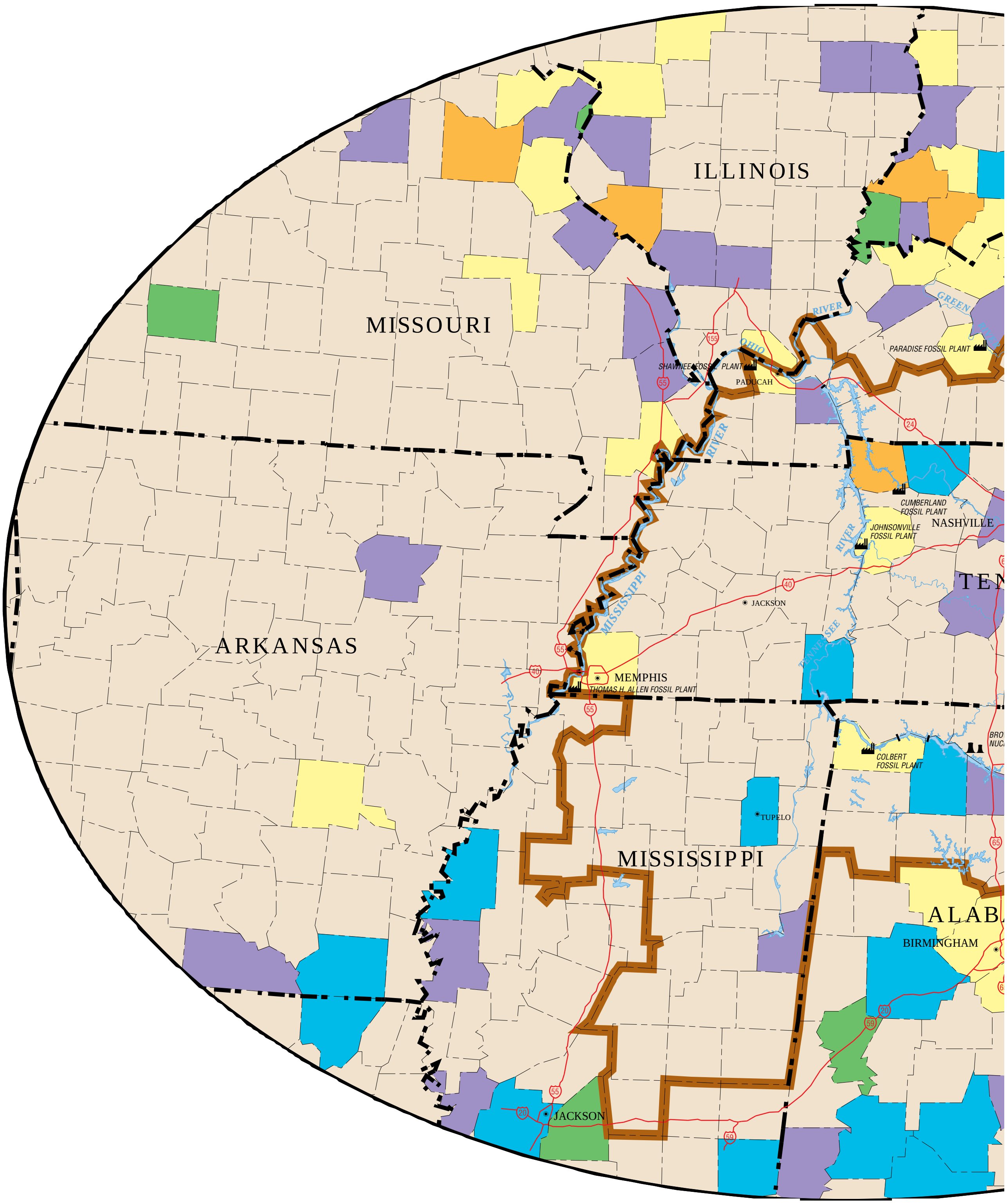


LEGEND

1 MINGO NATIONAL WILDERNESS AREA
2 MAMMOTH CAVE NATIONAL PARK
3 SIPSEY NATIONAL WILDERNESS AREA
4 JOYCE KILMER/SLICKROCK NATIONAL WILDERNESS AREA
5 SHINING ROCK NATIONAL WILDERNESS AREA
6 GREAT SMOKY MOUNTAINS NATIONAL PARK
7 COHUTTA NATIONAL WILDERNESS AREA
8 LINVILLE GORGE NATIONAL WILDERNESS AREA

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-20. **Total Sulfur Dioxide Emissions from Point, Area, and Mobile Sources in the Greater Source Area for Energy Vision 2020**



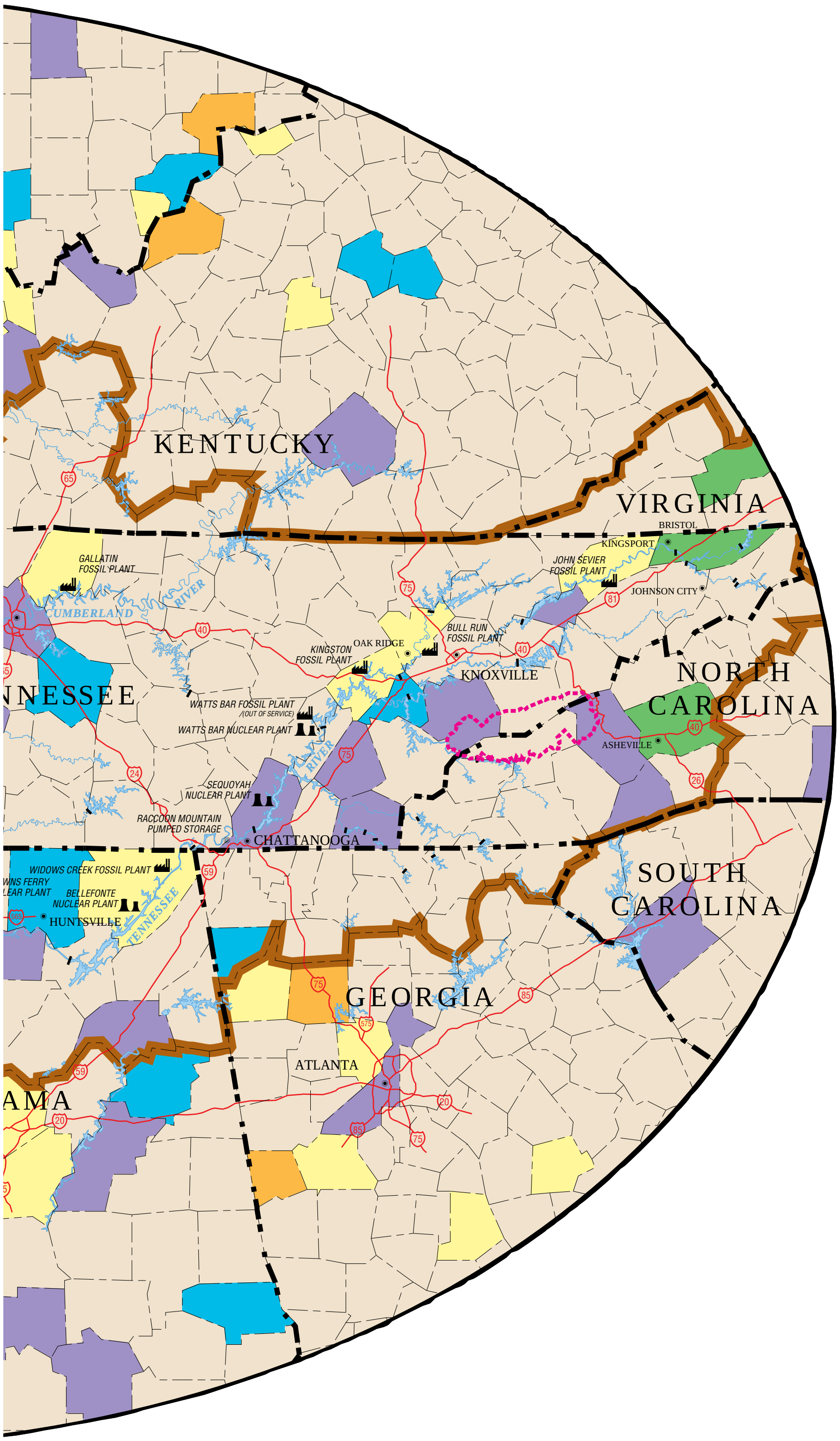
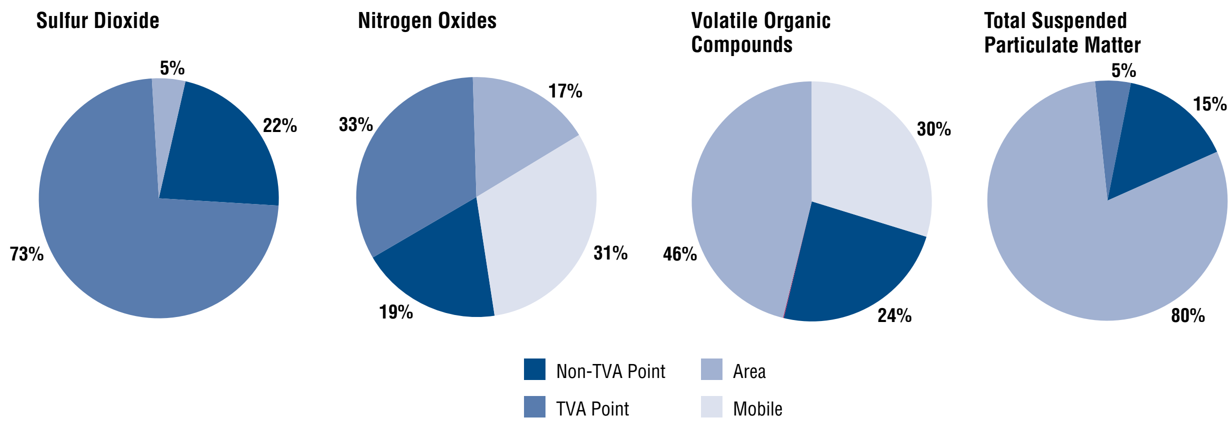

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
GALLATIN FOSSIL PLANT
CUMBERLAND
RIVER
OAK RIDGE
KINGSTON FOSSIL PLANT
BULL RUN FOSSIL PLANT
KNOXVILLE
NORTH CAROLINA
NNESSEE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
SEQUOYAH NUCLEAR PLANT
RACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
WIDOWS CREEK FOSSIL PLANT
BELLEFONTE NUCLEAR PLANT
HUNTSVILLE
TENNESSEE
SOUTH CAROLINA
GEORGIA
ATLANTA
AMA

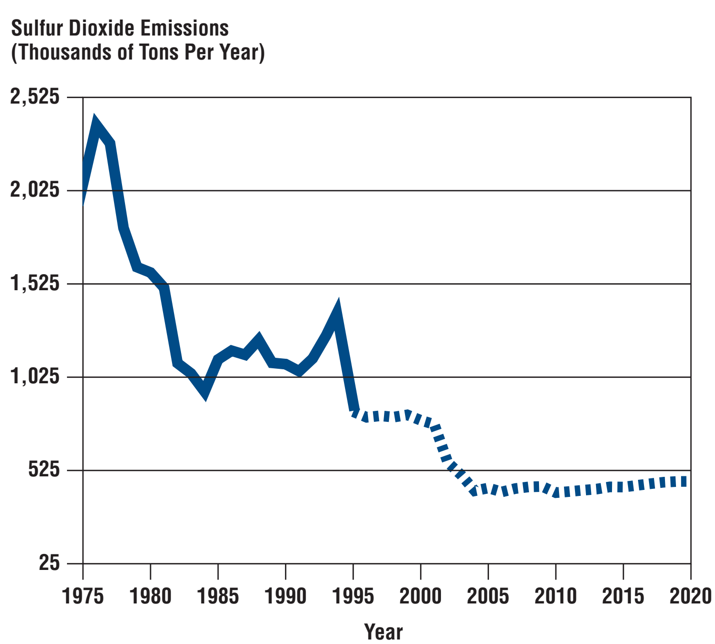
FIGURE T1-21. **Total Emissions of Human-Produced Sulfur Dioxide, Nitrogen Oxides, Volatile Organic Compounds, and Total Suspended Particulate Matter from the 201-County TVA Service Area**



Total emissions of sulfur dioxide, nitrogen oxides, and volatile organic compounds emissions from point, area, and mobile sources from the 201-county TVA service area are derived from Environmental Protection Agency 1990 Interim Inventory. Total suspended particulate matter emissions are derived from the 1985 Interim Inventory.

In the 201 counties of the TVA service area, TVA accounts for three-fourths of the total human-produced sulfur dioxide emissions as shown in *Figure T1-21*. In the greater source area that contributes to sulfur dioxide loadings in the Tennessee Valley, TVA's emissions are roughly one-fourth of total human-produced emissions. TVA sulfur dioxide emissions peaked in 1976 at 2,376,000 tons and have been reduced by two-thirds over the past two decades through installation of emission controls, coal washing, or switching to coals with lower sulfur content, as shown in the graph in *Figure T1-22*. Following full implementation of the 1990 Clean Air Act Amendments, TVA sulfur dioxide emissions are estimated to remain below 500,000 tons per year.

FIGURE T1-22. **Historic and Projected TVA Emissions of Sulfur Dioxide**



TVA emissions of sulfur dioxide have been reduced 60% since the1970s and will be further reduced in compliance with the 1990 Clean Air Act Amendments.

Ambient Trends

Figure T1-23 depicts emissions for each TVA coal-fired plant during fiscal year 1993. In 1995 scrubbers were placed into operation at the Cumberland Plant. This reduced sulfur dioxide emissions by 95 percent. Of the seven Valley counties with sulfur dioxide nonattainment areas in 1979, five have been reclassified as attainment areas, and two are pending reclassification. *(See Figure T1-14.)*

Future Regulations

The current national standard designates 3-hour, 24-hour, and annual average limits for ambient sulfur dioxide exposures. On November 15, 1994, the Environmental Protection Agency proposed to confirm the existing standards as adequate. They also proposed three alterna-

tive standards to address the possible health risk associated with short-term (five-minute) exposures by exercising asthmatic individuals. All three alternatives are likely to rely on increased monitoring in the vicinity of industrial sources to demonstrate compliance and could result in additional sulfur dioxide reductions.

Briefly, the three alternatives are:

- Revise National Ambient Air Quality Standard to include a 5-minute standard of 0.60 parts per million. This concentration could not be exceeded more than once per year.
- Establish a new regulatory program under section 303 (Emergency Powers) of the Clean Air Act. A five-minute standard of 0.60 parts per million would be used and action could be required after the first time concentrations are exceeded.
- Augment enforcement of existing standards through enhanced monitoring and by targeting sources that are most likely to produce high five-minute peak concentrations.

Sulfur dioxide monitoring in the vicinity of TVA coal-fired power plants is routinely collected as hourly rather than 5-minute averages. Extrapolating from this data, five-minute levels might exceed 0.60 parts per million at some TVA coal-fired plants. Implementation of a five-minute standard as described could result in additional sulfur dioxide control requirements at these plants.

NITROGEN DIOXIDE/NITROGEN OXIDES

Health and Welfare Concerns

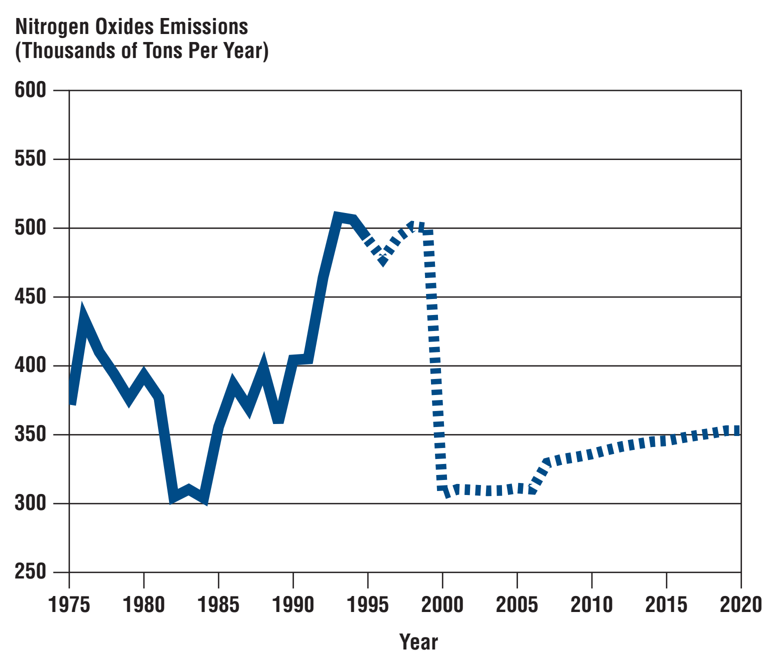
Depending on concentration, nitrogen dioxide can be a respiratory irritant. At current ambient levels in the TVA region, nitrogen dioxide health-related impacts are negligible. Nitrogen dioxide levels in the Tennessee Valley are well below the annual standard. There are no nitrogen dioxide nonattainment areas in the TVA region. Nitrogen oxides emissions do, however, contribute to regional acidic deposition and ozone formation. These are discussed in later sections. A very small amount (less than 5 percent) of the total nitrogen oxides emitted from a coal-fired power plant is nitrogen dioxide. Nitric oxide is the primary nitrogen species emitted and reacts rapidly with ozone in the atmosphere to form nitrogen dioxide.

Sources of Contribution

Natural sources of nitrogen oxides include microbial activity, lightning, and forest fires. Major human-produced sources include motor vehicles, fossil fuel power plants, industrial boilers, nitrogen fertilizers, and agricultural burning. The map in *Figure T1-24* displays total nitrogen oxides emissions from human sources, point (utility and industry), area (urban and small point source), and mobile (vehicle) sources in the greater source area likely to contribute to ozone levels in the Tennessee Valley, based on the Environmental Protection Agency's Interim 1990 emissions inventory. Within the 201 counties of TVA's service area, TVA emissions accounted for 33 percent of total human-produced nitrogen oxides, while mobile sources accounted for 31 percent. The map in *Figure T1-25* shows biogenic or natural emissions of nitrogen oxides estimated for the greater TVA source region. The Environmental Protection Agency's Biogenic Emissions Inventory, System II Model was used. Emissions of nitrogen oxides from fertilized soils on a hot, sunny summer afternoon can contribute up to 20 percent of daily nitrogen oxides emissions from all sources.

The graph in *Figure T1-26* illustrates TVA emissions of nitrogen oxides since 1975. The decline and rise of emissions between 1975 and 1990 is tied to coal use which varies with power system sales and the level of power production by nuclear

FIGURE T1-26. **Historic and Projected TVA Emissions of Nitrogen Oxides**



TVA nitrogen oxides emissions increased during the 1990s as coal-fired generation increased. Emissions will decrease as TVA complies with the 1990 Clean Air Act Amendments.

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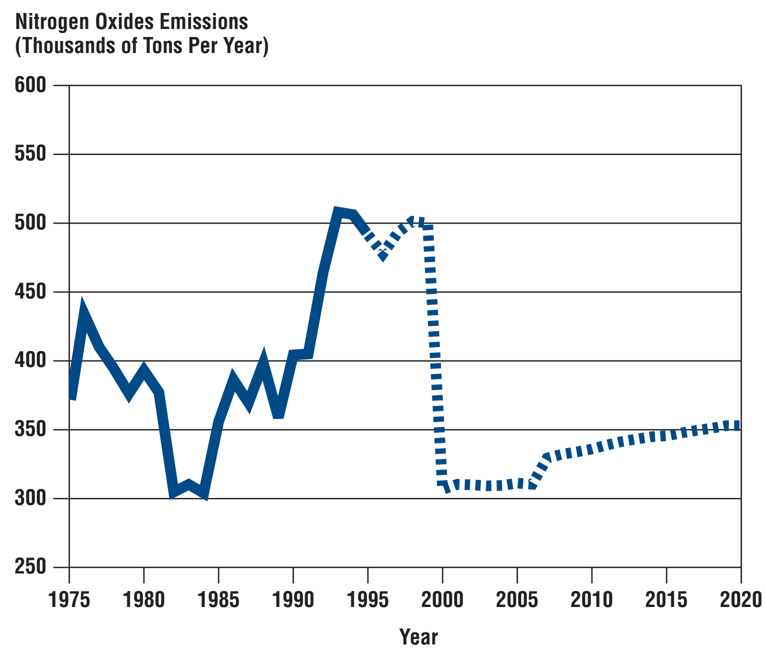
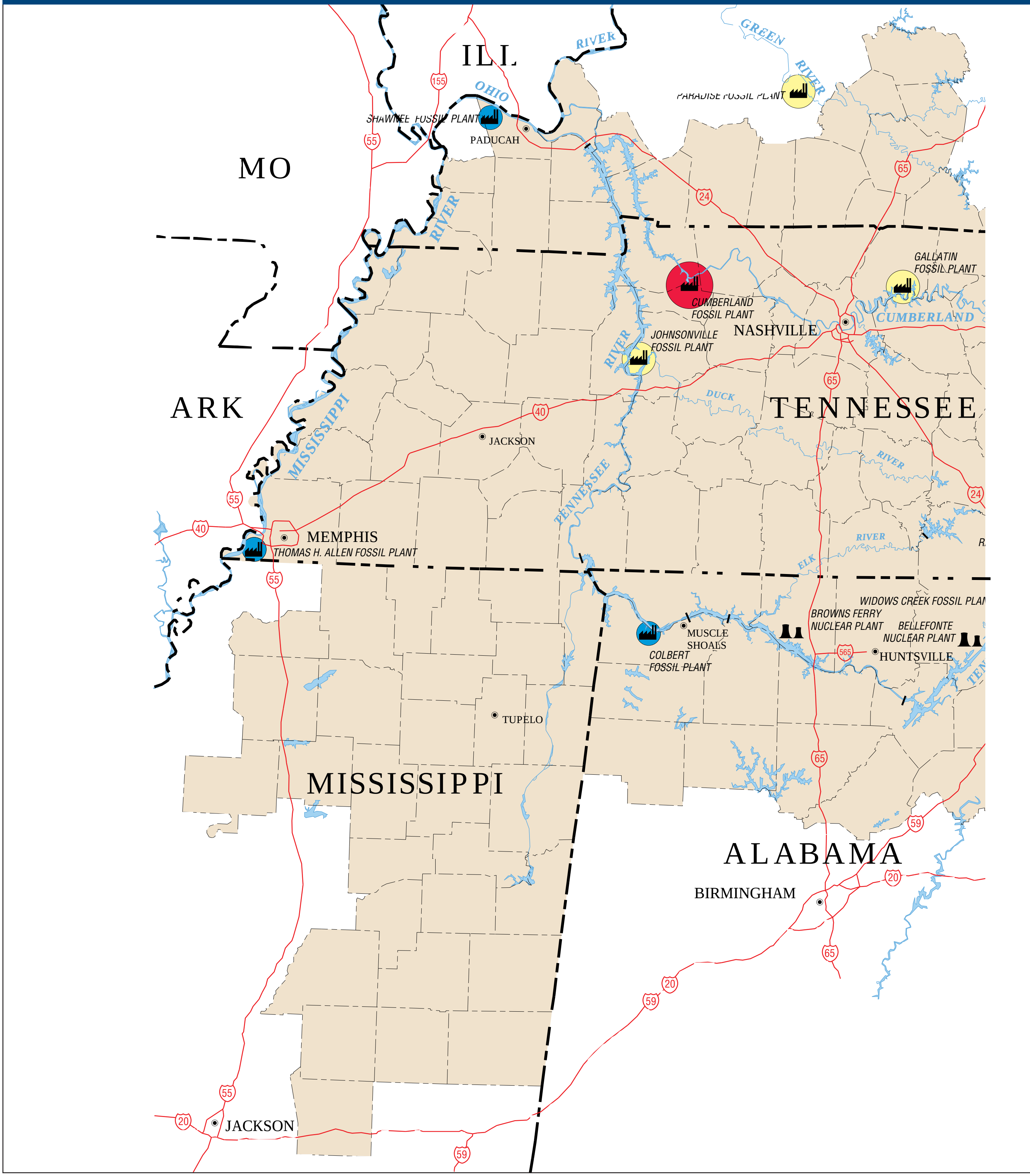


TVA nitrogen oxides emissions increased during the 1990s as coal-fired generation increased. Emissions will decrease as TVA complies with the 1990 Clean Air Act Amendments.

FIGURE T1-23. **Sulfur Dioxide Emissions From TVA Coal-Fired Power Plants in 1993 (Reductions From Cumberland Scrubbers Not Shown)**



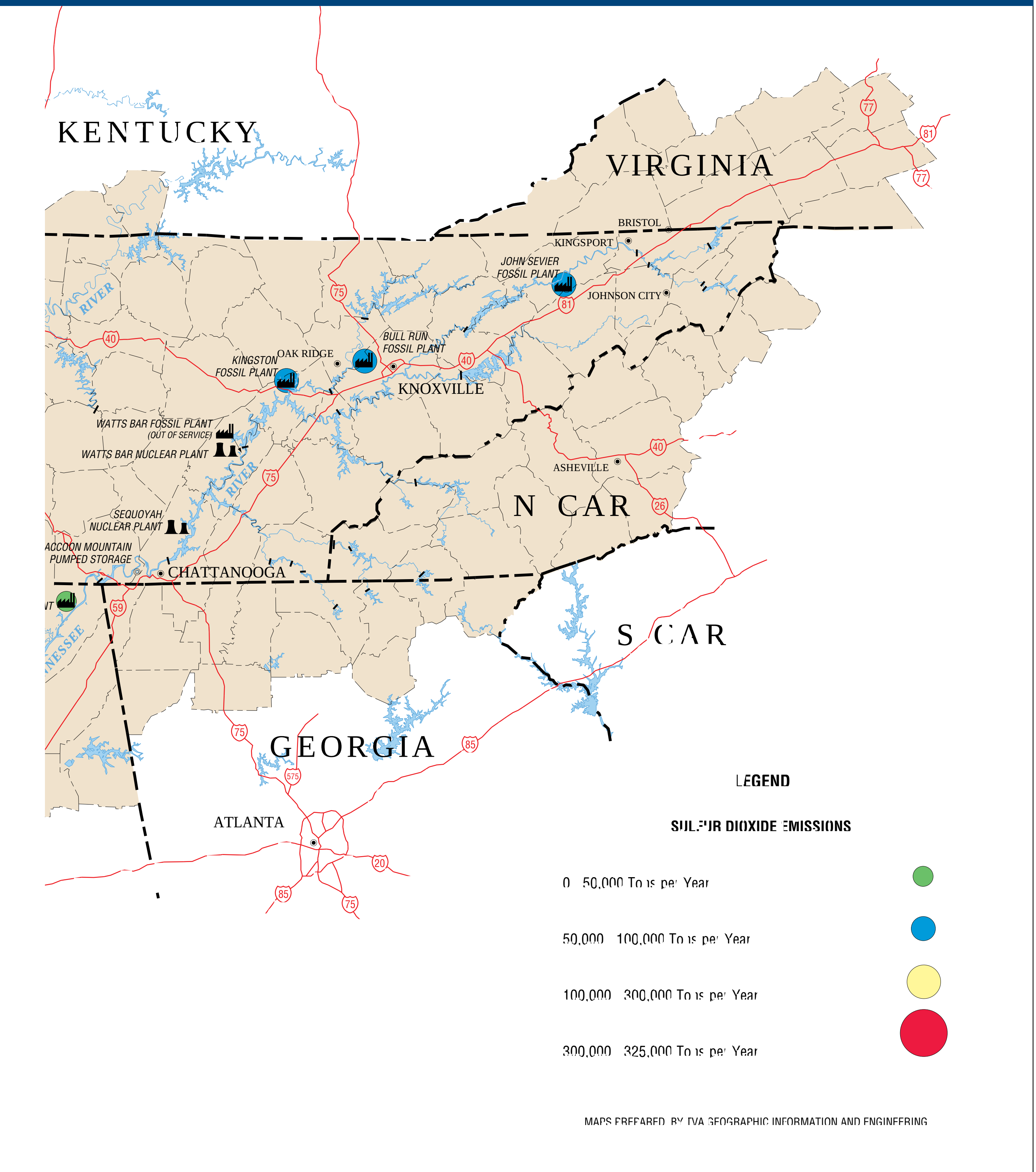
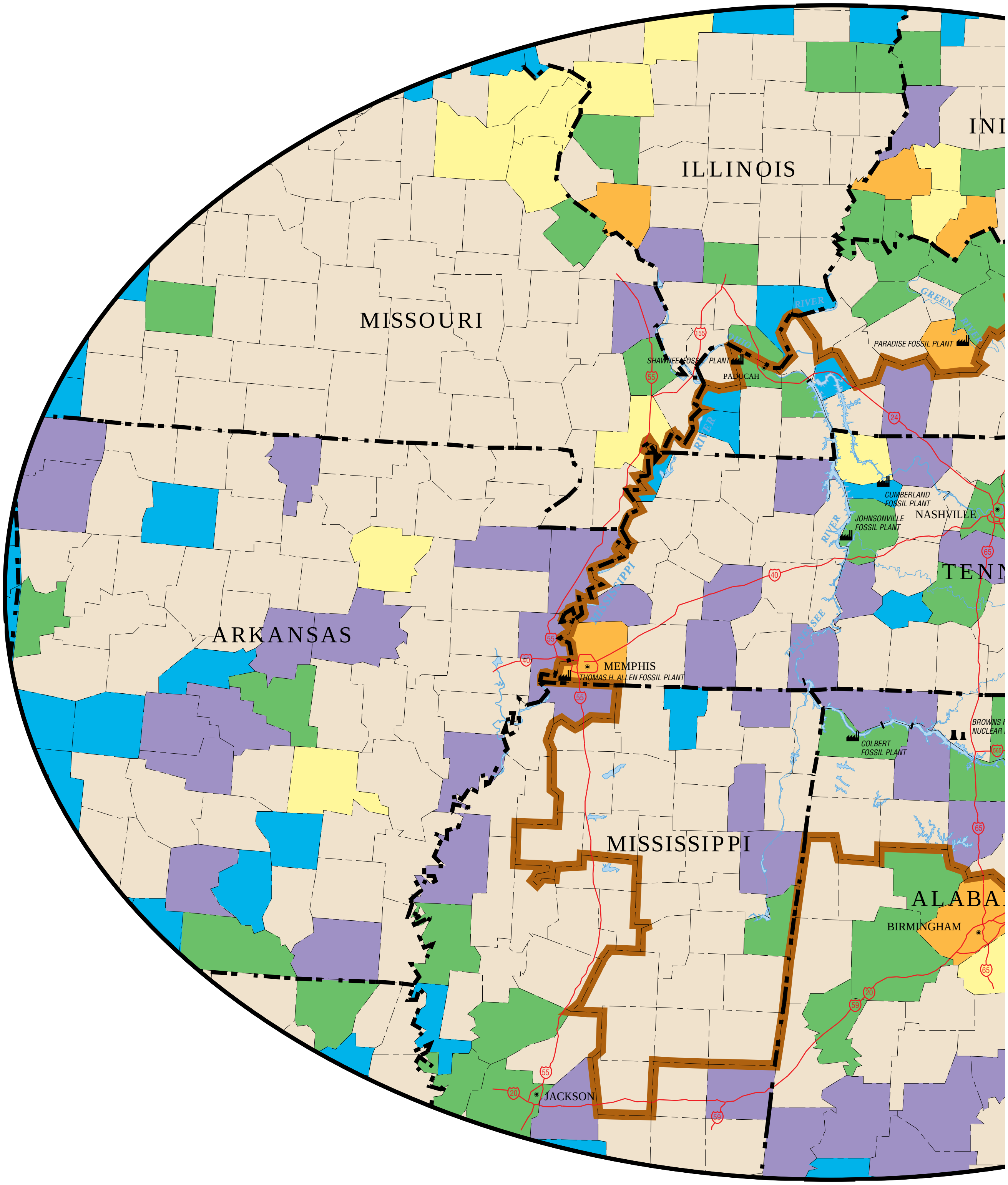
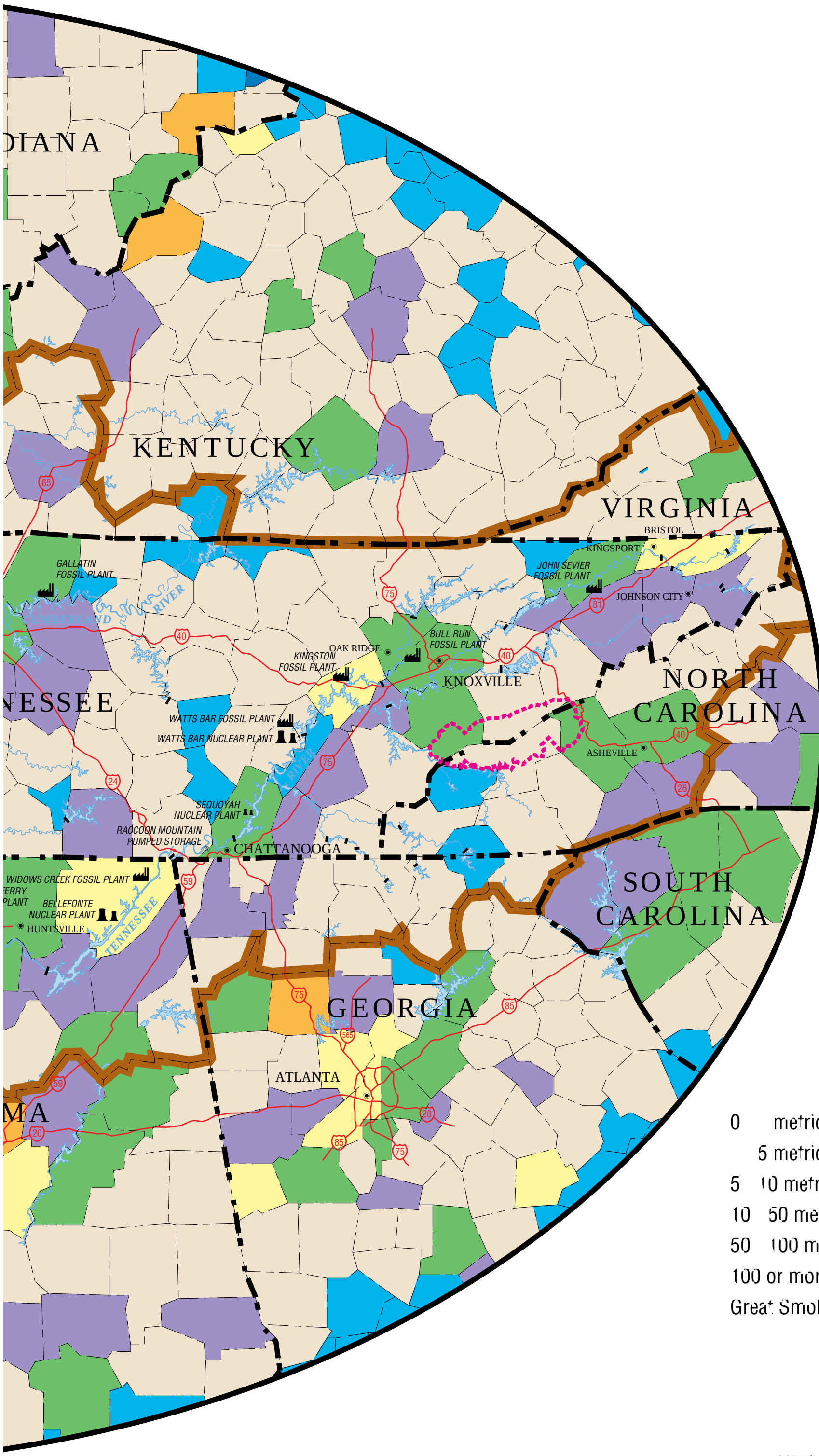

KENTUCKY
VIRGINIA
GEORGIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
SEQUOYAH NUCLEAR PLANT
PUMPED STORAGE
CHATTANOOGA
ASHEVILLE
ATLANTA
RIVER
LEGEND

FIGURE T1-24. **Total Nitrogen Oxides Emissions from Point, Area, and Mobile Sources in the Greater Source Area for Energy Vision 2020**





LEGEND

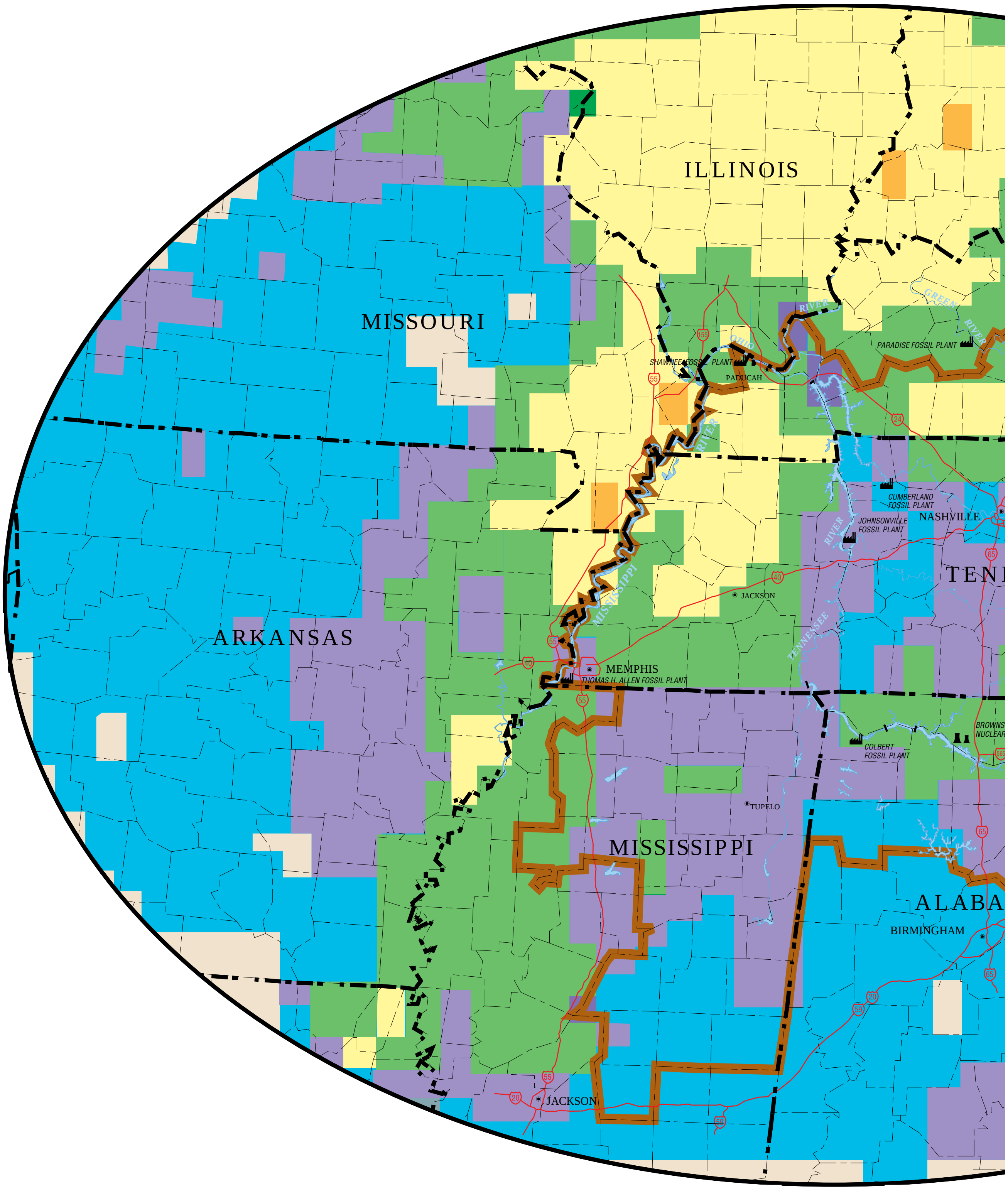
NITROGEN OXIDE EMISSIONS

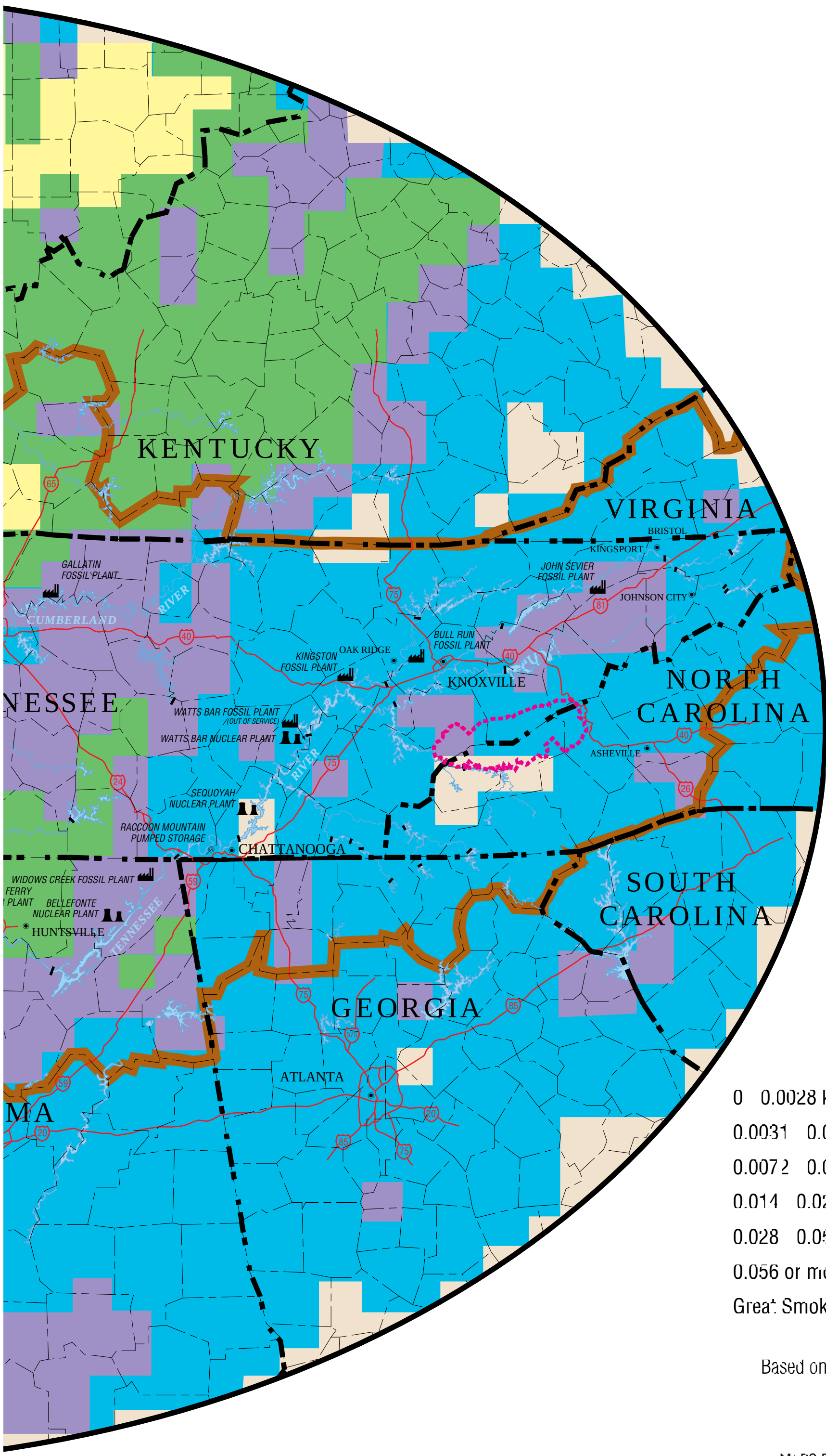
0 metric tons per day
5 metric tons per day
5 10 metric tons per day
10 50 metric tons per day
50 100 metric tons per day
100 or more metric tons per day
Great Smoky Mountains National Park

Interim 1990 Emissions Inventory

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-25. **Summer Nitrogen Oxide Emissions from Natural Sources in the Greater Source Area for Energy Vision 2020**





LEGEND

0 0.0028 kilogram per hectare per day
0.0031 0.007 kilogram per hectare per day
0.0072 0.0139 kilogram per hectare per day
0.014 0.028 kilogram per hectare per day
0.028 0.055 kilogram per hectare per day
0.056 or more kilograms per hectare per day
Great Smoky Mountains National Park

Based on results of EPA Biogenic Emissions Inventory System Model

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

power plants. Emissions, which have recently been about 500,000 tons per year, are projected to decline to approximately 300,000 tons per year following implementation of the 1990 Clean Air Act Amendments. They are also expected to increase roughly 17 percent over the years 2000 to 2020 as generation increases. *Figure T1-27* depicts fiscal year 1993 emissions of nitrogen oxides for each TVA coal-fired plant.

Future Regulations

In its 1994 review of the ambient air quality standard for nitrogen dioxide, the Environmental Protection Agency concluded that the current standard is adequate to protect human health and welfare. Additional nitrogen oxides control requirements are scheduled to be promulgated in 1997 under provisions of the 1990 Clean Air Act Amendments to address acid rain and ozone nonattainment areas.

CARBON MONOXIDE

Health and Welfare Concerns

Carbon monoxide is a colorless, odorless gas formed as a byproduct of fossil-fuel combustion. Exposure to carbon monoxide can reduce the oxygen-carrying capacity of the blood. At current ambient outdoor levels, carbon monoxide exposures are considered a low risk to human health.

Sources of Contribution

Natural sources of carbon monoxide are minor. The principal human-produced source is incomplete combustion of gasoline in motor vehicles. Carbon monoxide air pollution is primarily an urban problem, with highest levels occurring during heavy traffic under congested conditions. There has been a gradual but persistent improvement in average carbon monoxide levels throughout the last decade. In 1979 there were four nonattainment counties in the Tennessee Valley. Ambient levels of carbon monoxide in the Tennessee Valley are below the level of the National Ambient Air Quality Standards. Ambient concentrations of carbon monoxide should continue to decline as newer, less polluting vehicles make up an increasing portion of all vehicles driven in the region.

Future Regulations

The Environmental Protection Agency is not currently considering revisions to the carbon monoxide standard. TVA emissions account for less than 1 percent of total carbon monoxide emissions in the TVA service region and therefore will not be used as a factor to differentiate among strategies in Energy Vision 2020.

LEAD

Health and Welfare Concerns

The criteria pollutant lead is also one of a category of hazardous air pollutant that can be emitted from the combustion of coal. The Environmental Protection Agency established lead as a criteria pollutant because there was clear evidence of its sources and its impact on human health. Elevated exposures to lead can:

- Contribute to hypertension, heart attacks, and strokes in adults
- Increase the likelihood of birth defects and infant mortality
- Inhibit the growth and mental development of children

However, risk assessment models demonstrate that current lead emissions pose very little risk to human health (ORNL 1994).

Sources of Contribution

Lead exposure can occur through inhalation or ingestion. Children are the most vulnerable segment of the population because they ingest lead more often than do adults. Children swallow lead when they put toys or other objects bearing lead-contaminated dust in their mouths. Furthermore, a greater portion of ingested lead enters children's bodies than adults' bodies. Lead is now banned from use in gasoline, paints, solder, and metals that could contact drinking water, beverages, or foods. Concentrations of lead in the ambient environment have been reduced dramatically over the past two decades (ORNL 1994). Residual levels of lead in soils and flakes from lead-based paints remain a concern. Differences in lead emissions are not considered in evaluating TVA energy supply strategies.

TOTAL SUSPENDED PARTICULATE MATTER/PM10

Health and Welfare Concerns

Particulate matter is of concern because of the adverse effects it can have on visibility and on the respiratory function of sensitive individuals. Particulate matter was the focus of early air pollution control efforts because of the obvious visual impact of smoke and its association with acute air pollution episodes in England and the United States. Particulate matter consists of small aerosol particles in the atmosphere. Some particles are large enough to be seen with the naked eye, but the particulates of major concern for human health are less than 10 microns in size. Larger particles tend to be filtered out in the nose and throat and pose few health problems.

Particles emitted directly from a source are called primary particles. Those formed in the atmosphere from emitted gases are called secondary particles. Primary particles tend to be larger than 2.5 microns in size and are likely to be deposited within

50 kilometers of the source. Formation of secondary particles from sulfur dioxide and nitrogen oxides occurs in the atmosphere as the pollutants are transported downwind from the points of origin. Sulfate and nitrate particles are typically smaller than 1 micron in diameter and may remain aloft for days at a time (Mason 1971). Summer weather conditions favor the photochemistry that leads to sulfate and nitrate particle formation. Visibility is poorest in the summer because sulfate particles provide the major source for regional haze.

Sources of Contribution

Many natural and human sources produce particulate matter. Natural sources include wind-blown soil, volcanoes, forest fires, and the ocean. Human-produced sources include agriculture, waste incineration, industrial processing, fossil-fuel combustion, construction, and mining. On a global scale, natural emissions far exceed human-produced, but human-produced emissions predominate in urban and industrial areas. TVA contributed 5 percent of the total suspended particulates emitted in the 201 counties of the Tennessee Valley, according to the 1985 emissions inventory by the National Acid Precipitation Assessment Program *(See Figure T1-21)*. TVA emissions are primarily from coal-fired boilers. Particulate collection devices such as fabric filters or electrostatic precipitators have been installed on all TVA coal-fired boilers to remove particulates from the flue gases. Fugitive dust from TVA's operation of motor vehicles and from coal and other material-handling processes (e.g., coal transport and washing) also contributes low levels of fine particles.

Ambient Trends

Particulate control has been very successful, with removal efficiencies exceeding 95 percent. In 1979, parts of 21 counties in the Tennessee Valley did not attain the ambient particulate standard; now only 4 nonattainment areas remain. Loadings of fine particles are greatest in summer months. *Figure T1-28* illustrates the trend in particulate matter smaller than 10 microns from July through September, during 1986 to 1993, at 5 cities in the Tennessee Valley. These five cities are typical of trends for other cities in the Valley. For the majority of the sites, ambient concentrations of particles smaller than 10 microns decreased over this period.

Future Regulations

The National Ambient Air Quality Standard for particulate matter initially targeted concentrations of total suspended particulate matter. While this improved the visible particulate emissions problem, potential impacts to human health were still a problem. The total suspended particulate standard was amended in 1977 to address levels of particles smaller than 10 microns. Particulates of this size are respiratory irritants and pose greater risk to human health than the larger, more visible particles.

The Environmental Protection Agency is currently reviewing the adequacy of the particulate standard. A draft criteria document, which is the Environmental Protection Agency's state of science report on particulate matter, was published in November 1994, and peer review workshops were conducted in spring 1995. The final criteria document is to be completed by October 1995; the Federal Register proposal is due by April 1996; and the publication of final action is due not later than January 31, 1997. The draft criteria document reports an association between daily particulate matter concentrations and mortality rates, although the exact size fraction best predictive of health effects is not conclusively determined.

A comparative study of the health of individuals in six communities, including Kingston-Harriman in Tennessee, suggests

FIGURE T1-28. **Concentrations of Particulate Matter Less than 10 Microns (PM10) in Size During July-September for 5 Cities in the Energy Vision 2020 Study Area Have Been Decreasing**

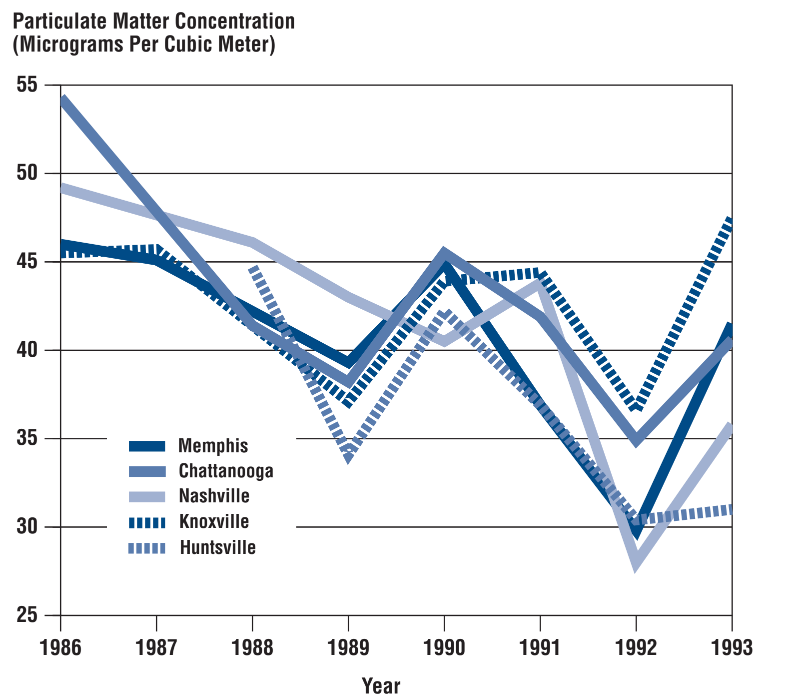
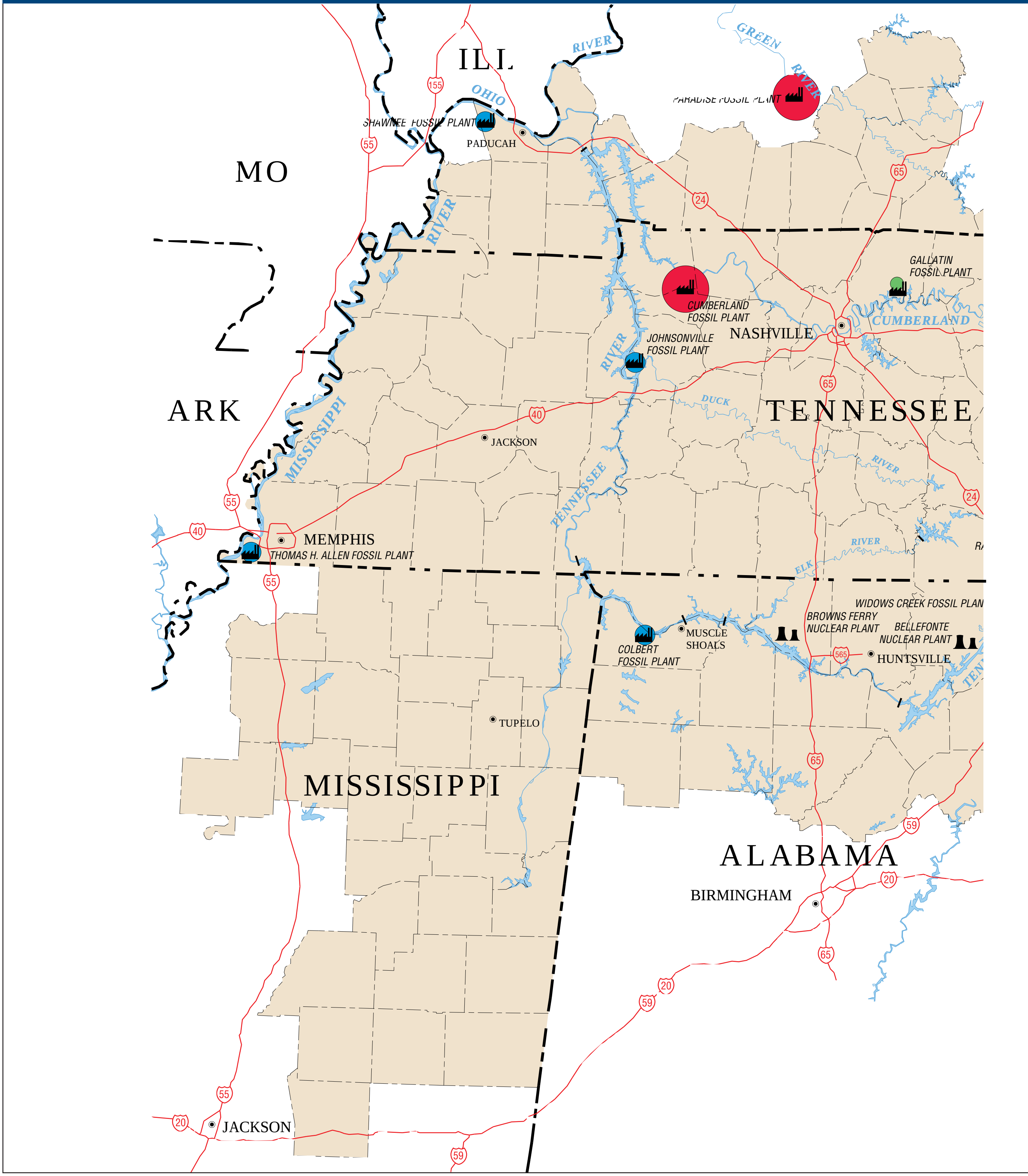
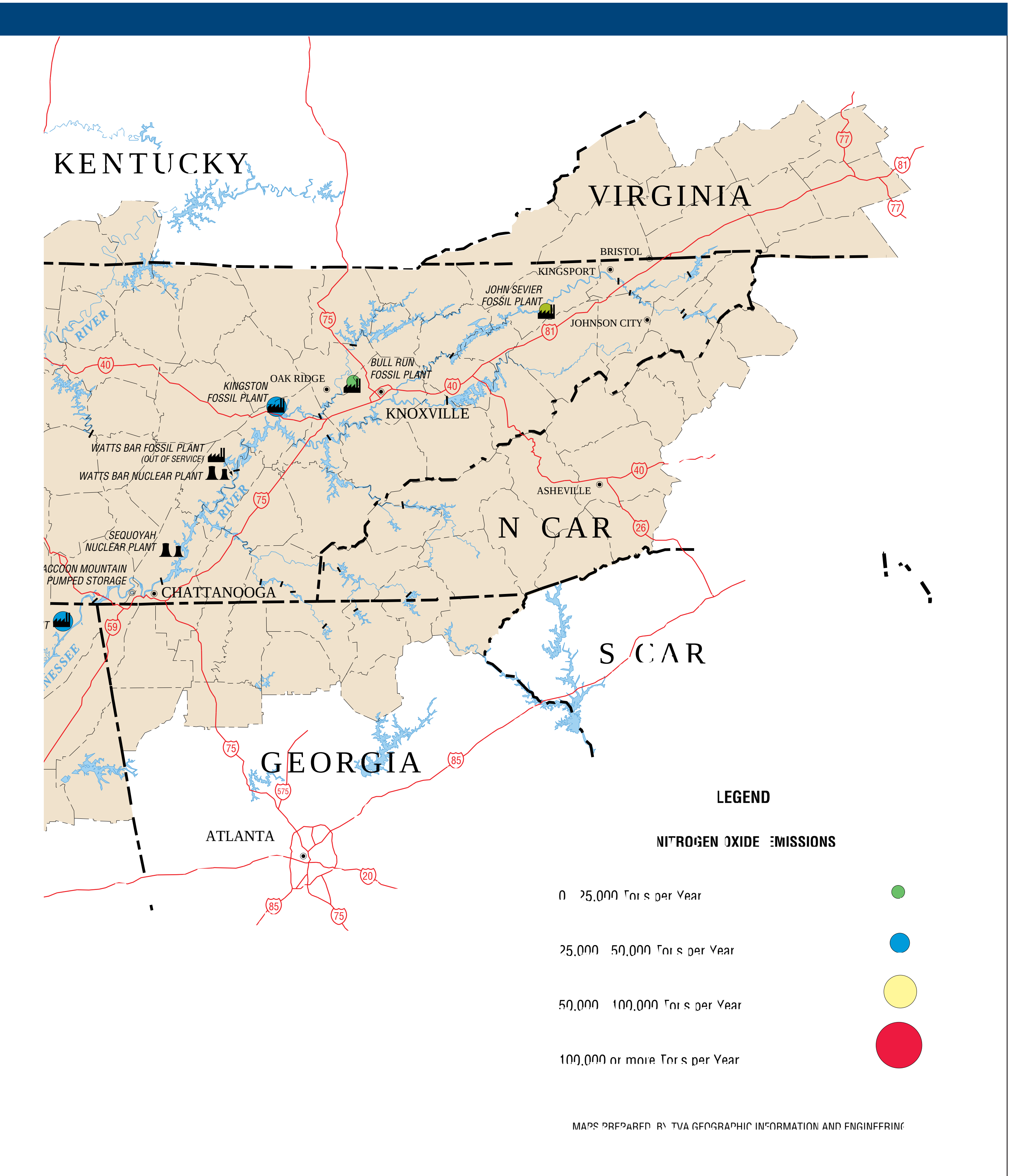


FIGURE T1-27. **Nitrogen Oxides Emissions From TVA Coal-Fired Power Plants in 1993**




KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
RIVER
OAK RIDGE
KINGSTON FOSSIL PLANT
BULL RUN FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
RIVER
ASHEVILLE
SEQUOYAH NUCLEAR PLANT
PUMPED STORAGE
CHATTANOOGA
GEORGIA
ATLANTA
LEGEND
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

that increased particulate exposure increases health risk (Dockery et al. 1993). Characterizing the relationship between particulate concentration and health impacts is complicated by contributions of weather, other co-occurring environmental pollutants, and a lack of extensive measurements of particle sizes other than 10 microns. It has been difficult to identify a single causal factor when several air pollutants are elevated at the same time.

A fine-particulate standard is now being considered for particles less than or equal to 2.5 microns. Available monitoring data suggests that large areas of the country would not be in attainment with such a standard.

In addition to possible health effects, the Environmental Protection Agency's draft criteria document also addresses the contribution of secondary particles to regional haze. Title I of the 1990 Clean Air Act Amendments authorizes the development of control strategies to mitigate visibility impacts. The Environmental Protection Agency could use Title I provisions to respond to the federal land managers' findings of visibility impairment in Class I areas. The Environmental Protection Agency could alternatively use the ambient standard process to set a visual range goal.

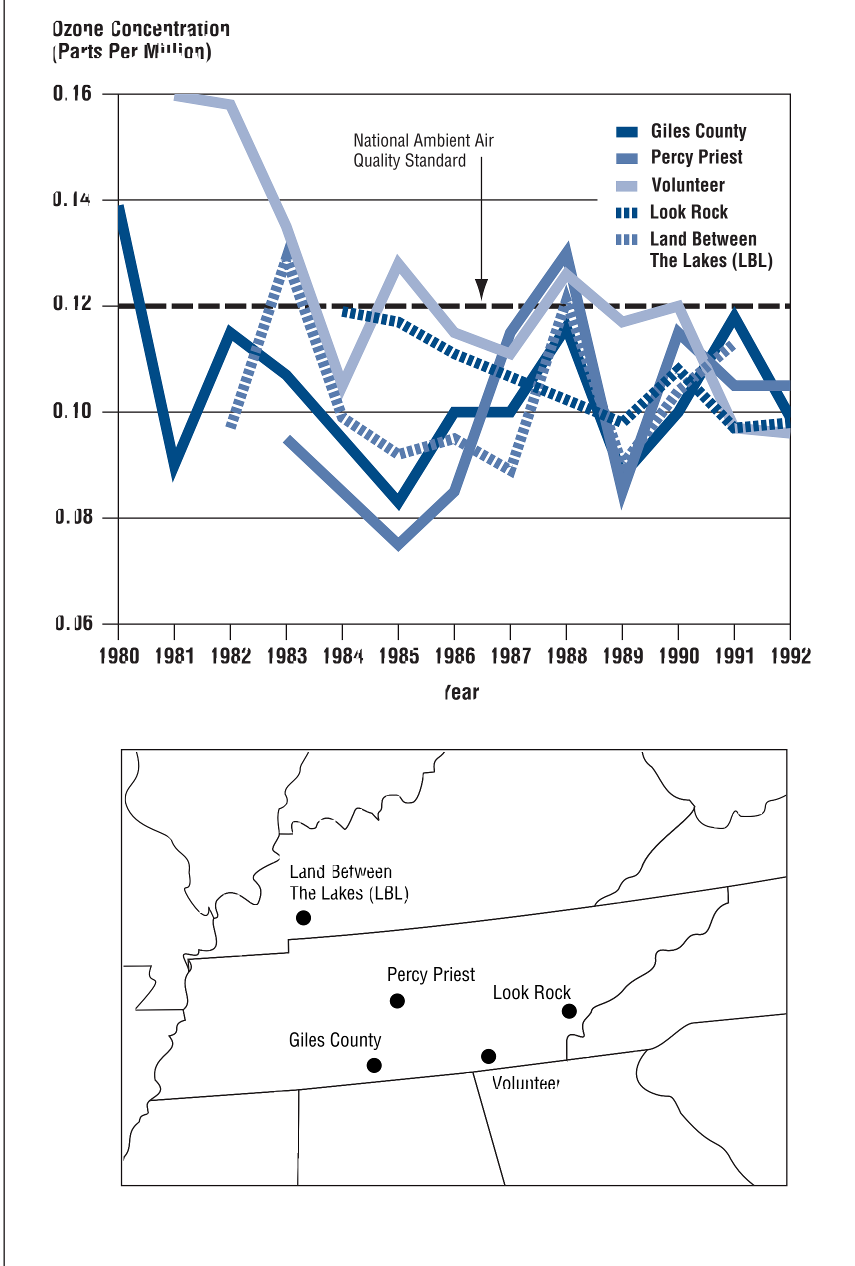
If the ambient standard were revised to limit fine particles (less than 2.5 microns in size), TVA would likely install higher efficiency electrostatic precipitators and add filters to coal-handling areas. Factors to differentiate among energy strategies do not include those to comply with uncertain future regulations of fine particles.

TROPOSPHERIC OZONE

Health and Welfare Concerns

Ozone is a secondary air pollutant produced in the presence of sunlight from the primary emissions of nitrogen oxides and volatile organic compounds in the lower atmosphere (troposphere). In some areas of the southeastern United States, ambient levels of ozone exceed levels demonstrated to impair human respiratory function and to impact crops, forests, and materials. Several urban areas in the Southeast do not attain the current National Ambient Air Quality Standard (maximum one-hour average concentration not to exceed 0.12 parts per million more than three times in three years). The Environmental Protection Agency is considering revisions to the current standard to address health impacts from extended exposures and cumulative impacts to crops and forests. The National Park Service has reported that ambient levels of ozone are adversely

FIGURE T1-29. **Maximum Hourly Ozone Concentrations at Five Monitoring Sites in the Energy Vision 2020 Study Area Have Shown Little Improvement**



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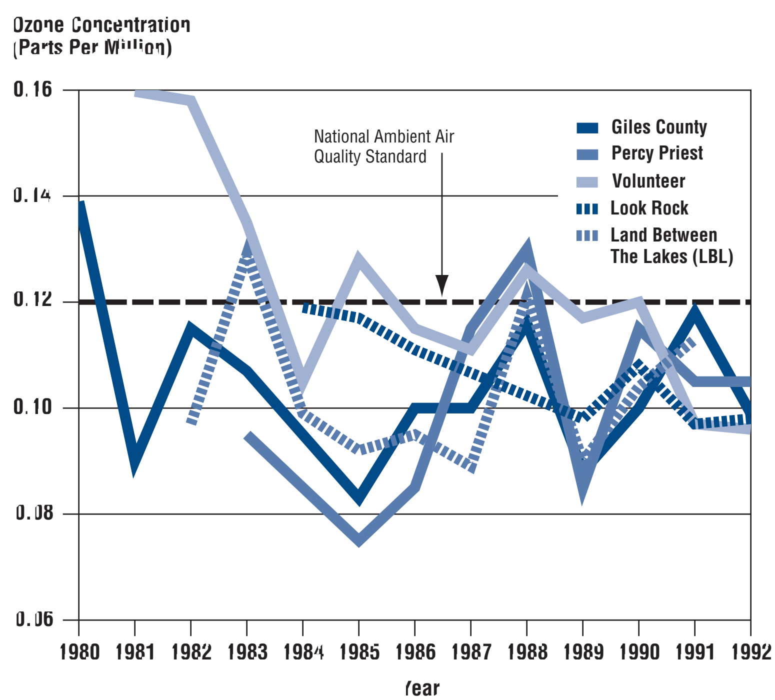
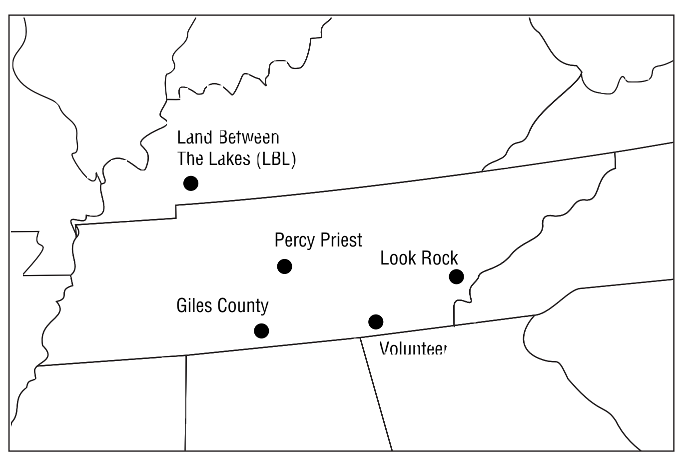
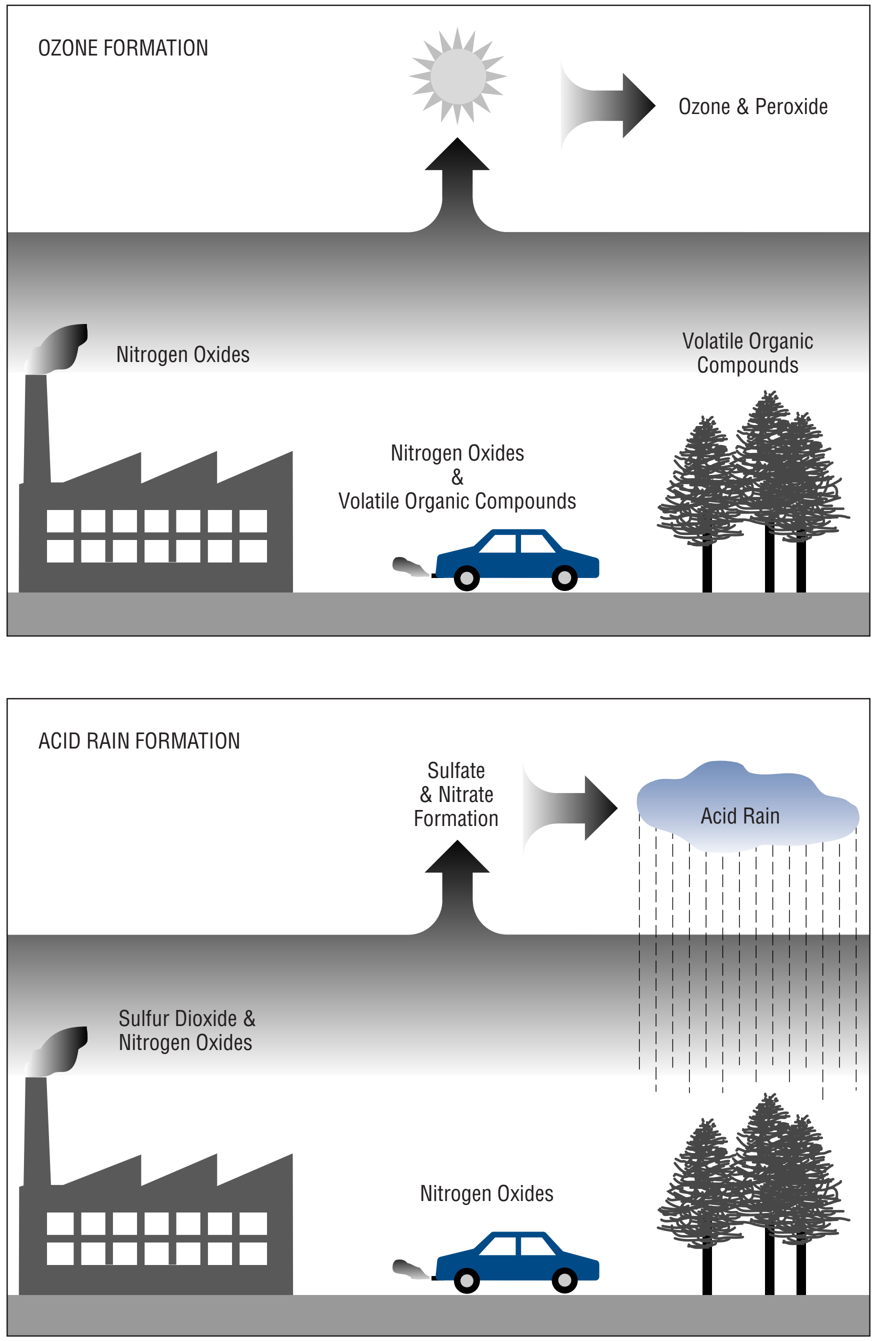




impacting resources in park and wilderness areas protected as designated Class I areas under the Clean Air Act (Shaver et al. 1994). For all these reasons, ozone is a major consideration for environmental consequences of energy strategies.

FIGURE T1-30. **Ozone and Acid Rain Formation**



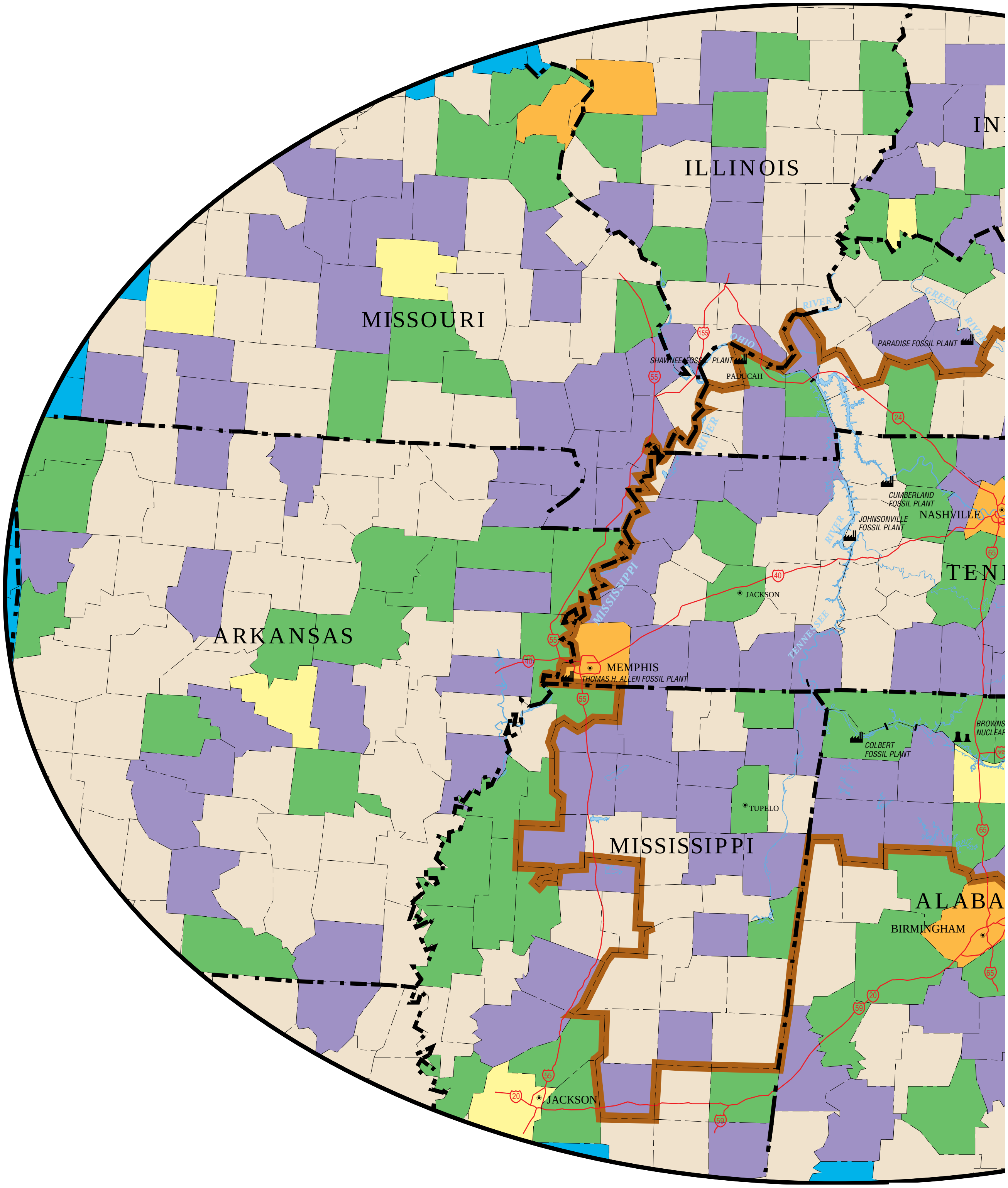
Ozone Formation

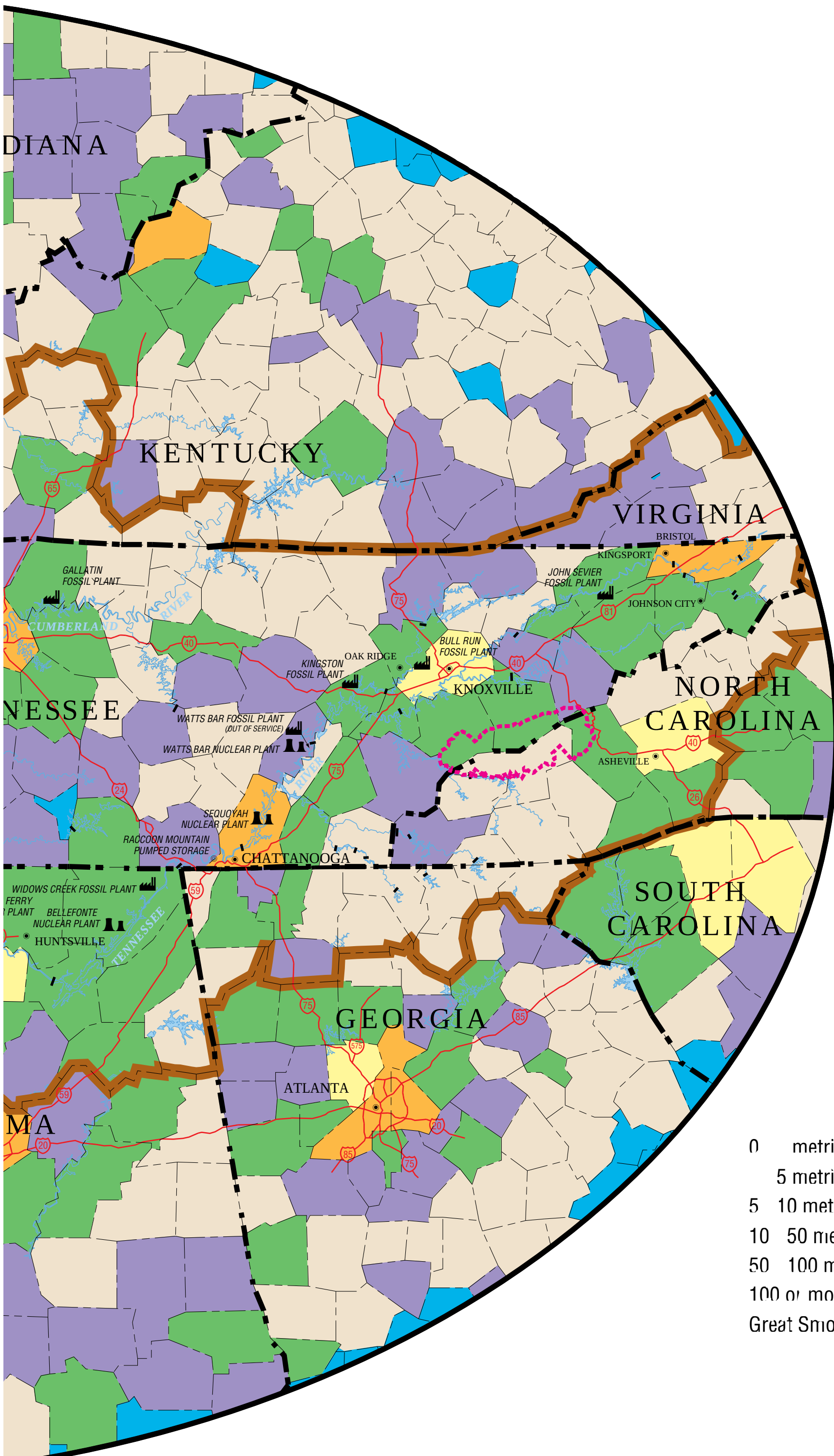
Sunlight is required for ozone formation. The rate of formation increases with increasing solar intensity and temperature. Thus, ozone levels are greater in the summer than in the winter and tend to be greater in drier years. The frequency and magnitude of ozone episodes is a function of meteorologic variables such as wind speed and direction, solar radiation, and humidity. The southeastern United States is particularly susceptible to elevated ozone exposures, due to its warm, sunny climate; the high frequency of air stagnation episodes; and the large contribution of natural emissions sources. *Figure T1-29* illustrates the maximum ozone concentration at five monitoring sites in the Tennessee Valley. *Figure T1-30* illustrates the way in which ozone is formed.

Sources of Contribution

Human-produced and natural sources of nitrogen oxides were discussed previously. Human-produced sources of volatile organic compounds include motor vehicles, petrochemical storage and transport, chemical and industrial processing, and smaller sources such as dry cleaners and bakeries. The map in *Figure T1-31* illustrates human-produced point, area, and mobile sources of volatile organic compounds. Vegetation, microbial activity, and forest fires are natural sources of volatile organic compounds. Comparing *Figures T1-31* and *T1-32* shows that in many areas of the southeastern United States, natural sources can equal or exceed human-produced sources. *Figure T1-33* illustrates that TVA's emissions of volatile organic compounds are insignificant when compared to its emissions of other pollutants and to other sources of volatile organic compounds.

FIGURE T1-31. **Total Volatile Organic Compound Emissions from Point, Area, and Mobile Sources in the Greater Source Area for Energy Vision 2020**





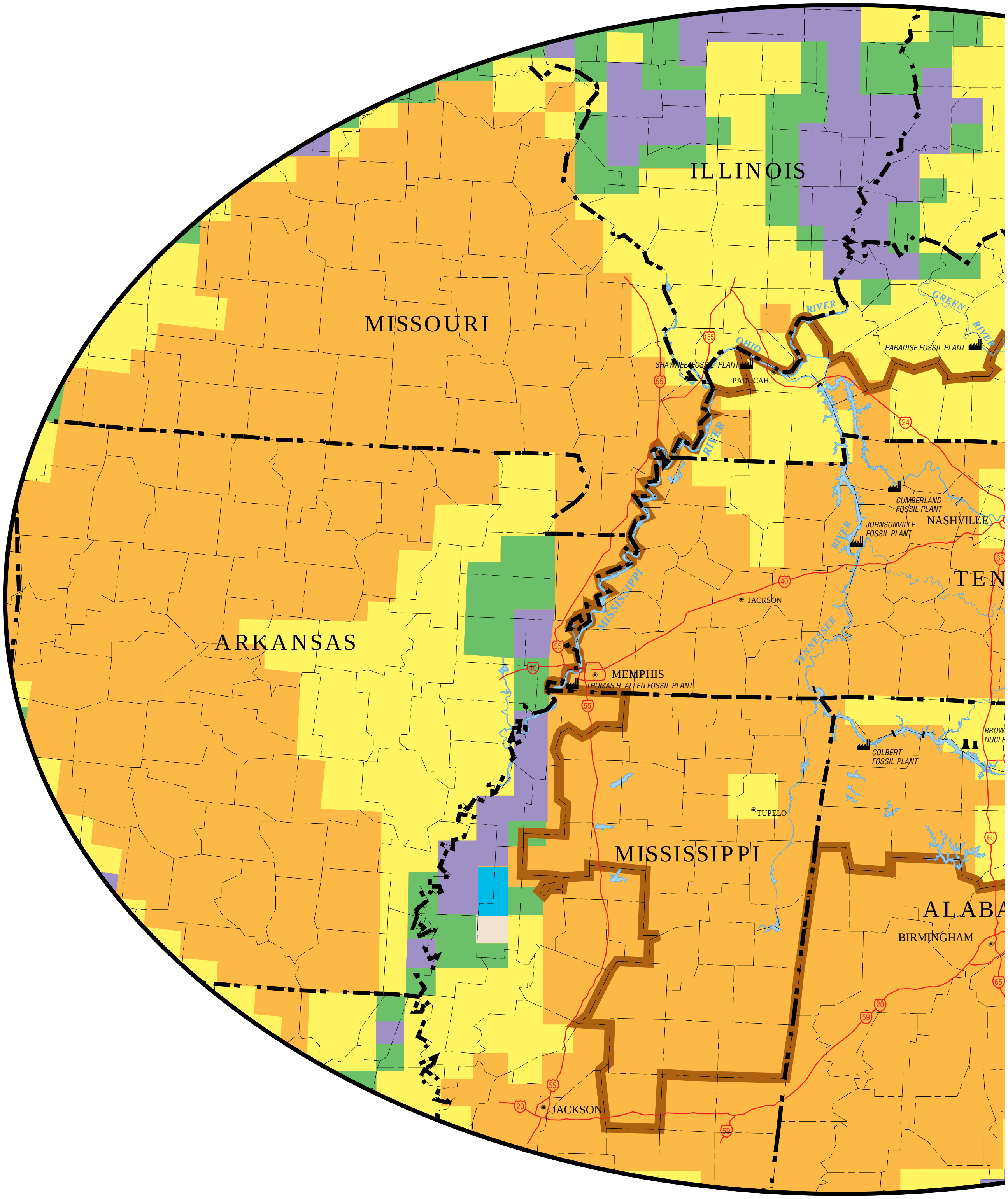
LEGEND

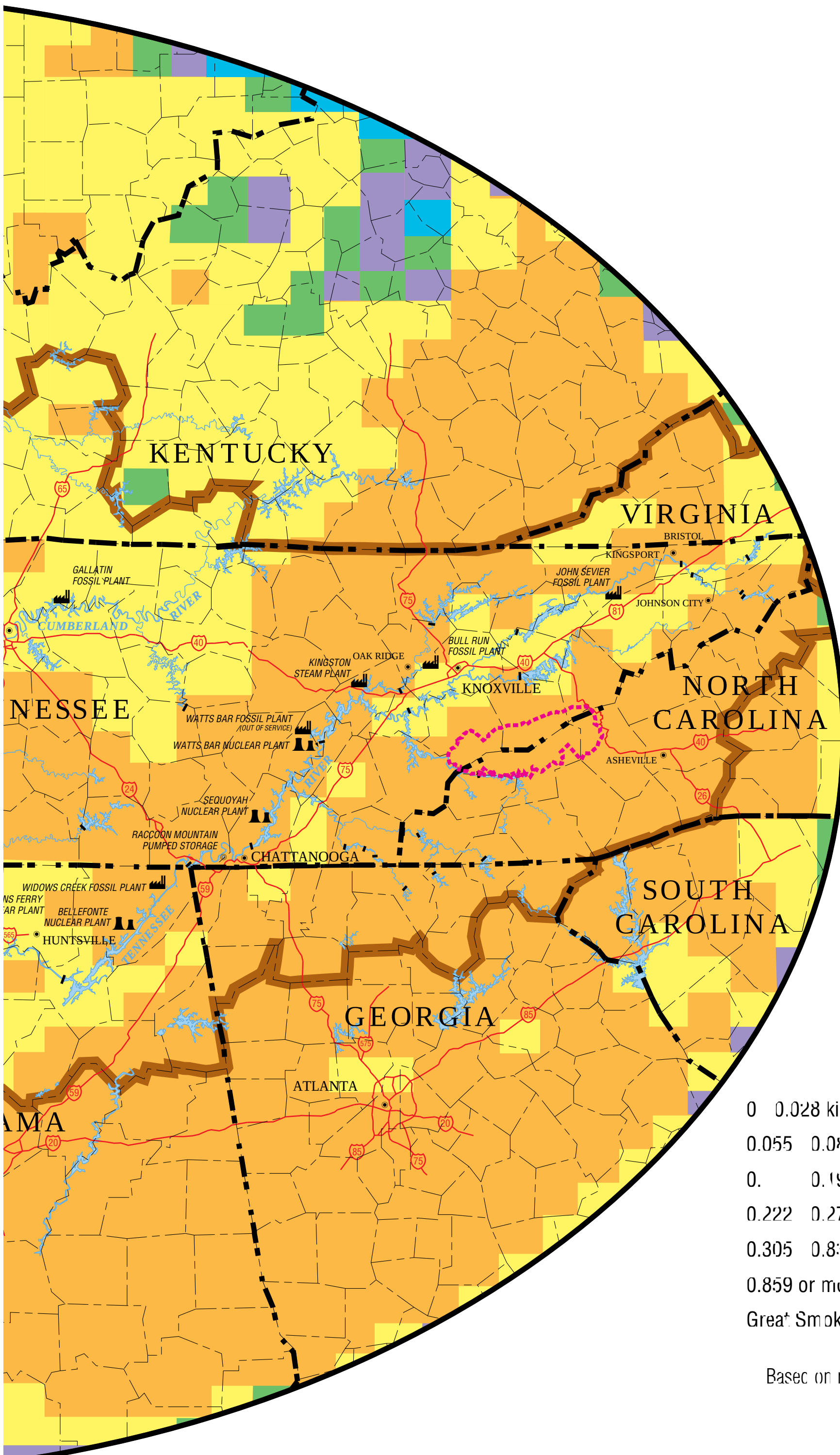
0 metric tons per day
5 metric tons per day
5 10 metric tons per day
10 50 metric tons per day
50 100 metric tons per day
100 or more metric tons per day
Great Smoky Mountains National Park

Interim 1990 Emissions Inventory

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-32. **Summer Volatile Organic Compound Emissions from Natural Sources in the Greater Source Area for Energy Vision 2020**





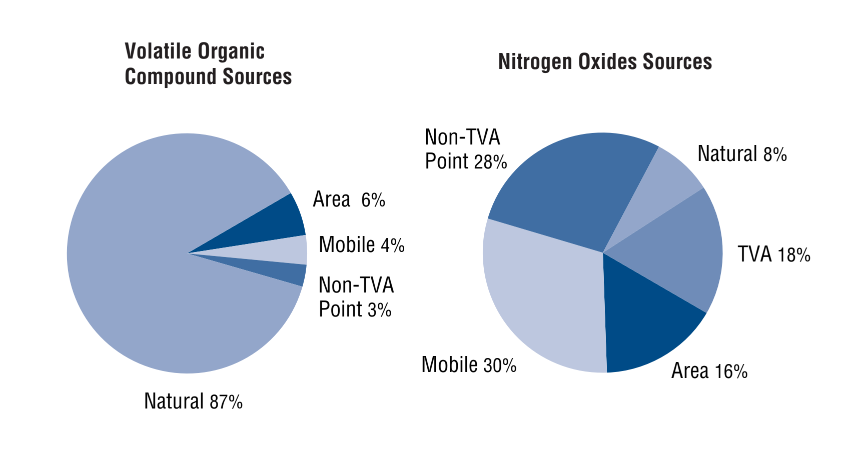
LEGEND

0 – 0.028 kilogram per hectare per day	
0.055 – 0.083 kilogram per hectare per day	
0. – 0.194 kilogram per hectare per day	
0.222 – 0.277 kilogram per hectare per day	
0.305 – 0.831 kilogram per hectare per day	
0.859 or more kilograms per hectare per day	
Great Smoky Mountains National Park	

Based on results of EPA Biogenic Emissions Inventory System II Model

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-33. **Source Contributions to Ozone in Great Smoky Mountains National Park**



Ambient Trends

Progress on ozone exposures has been mixed, despite the expenditure of billions of dollars on emission reductions in the Southeast over the past decade and a half. In the Tennessee Valley, the cities of Chattanooga, Knoxville, Memphis, and Huntsville have attained the ozone standard. However, Nashville and other cities in the southeastern United States (Atlanta, Charlotte, and Birmingham) remain in nonattainment status. (See nonattainment map in *Figure T1-15.*) Other measures of ozone exposure have not shown an improvement that is discernible above the annual variability in trends due to weather patterns.

Figure T1-34 shows trends during the ozone season (April to September) from 1980 to 1992 at five sites selected to represent urban and rural exposures in the Tennessee Valley.

The maximum hourly ozone exposure shown in the graph in *Figure T1-29* provides insight into the annual variability in ozone trends. There has not been a demonstrable improvement over the past decade in maximum hourly ozone at these sites except at the Volunteer site located near Chattanooga. There can be annual variation in exposure that can occur simply as a function of weather patterns. The driest year on record in the Tennessee Valley was 1988; 1989 was the wettest *(Figure T1-11)*. While the maximum one-hour exposure at these sites was similar in 1988 and 1989, the frequency of hours of elevated ozone was much greater at all sites in 1988 than in 1989. During the 1988 ozone season, elevated exposures occurred much more frequently at urban sites (Volunteer site near Chattanooga, and Percy Priest site within Nashville) than at rural sites.

Since ozone formation is dependent on sunlight, the pattern for daily ozone exposure typically is lowest before dawn and builds over the day to peak in late afternoon and evening, as shown in the graph in *Figure T1-35*. In the presence of nitric oxide, ozone is consumed in the formation of nitrogen dioxide. Ozone consumed during evenings and nighttime hours is not replaced by ozone formation. In areas where nitric oxide is plentiful, ozone levels are commonly depleted during evening and nighttime hours. Monitoring at 40 stations in rural areas of the Southeast indicates that ozone levels are similar in daily cycles and timing of peaks as urban exposures (Lee and Ekles 1993). At high elevation (more than 2,500 feet) or remote sites, absence of local sources of nitrogen oxide emissions can cause ozone levels to remain elevated throughout the evening. Exposures at remote sites can also exhibit peaks later in the afternoon, evening, and night hours than nearby urban areas, indicating regional transport of ozone formed outside the remote areas (Mueller 1994; LeFohn 1994). *Figure T1-35* illustrates that ozone exposures can be greater at high elevation sites than at low elevation sites in the Valley.

Current Regulatory Issues

The National Ambient Air Quality Standard for ozone was initially set at 0.08 rather than 0.12 parts per million for the maximum one-hour standard. The level was raised in 1978 because the stricter standard was an unattainable goal for many urban areas in the country. Ozone nonattainment areas are classified as marginal, moderate, serious, severe, or extreme. Classifications are based on the frequency of episodes that exceed the standard. Nashville is currently classified as moderate. If meteorological conditions are mild in 1995, Nashville could achieve the requirement for three consecutive years without a violation of the 0.12 parts per million maximum one-hour standard, and would be designated as being in attainment with the ozone standard. If there is a violation of the standard this year, the current regulation requires that the Nashville area be reclassified as serious. A redesignation would require the State of Tennessee to consider additional emissions reductions to reduce ozone. Past emissions strategies have focused on reducing emissions of volatile organic compounds. Future strategies could consider sources of nitrogen oxides emissions, including TVA's Gallatin, Cumberland, and/or Johnsonville Fossil Plants. TVA is participating in the Southern Oxidants Study to better understand sources contributing to ozone formation in the Nashville area and the southeastern United States. (See discussion in section on cooperative research and assessment programs.)

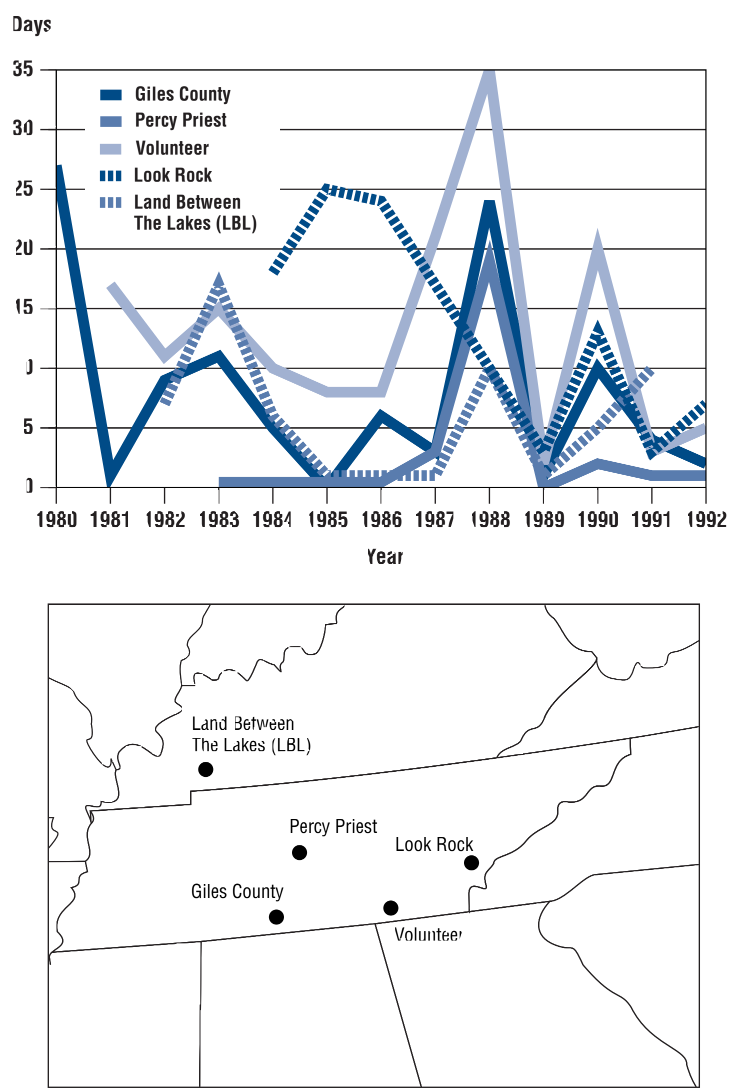


FIGURE T1-34. **Frequency of Occurrence of 8-Hour Average Ozone Concentration Above 0.08 Parts per Million for Five Selected Sites in the Tennessee Valley**

Future Regulations

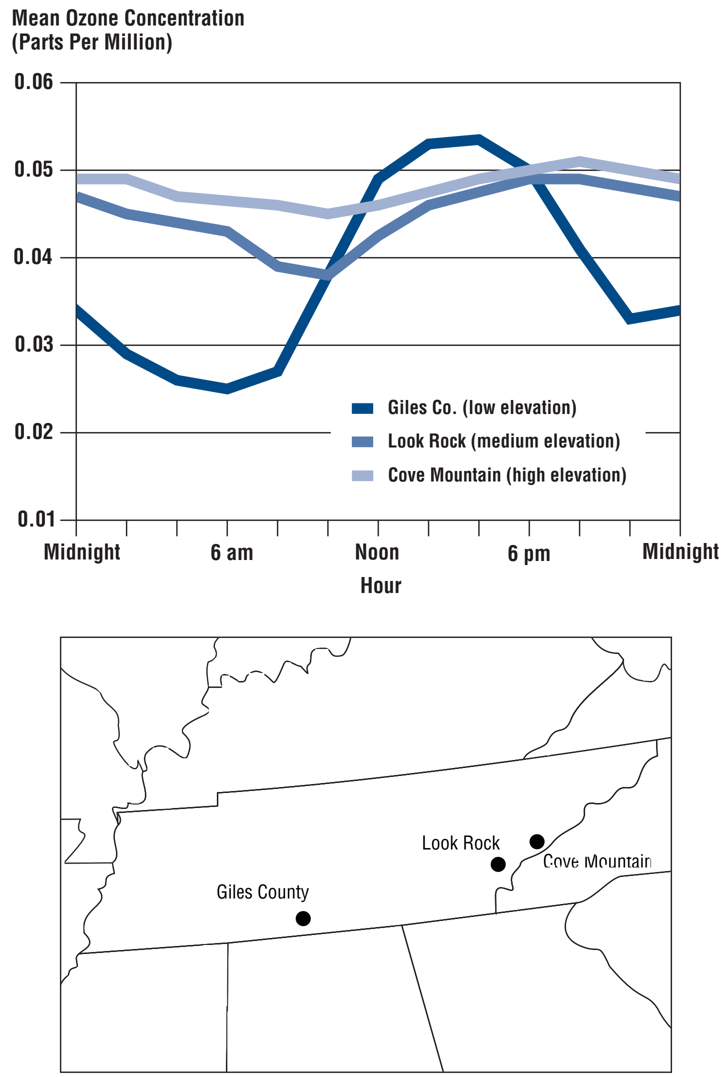
The Environmental Protection Agency is currently reviewing the adequacy of the one-hour maximum standard of 0.12 parts per million ozone to protect human health and welfare. While the Environmental Protection Agency has indicated that it expects to complete its review in 1997, the American Lung Association has sued the Environmental Protection Agency to complete its review by the end of 1995. The Environmental Protection Agency could decide to make the ozone standard more stringent. An Environmental Protection Agency staff paper released for review in spring 1995 (Environmental Protection Agency 1995a) summarized the human health risks and proposed alternative forms for a revised primary standard to protect human health. The revised primary standard could take the form of an eight-hour mean not to exceed 0.08 parts per million. An allowance of one to five exceedances per year are being considered.

The Environmental Protection Agency is also considering a separate secondary ozone standard to better protect crops and forests. In the draft 1995 ozone criteria document (Environmental Protection Agency, 1995b), the Agency suggests a cumulative ozone exposure, calculated as the sum of all hours exceeding 0.06 parts per million (SUM06) during the maximum three-month period between April and October, that does not exceed 26.4 parts per million-hours would protect 50 percent of agricultural crops from a 10 percent yield reduction. Because plants respond more severely to the peak exposures, the frequency of hours greater than 0.10 may also be considered in the future in evaluating potential impacts of ozone exposures. This threshold is based on evidence from crop exposure studies. The threshold for damage to trees may be lower than that suggested for crops because trees have longer lives than annual crops and are therefore exposed to ozone for a greater period of time. (See discussion under crop and forest impacts.)

Further emissions reductions to reduce ambient ozone exposures in Class I areas of southern Appalachia are being recommended. The National Park Service has asked for emissions offsets from existing sources as a condition for new source permits. The Southern Appalachian Mountain Initiative, discussed earlier in this section, is considering emissions management options and could make recommendations to the states for emissions reductions that would go beyond the 1990 Clean Air Act Amendments.

The State of New York has petitioned the Environmental Protection Agency to consider states outside the Northeast Ozone Transport Region in its efforts to attain the ozone standard within New York. Research under the North American

FIGURE T1-35. **Daily Ozone Trends at Different Elevations**



Research Strategy on Tropospheric Ozone will help define sources contributing to ozone in the northeastern United States Results will assist development of regulatory policy.

Ozone Trends Under Revised Standards

The Environmental Protection Agency's proposed primary standard for ozone is more rigorous than the current maximum one-hour standard. The historical (1980-1992) frequency of occurrence of 8-hour average ozone concentrations greater than 0.08 parts per million for five selected Valley sites are shown in *Figure T1-34*. Depending on the number of occurrences above 0.08 parts per million allowed in one year, all five sites could be classified as nonattainment under a revised standard (currently only one of the sites, Percy Priest, is located in a nonattainment area). Notably, the Look Rock site, located on the western boundary of Great Smoky Mountains National Park, has a high frequency of 8-hour means greater than 0.08 parts per million. Data from 40 rural and urban monitoring stations in 1992, the year with the greatest number of rural monitoring stations, indicates that large areas of the southeastern United States would likely not be able to meet a revised standard of 8-hour mean not to exceed 0.08 parts per million. *(See Figure T1-36.)* The year 1992 was a comparatively mild ozone season. Sites where data is also available for 1990 and 1991 show that the number of days exceeding the 8-hour mean of 0.08 parts per million were greater in the earlier years than in 1992.

Most of the ozone monitoring in the United States has focused on establishing exposures in urban areas. The available data base for examining ozone trends in rural areas in the Southeast where crops and forests occur most frequently is limited prior to 1990. In 1990 the Southern Oxidants Study integrated existing rural sites and established new sites in a network to provide spatially representative coverage of ozone exposure in the rural Southeast. *Figure T1-37* presents the maximum three-month sum of hours exceeding 0.06 parts per million (SUM06) in 1992 at 40 urban and rural monitoring stations. The SUM06 ozone statistic was lowest in Middle Tennessee and highest in northeastern and southwestern Tennessee. Higher values in rural and high elevation areas reflect the higher evening and nighttime ozone exposures at sites removed from sources of nitric oxide.

The number of hours greater than 0.10 parts per million is a useful measure to describe the severity of ozone exposure, since both humans and plants are sensitive to peak exposures. Because nighttime ozone levels can be greater in rural than in urban areas, the SUM06 statistic may be equal to or greater at a rural site compared to an urban site, yet experience fewer hours greater than 0.10 parts per million. *Figure T1-38* illustrates that few areas in the Tennessee Valley experienced more than five hours greater than 0.10 parts per million of ozone during the period from April through September in 1992. The summer of 1992 was cooler than average. Analysis of Southern Oxidant Network data for 1990 and 1991 indicated these years

had higher cumulative exposures and greater numbers of hours exceeding 0.10 parts per million than occurred in 1990.

Understanding Emissions Contributing to Ozone

Ozone control strategies to date have focused on control of human-produced volatile organic compounds. Controls of volatile organic compounds have been less effective in reducing ozone levels than expected for several reasons:

- Natural organic compounds comprise more than half of total emissions of volatile organic compounds in the Southeast.
- Many human-produced sources were underestimated in early strategies.
- Vehicles and vehicular miles traveled have increased in number over the past decades.
- Nitrogen oxides levels were not considered.

The National Academy of Science in its 1991 review, "Rethinking the Ozone Problem in Urban and Regional Air Pollution," recommended reexamination of the strategy (National Research Council 1991). Past experience has demonstrated that the most effective strategy to reduce ozone depends on the relative concentrations of nitrogen oxides and volatile organic compounds in ambient air. In areas where nitrogen oxides concentrations exceed those of volatile organic compounds, ozone formation is limited by levels of volatile organic compounds. This means that reductions in volatile organic compound emissions will reduce ozone levels. These conditions occur most frequently in and downwind of large urban areas such as Nashville.

In an area where volatile organic compound emissions exceed nitrogen oxides, ozone formation is limited by levels of nitrogen oxides. This means that nitrogen oxides reductions will likely result in decreases in ozone. Given the high levels of natural volatile organic compounds, especially in forested areas, ozone production in much of the rural Southeast is limited by levels of nitrogen oxides (Fehsenfeld et al. 1994).

Exposures in rural and urban areas are closely interdependent. Studies in 1992 indicated that a large portion of ozone measured in the Atlanta urban nonattainment area was transported there from the surrounding region (Fehsenfeld et al. 1994). An extensive field study of rural and urban ozone formation was conducted in the Nashville area in summer 1995 by the Southern Oxidants Study. (See discussion of cooperative research and assessment programs on page T1-70.) Results will allow more accurate analysis of TVA emission contributions to regional ozone formation.

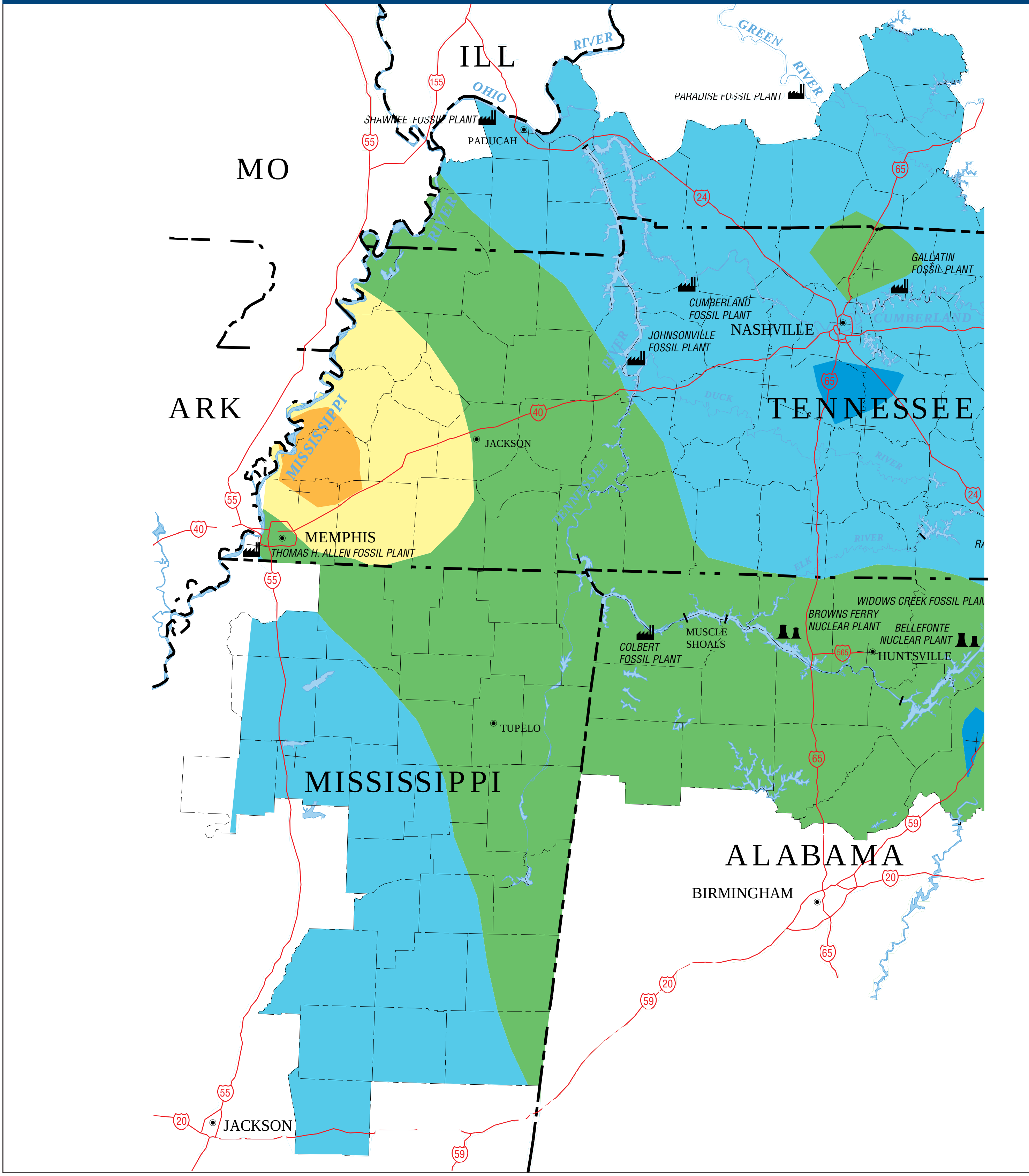
Nitrogen oxide emissions from a coal-fired power plant can either decrease or increase ambient ozone levels, depending on the local atmospheric mix of nitrogen oxides and volatile organic compounds. Within the first 20 kilometers of the source, nitric oxide emissions in a power plant plume will react with ozone to form nitrogen dioxide. Ambient ozone levels can be significantly decreased in this area. If the atmosphere is limited by concentrations of nitrogen oxides, nitrogen dioxide in a power plant plume will react photochemically with volatile organic compounds to form ozone. Ozone formation begins roughly 20 kilometers downwind of the emissions source.

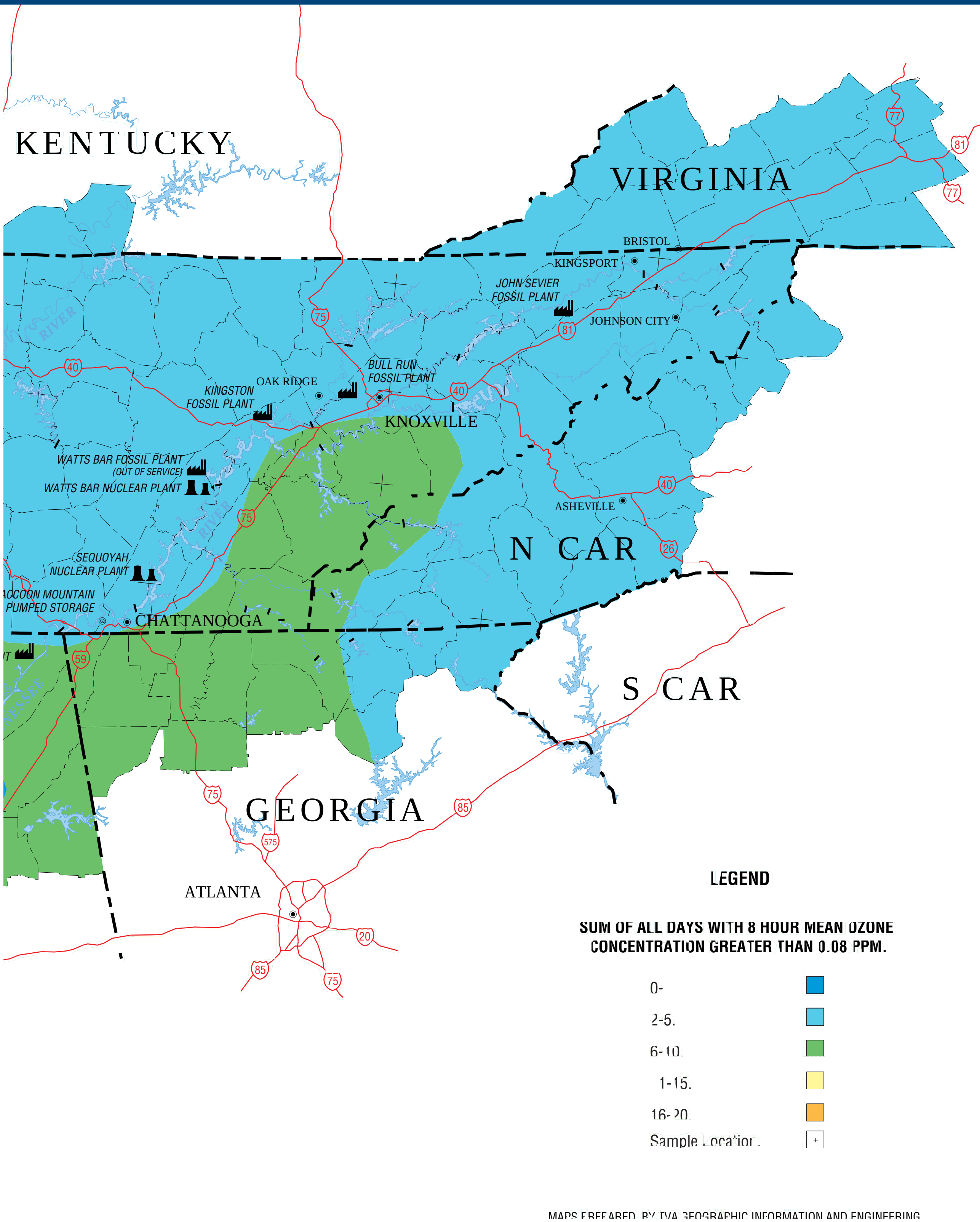
Nashville is currently classified as a "moderate" nonattainment area for ozone. TVA's Gallatin coal-fired power plant is located 15 kilometers east to northeast of the city. Depending on the prevailing weather pattern, nitrogen oxides emissions from Gallatin could reduce ozone in the metropolitan area to the southwest or contribute to ozone exposures in areas downwind. TVA's Johnsonville and Cumberland Fossil Plants are located west of Nashville and, depending on meteorology, could contribute to ozone exposures in the Nashville area. As part of TVA's compliance with the acid rain provisions (Title IV) of the 1990 Clean Air Act Amendments, TVA has already reduced nitrogen oxides emissions from Gallatin and Johnsonville and may reduce nitrogen oxides emissions from Cumberland prior to 2000.

Reliable assessment of source contributions requires detailed meteorological and atmospheric modeling that is beyond the scope of the current analysis. Simplifying assumptions can be made to estimate the source area contributing to ozone exposures in the Tennessee Valley. Ozone formation generally occurs within 12 hours after nitrogen oxides are emitted, depending on sunlight and levels of volatile organic compounds in the atmosphere. Once formed, ozone can be consumed in atmospheric reactions with other pollutants or transported hundreds of kilometers downwind.

Ozone transport is controlled by wind patterns both near the ground and aloft. Elevated power plant stacks emit nitrogen oxides hundreds of feet above the ground. Winds at this level are predominantly from the west through west-southwest directions in the Tennessee Valley *(Figure T1-12)*. Point sources emissions are generally elevated. Mobile and area source emissions and natural source emissions of nitrogen oxides occur near ground level. Surface winds that transport pollutants from near-ground sources usually flow from the south through southwest directions *(Figure T1-12)*. Winds from other directions also contribute to ozone transport. Average wind speeds and directions over the summer months would suggest that sources of nitrogen oxides 200 to 400 kilometers away could contribute to ozone levels in the Tennessee Valley *(Figure T1-24)*. During air stagnation episodes, local sources of nitrogen oxides and volatile organic compounds can predominate. Relative contributions of specific sources to specific receptors vary day to day as a function of

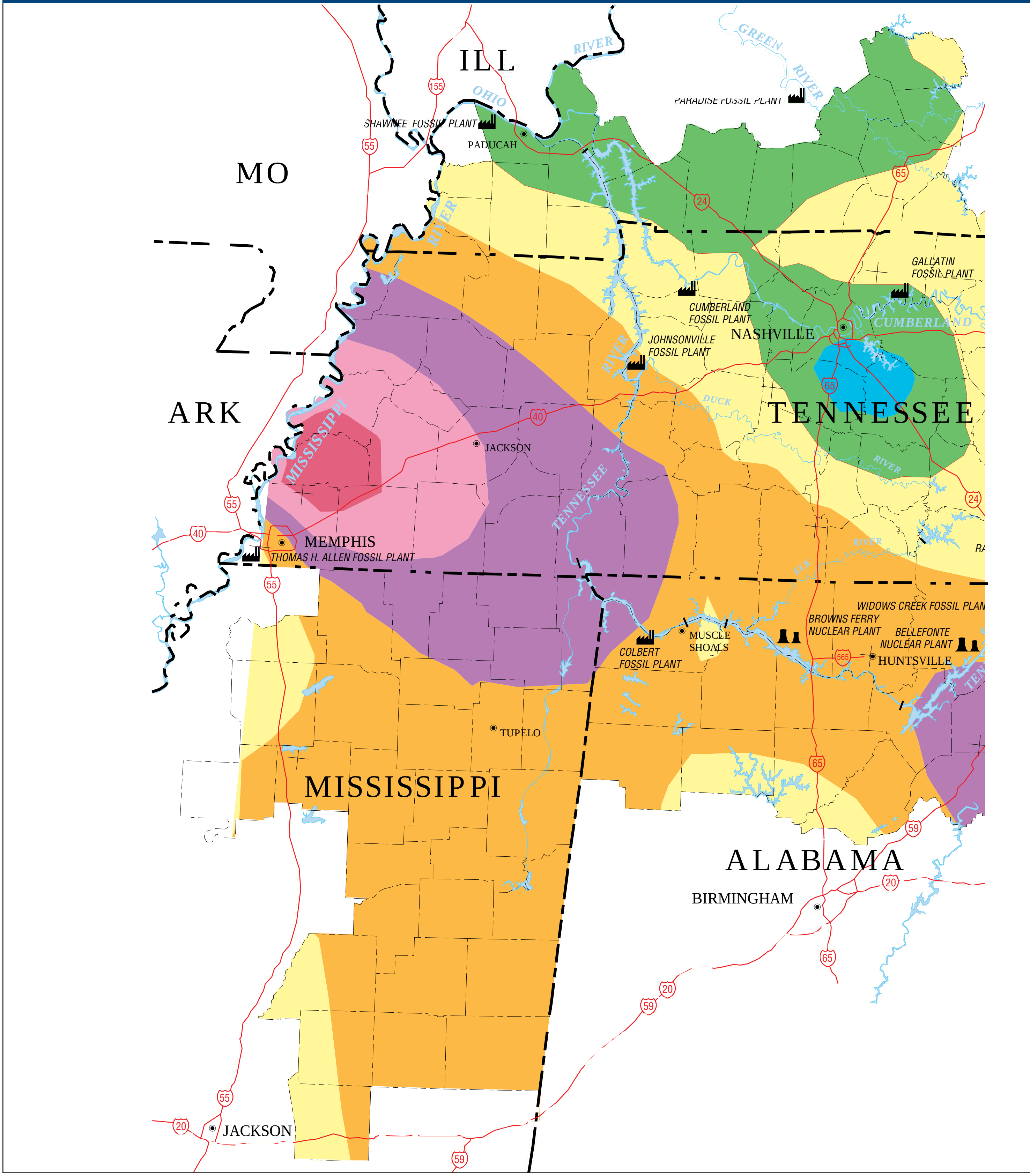
FIGURE T1-36. **Sum of All Days with 8-Hour Mean Ozone Concentration Greater Than 0.08 Parts per Million**





KENTUCKY
VIRGINIA
N CAR
S CAR
GEORGIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
SEQUOYAH NUCLEAR PLANT
PUMPED STORAGE
CHATTANOOGA
ATLANTA
RIVER
75
81
40
77
26
59
85
575
20
LEGEND
SUM OF ALL DAYS WITH 8 HOUR MEAN OZONE CONCENTRATION GREATER THAN 0.08 PPM.
0-
2-5.
6-10.
1-15.
16-20

FIGURE T1-37. **Cumulative Ozone Exposure Greater Than 0.06 Parts Per Million in a 3-Month Period**



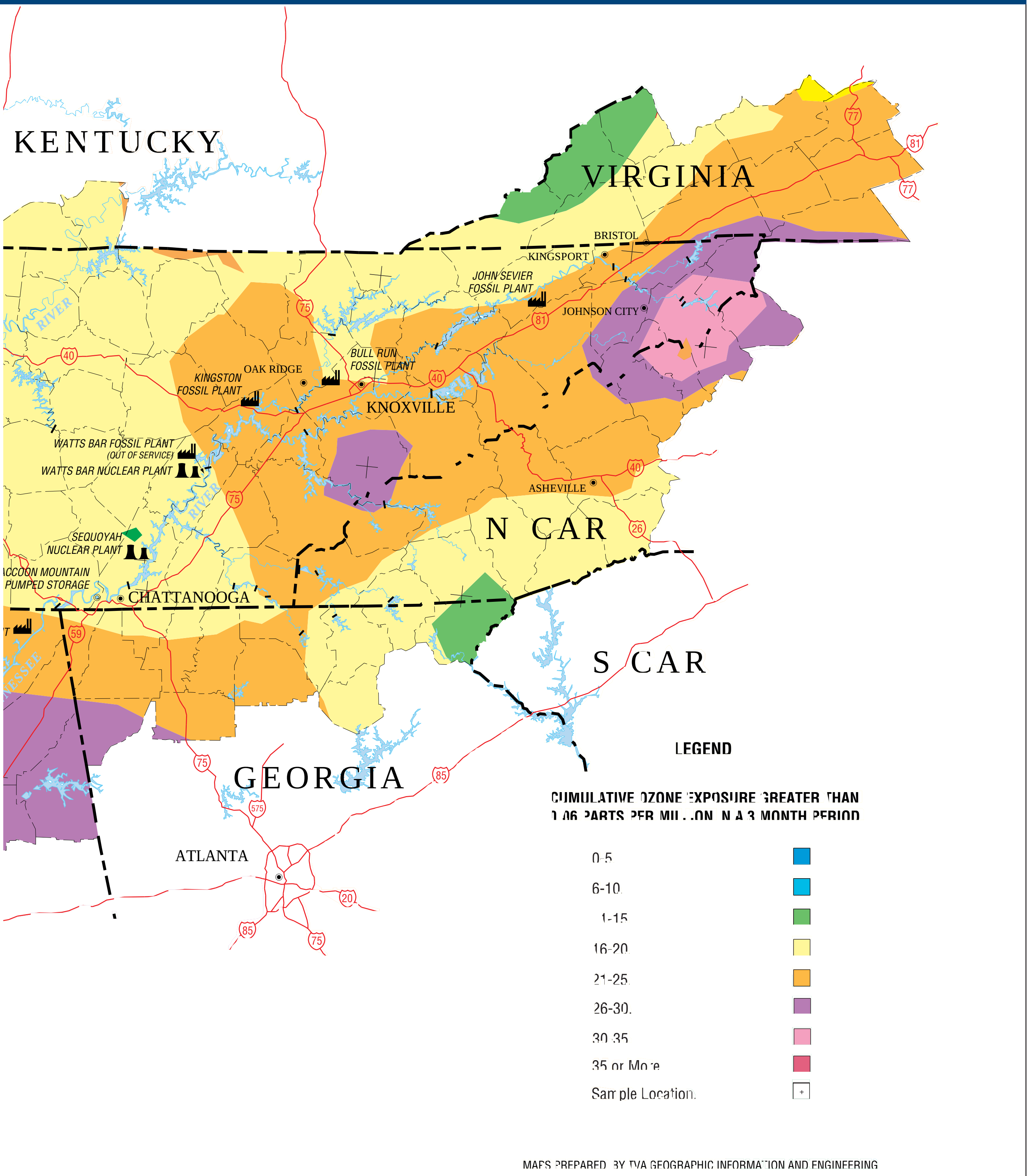
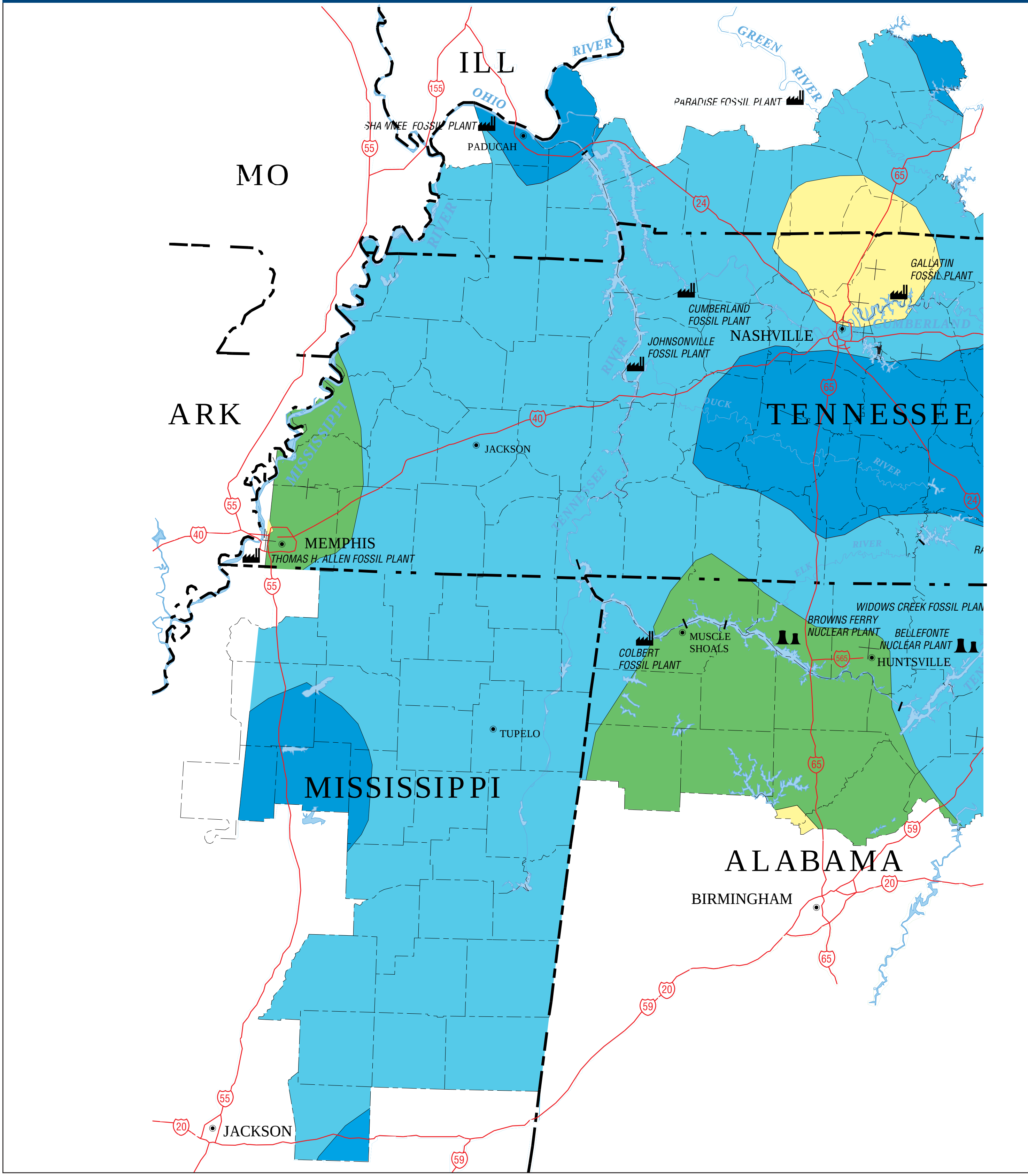
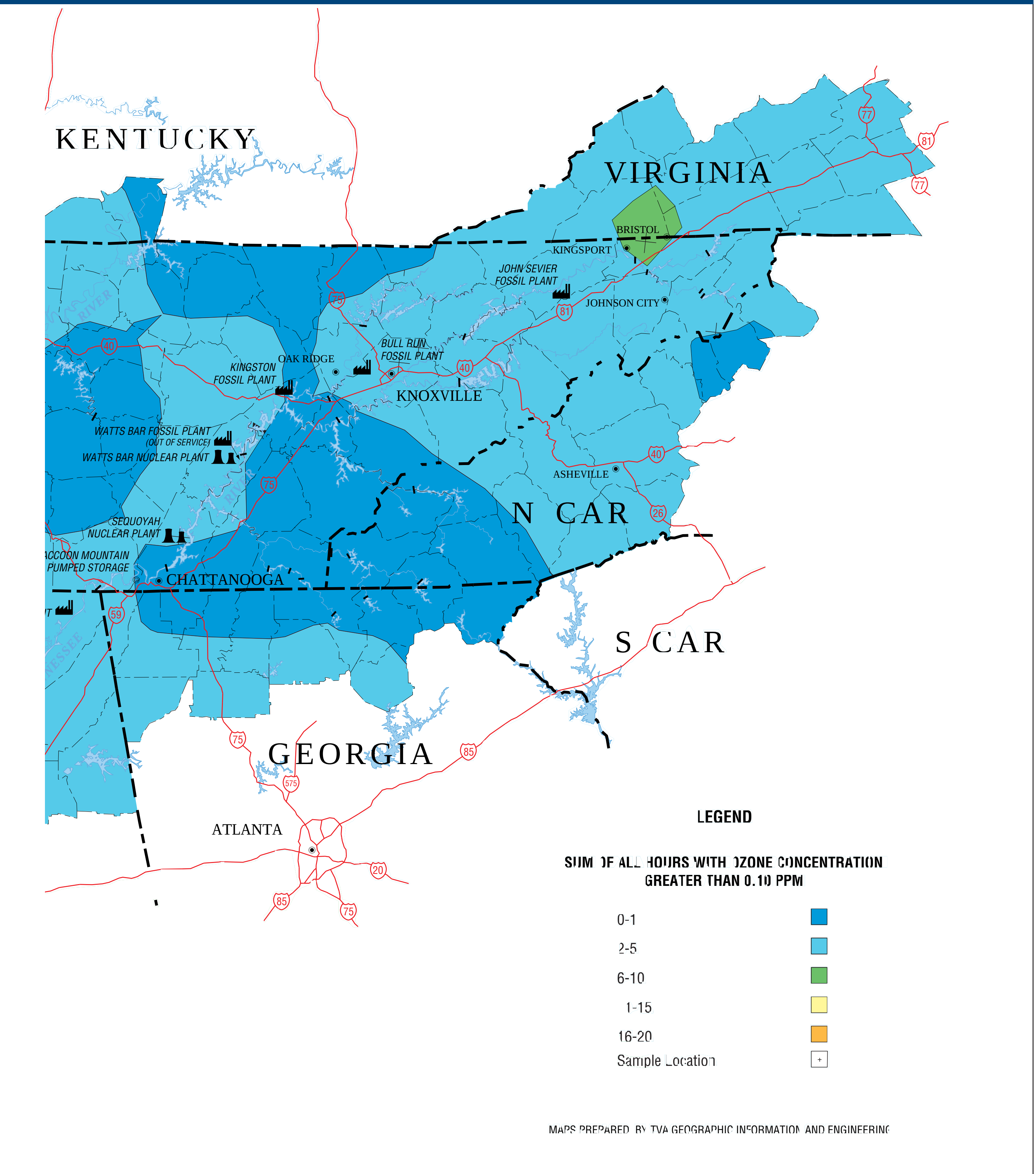

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
RIVER
LEGEND
CUMULATIVE OZONE EXPOSURE GREATER THAN
0-5
6-10
16-20
21-25
26-30
30-35
Sample Location
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-38. **Sum of All Hours with Ozone Concentration Greater Than 0.10 Parts per Million**




KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
LEGEND
SUM OF ALL HOURS WITH OZONE CONCENTRATION GREATER THAN 0.10 PPM
0-1
2-5
6-10
1-15
16-20
Sample Location
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

weather atmospheric mixing and transport. Similarly, TVA emissions of nitrogen oxides can contribute to ozone exposures at distances 200 to 400 kilometers downwind of specific sources. Percentage contribution cannot be accurately predicted without atmospheric modeling.

Based on prevailing wind speeds and direction, the source area for nitrogen oxide emissions contributing to ozone levels in the Great Smoky Mountains National Park is assumed to be a circle with a 300-kilometer radius and centered 150 kilometers west of the park. Within this source area and on a seasonal average basis, TVA emissions are estimated to be 18 percent of the total. Mobile, non-TVA point, area, and natural sources are estimated to contribute 30, 28, 16, and 8 percent, respectively, to ozone levels in the park *(Figure T1-33)*. Depending on the receptor and specific meteorologic conditions, TVA emissions may contribute 15 to 30 percent to ozone exposures in the TVA region.

ACID DEPOSITION

Acid deposition, acid rain, and acid precipitation are all terms used to describe the atmospheric input of acidic molecules, particularly sulfate and nitrate, to terrestrial and aquatic systems. Often this occurs as rainfall which is below natural pH levels. The term pH expresses the acidity or alkalinity of a concentration on a scale from 0 to 14, with 7 being neutral. Numbers less than 7 mean a concentration is acidic, while numbers greater than 7 mean the solution is alkaline. In the absence of human influence, precipitation would still be acidic due to the contribution of naturally occurring acids. Carbonic acid is formed when carbon dioxide is absorbed into cloud droplets. With other sources absent, precipitation would be weakly acidic with a pH of 5.2 to 5.6. Chloride, sulfate, and nitrate ions from natural sources such as sea salt, volcanic activity, and biological decay can further acidify precipitation. Alkaline substances in the atmosphere, particularly soil particles containing calcium, can have a neutralizing effect on cloud and rain water acidity. Acid deposition is of concern because human-produced emissions of sulfate and nitrate can acidify precipitation at levels well below that which would otherwise occur.

Acid deposition occurs in three forms: wet, dry, and cloud water.

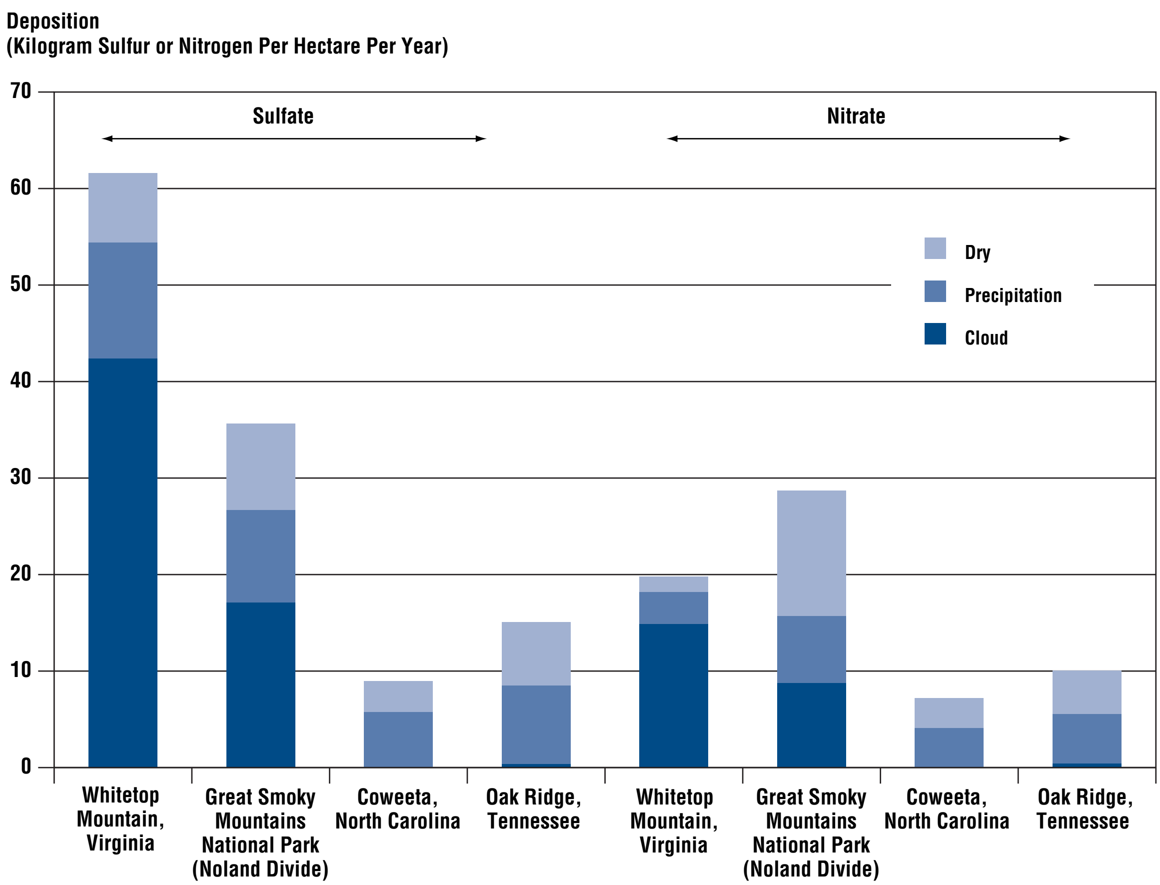
- Wet deposition is liquid or frozen precipitation. The concentration of acidic gases and particles in the atmosphere where clouds are formed determines the acidity of precipitation. Precipitation can deposit acidic pollutants hundreds of kilometers from the sources of origin.
- Dry deposition occurs when acidic aerosols such as sulfuric acid or acidic gases such as nitric and hydrochloric acids react with and deposit directly to surfaces without the presence of precipitation. Dry deposition processes occur constantly. The rate of deposition at any given location depends on the air concentrations of acidic gases and particles, the type of surface to which the deposition occurs, and the relative turbulence of the atmosphere just above the ground. Dry deposition is often greater near major sources of acidic pollutants.
- Cloud water deposition occurs when cloud droplets directly deposit their contents on surfaces. This phenomenon occurs primarily over elevated topography where clouds are intercepted. Acidic species are more concentrated in cloud water droplets than in rainwater. Forest canopies are especially efficient surfaces for cloud water interception. In areas such as the southern Appalachian Mountains, where immersion in clouds occurs frequently, cloud water deposition can be the predominant pathway for acidic deposition.

Ambient Trends

The relative importance of each deposition mechanism depends on site elevation, vegetation cover, and the location of a site relative to major human sources. At sites in the eastern United States where cloud deposition is not important, wet and dry depositions are about equal. In high elevation forests of the Appalachian Mountains, studies have found that cloud water can account for 50 percent or more of the total sulfate and nitrate deposition *(Figure T1-39)*. Cloud water pH, which averages about 3.6 in many areas, is typically lower than that of rainwater, which averages about 4.2 in the Appalachian region. Some sites may experience cloud interception more than 30 percent of the year (Mueller and Weatherford 1988; Lindberg and Lovett 1992; Lovett and Lindberg 1993). At these same sites, precipitation is often enhanced by the effect of the mountainous terrain lifting and cooling the air above it. Thus both the volume of precipitation and the total wet, dry, and cloud deposition at high elevation sites in the southern Appalachian Mountains can be greater than that of other areas of the Valley.

The trends for annual mean pH in precipitation for six low-elevation sites in the Tennessee Valley are presented in *Figure T1-40*. Annual mean pH generally increased over the period. The most acidic (lowest pH) precipitation in the Tennessee Valley region occurs in portions of Kentucky and east Tennessee, with slightly lower acidity to the east and south. Lowest annual pH values are near 4.2. Ranges of measured sulfate and nitrate concentrations at these sites are representative of all but the highest elevations of the Tennessee Valley. Loadings of sulfate are roughly twice loadings of nitrate in the Tennessee Valley and nationally according to data collected under the National Acid Deposition Program. This is the basis for targeting greater reductions in sulfur dioxide than in nitrogen oxides in the 1990 Clean Air Act Amendments. The Environmental Protection

FIGURE T1-39. **Growing Season Deposition of Sulfate and Nitrate Deposition by 3 Pathways at 4 Locations in the Eastern Part of the Tennessee Valley (1986 and 1987)**



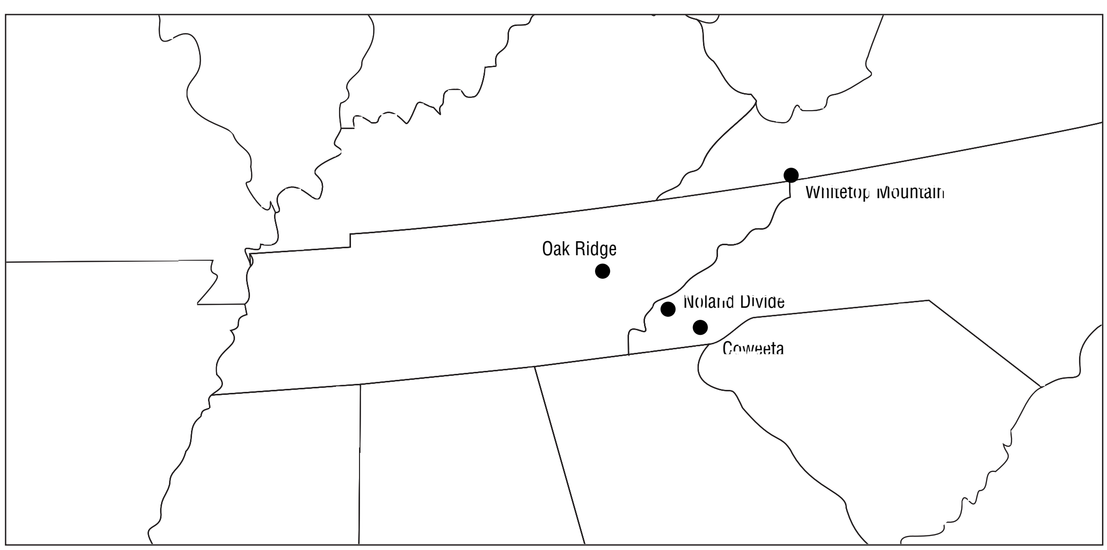
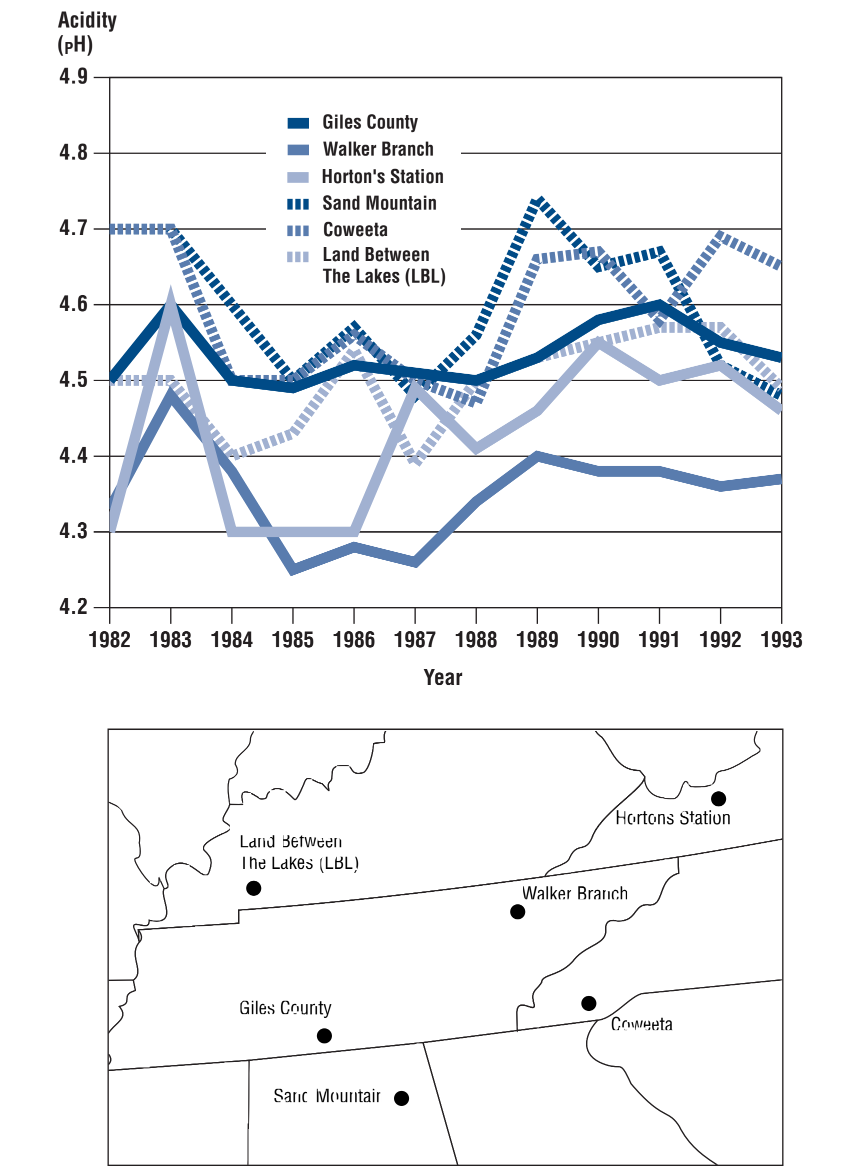


FIGURE T1-40. **Annual Mean Acidity (pH) of Precipitation at Six Monitoring Sites in the Energy Vision 2020 Study Area**



Agency is currently evaluating whether the reductions will be sufficient and is considering an acid deposition standard.

Some of the highest acidic inputs in the country are found in mountaintop forests of the southern Appalachians (Mueller and Weatherford 1988; Lindberg and Lovett 1992; Lovett and Lindberg 1993). Comparison of sulfate and nitrate deposition in 10 forest locations across the country indicates the highest loadings of sulfate and nitrate were measured at the Great Smoky Mountains site. Measurements at Whitetop Mountain and Mount Mitchell under the Mountain Cloud Chemistry Program (Vong 1990) support the same conclusions. However, because levels of cloud water deposited can vary twofold within a single forest stand, results from these specific sites cannot be generalized to be representative of all high elevation forests.

Understanding Emissions Contributions to Acid Deposition

The probable source region for nitrate in deposition is similar to that for ozone (200 to 400 kilometers). *(See Figure T1-24.)* The probable source region for sulfate deposition is larger than for nitrate and ozone because the rate of sulfate formation is slower. Oxidants, particularly peroxides, are required for sulfate formation. Summertime conversion of sulfur dioxide to sulfate occurs at a rate of roughly 1 percent per hour in the absence of clouds. Within clouds, conversion can reach 100 percent. In wintertime, oxidant levels, and thus rates of sulfate formation, are low. Assuming 24 to 48 hours for summertime formation and transport, sources 400 to 800 kilometers away are likely contributing to sulfate deposition in the Tennessee Valley *(Figure T1-20)*. As with ozone, local sources could predominate under some meteorological conditions, such as air stagnation episodes or favorable cloud chemistry. Sources within the assumed source area are not suggested to have equal contribution to deposition. Detailed atmospheric modeling would be required to determine contributions of specific sources to specific episodes. Based on the assumptions stated above, on a seasonal average basis, TVA sulfur dioxide emissions could contribute 18 percent to sulfate and 19 percent to nitrate deposited in the Great Smoky Mountains National Park. *(See Figure T1-41.)* TVA emissions could be greater under specific meteorological events.

Modeling results specifically linking TVA emissions with sulfate or nitrate deposition do not exist. The only modeling that has been done has grouped sources within geographic areas.

FIGURE T1-41. **Emission Comparisons for the Ozone Impact Source Region and the Acid Rain/Visibility Source Region**

SOURCE REGION FOR OZONE IMPACTS

POLLUTANT EMISSIONS (ca. 1990) [4,5]

Sources	Carbon Monoxide Tons/Day	Carbon Monoxide % of Total	Nitrogen Oxides [6] Tons/Day	Nitrogen Oxides [6] % of Total	Volatile Organic Compounds Tons/Day	Volatile Organic Compounds % of Total
Human Produced [1]	14,574	100.0	2,659	92.0	3,441	13.0
Natural [2]	0	0.0	237	8.0	23,273	87.0
Total	14,574	100.0	2,896	100.0	26,714	100.0
TVA Portion of Human Produced [3]	24	0.2	512	18.0	3	0.0

SOURCE REGION FOR ACID RAIN VISIBILITY IMPACTS

POLLUTANT EMISSIONS (ca. 1990) [4,5]

Sources	Nitrogen Oxides Tons/Day	Nitrogen Oxides % of Total	Sulfur Dioxide [7] Tons/Day	Sulfur Dioxide [7] % of Total	Volatile Organic Compounds Tons/Day	Volatile Organic Compounds % of Total
Human Produced [1]	5,841	87.0	15,177	100.0	6,767	10.0
Natural [2]	873	13.0	10	0.1	63,234	90.0
Total	6,714	100.0	15,187	100.0	70,001	100.0
TVA Portion of Human Produced [3]	598	9.0	2,736	18.0	4	0.0

1 Based on annual values in Environmental Protection Agency 1990 Interim Inventory/365.

2 For NO_X and VOC: based on BEIS2 model, ROM/SUPROXA domain land use data and "typical" ozone meteorology (max. temperature=35 C and full sun). For equivalent SO_2: estimated from data presented in (Placet, 1990).

3 Portion of 1990 Inventory allocated to TVA sources.

4 All rates are in metric tons.

5 TVA estimates that its 1990 emissions in this region were within 2-6% of the 1990 inventory values.

6 Emissions expressed as equivalent NO.

7 Natural SO_2 emissions are assumed to be negligible; estimates represent biogenic sulfur emissions expressed as equivalent SO_2.

Thus, National Acid Precipitation Assessment Program modeling results using the Regional Acid Deposition Model cannot distinguish between TVA emissions and those from other nearby sources.

TVA emissions of sulfur dioxide will be reduced significantly under Title IV requirements of the 1990 Amendments to the Clean Air Act. New emissions controls, such as the sulfur dioxide scrubbers recently installed on the two boilers at the TVA Cumberland power plant, further reduce TVA contributions to downwind sulfur deposition. TVA's future energy options project further reductions in sulfur dioxide emissions that are discussed in Volume 2, Document 2, Environmental Consequences.

VISIBILITY IMPAIRMENT

Visibility impairment refers to atmospheric conditions in which the ability of an observer to discern form, color, or texture of a distant vista is reduced from that which would have existed under natural conditions, causing the scenic value of that vista to be diminished. An adverse impact on visibility is defined by 40 CFR 51.301 federal regulation (Federal Register 1977) as "…visibility impairment which interferes with the management, protection, preservation or enjoyment of the visitor's visual experience of the Federal Class I area." *Figure T1-42* contains the pollutants causing visibility impairment, emissions, and control technologies.

Visibility impairment can be considered in two categories:

FIGURE T1-42. **Pollutants Causing Visibility Impairment, the Primary Emissions, and Their Control Technologies**

Secondary Pollutant	Primary Emission	Control Technology
Primary Fine Particulate Matter	Primary Fine Particles	Electrostatic Precipitator, Baghouse, Venturi Scrubber, Cyclones
Particulate Nitrates	Nitrogen Oxides	Low Nitrogen Oxides Burners
Particulate Sulfates	Sulfur Dioxide	Low Sulfur Coal, Coal Washing, Scrubbers, Fluidized Bed Combustion
Acid Mist	Sulfite	Ammonia Addition, Low Sulfur Coal
Nitrogen Oxides	Nitrogen Dioxide, Nitrogen Oxide, Nitrous Oxide	Low Nitrogen Oxides Burners, Selective Catalytic Reduction

- Regional haze that occurs over a wide geographical area and often persists for a few days
- Plume opaqueness that occurs when emissions from a specific source are observable, usually within 100 kilometers of the source and for shorter duration than a regional haze episode.

In the TVA region, both types of visibility impairment may occur.

Regional Haze

Visibility is affected by the concentrations of gases and particles in the air, the angle of the sun, the object being viewed, and the viewer. Gases that affect visibility include water vapor and nitrogen oxides.

The light that contributes to our perception of an image can be altered by three mechanisms:

- Light is scattered out of the sight path between the viewer and the object (vista).
- Light is absorbed in the sight path.
- Ambient light is scattered into the sight path and competes with the image—forming light to reduce the clarity of the image.

The sum of scattering and absorption of light is referred to as atmospheric light extinction.

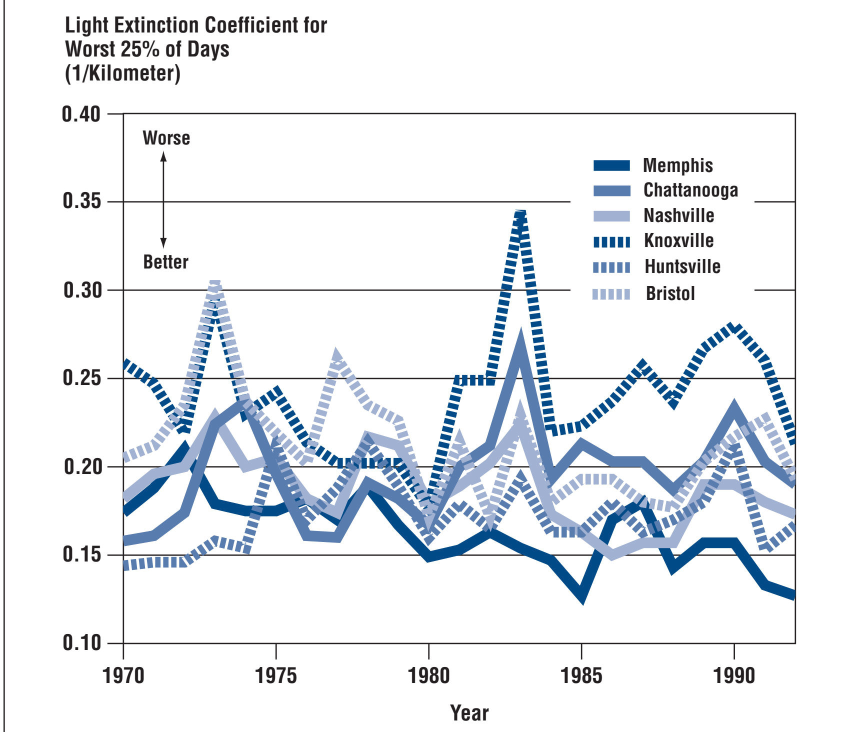
Atmospheric particles that reduce visual contrast and visual range by absorbing and scattering light have their origin in both natural and human-produced processes. Most of the soil components, such as silicates and other inorganic oxides, are of natural origin. Organic aerosols result from photochemical processes involving both natural and human-produced sources. The bluish haze characteristic of southern Appalachia originates from organic aerosols emitted by vegetation. Elemental carbon comes from combustion, including natural forest fires and human-made fires. Sulfates originate from human-produced sources of emissions, such as fossil fuel combustion and industrial processes. Natural sources such as volcanoes and hydrothermal vents, sea salt, and biogenic activity in the oceans and wetlands contribute significantly to global sulfate loadings (30 to 40 percent in the northern hemisphere). In the Tennessee Valley they are of minor importance. Formation of sulfate is seasonally dependent, with the rate of formation greater in the summer months. Compared to sulfate particulate matter, nitrate particulate matter is of secondary importance as a contributor to visibility impairment.

Relative humidity has a significant effect on light extinction, and thus visibility, in the eastern United States. Water vapor in the air provides surfaces for particles, especially sulfate, to bond. These particles grow in size to the size fraction (0.6 micrometers) that is most efficient in scattering light. Higher relative humidity in the eastern United States as well as higher emissions levels, explains why visibility is generally poorer in the eastern than western United States. Differences in relative humidity can also contribute to differences in average summer visibility trends between wetter and drier seasons. For example, visibility in cities in the Tennessee Valley was generally better in the dry summer of 1988 than the wet summer of 1989 *(Figure T1-43)*. Sulfate aerosol levels were 25 percent lower in the summer of 1988 than in the summer of 1989 (Eldred and Cahill 1994).

Ambient Trends

Several methods have been used to measure visibility. The longest record available is from human observations of visual range at airports across the country. Fine-particulate matter and some atmospheric gases scatter light in a phenomenon referred to as light extinction. This scattering causes objects to appear fuzzy or to merge with the background. Light extinction values are calculated from human observations. The measure of visual range is an inverse of the measure of light extinction; smaller extinction values represent clearer air and better visual range. Trends for light extinction at six urban airports in the Tennessee Valley from 1970 to 1992 during summer months (July to September) for the days with the worst 25 percent visibility are presented in *Figure T1-43*. Despite improvements in ambient levels of sulfur dioxide *(Figure T1-19)* and particulate matter less than 10 microns in size *(Figure T1-28)*, vis-

FIGURE T1-43. **Summer Visibility Trends for the Worst 25 Percent of Days in Six Cities in the Energy Vision 2020 Study Area as Shown by the Light Extinction Coefficient Have Shown Little Improvement**



Shenandoah National Park in 1982. IMPROVE sites have been established more recently at Mammoth Cave National Park and several national wilderness areas maintained by the U.S. Forest Service. Eldred and Cahill (1994) reported that sulfate concentrations at Great Smoky Mountain and Shenandoah National Parks increased from 1982 to 1993.

In addition to the IMPROVE data, camera images from the Class I areas are available for a longer time frame than are the light extinction measures of visibility. Camera data for the U.S. Forest Service wilderness areas will be published with the final report of the Southern Appalachian Assessment. Based on camera images in six U.S. Forest Service Class I wilderness areas, the median standard visual range in July and August is 25-30 kilometers. In December and January, median standard visual range is between 106 and 244 kilometers (Scott Copeland, unpublished data). The Southern Appalachian Mountain Initiative is also evaluating visibility and is considering emission sources contributing to visibility impairment. TVA's final analysis of environmental consequences may incorporate results from the Southern Appalachian Assessment and Southern Appalachian Mountain Initiative reports. (See discussion under Current Research and Assessment programs section in this document on page T1.70.)

ibility has not improved in the Tennessee Valley over this time period. Based on airport data, analyzes under the National Acid Precipitation Assessment Program concluded that visibility in the Southeast has decreased 60 percent since 1948 when measures were first made (Trijonis et al. 1990). Particulate matter in the fraction less than 2.5 microns would likely be better correlated with visibility, but there is very limited data available in the Southeast for particulates of this size.

Visibility has also been measured in Class I areas of southern Appalachia. Malm et al. (1994) report summertime 1985 extinction coefficients for Great Smoky Mountains National Park between 0.22 and 0.26 per kilometer. These are similar to values for Knoxville. *(See Figure T1-43).* Sulfate is the major contributor to the fine-particulate fraction that impairs visibility. In addition, soil dusts, elemental carbon, and organic aerosols also contribute to visibility impairment. Malm et al. (1994) estimated that sulfate was responsible for 48 percent of the measured light extinction for the 10 percent best summertime days in 1985 in the Great Smoky Mountains, 64 percent of the median days, and 76 percent of the worst days.

The Interagency Monitoring of Protected Visual Environments (IMPROVE) network began measuring visibility and particulate matter in Great Smoky Mountains National Park in 1984 and in

Understanding Emissions Contributions to Regional Haze

The source area discussed for sulfate in acid deposition is also applicable to sulfate aerosols that scatter light and impair visibility. The relationship between sulfate levels and light extinction is not linear. This means that a reduction in sulfate levels may not lead to an equal improvement in light scattering due to sulfate.

In regions with high aerosol loadings, a decrease in the concentration particulate matter may lead to only a small improvement in visibility. The National Acid Precipitation Assessment Program (NAPAP) produced an early assessment of regional visibility impacts expected to result from changes in sulfate emissions. Malm et al. (1994) modeled the expected change in visibility that would result from a 10 million ton per year reduction in sulfur dioxide emission rates in the eastern United States as a result of the Clean Air Act Amendments of 1990. The

greatest improvement in visibility was projected to be in the Ohio River Valley. The emission reductions were projected to have an impact that, when averaged across the eastern United States, would result in a 5 percent (just perceptible) improvement in light extinction on the 15 days in the year having the highest sulfate concentration. Malm et al. projected impacts for three Class I areas, with the Great Smoky Mountains National Park being the one most likely influenced by TVA emissions. The park had a projected decrease in sulfate concentrations of 44 percent, and a net decrease in light extinction of 35 to 45 percent due to implementation of the 1990 Clean Air Act Amendments.

Based on the 1990 emissions inventory for the greater source area *(Figure T1-20)*, and averaged over summer conditions, TVA emissions are estimated to be roughly one quarter of total sources contributing to sulfate particle loadings in the Great Smoky Mountains National Park. TVA emissions could be a greater contributor during specific episodes.

FIGURE T1-44. **Hazardous Air Pollutants Studied at TVA Coal-Fired Power Plants.**

Inorganics	Organics
Antimony (Sb)	Benzene
Arsenic (As)	Toluene
Beryllium (Be)	Formaldehyde [e.g., Benzo-a-Phrene (BAP)]
Cadmium (Cd)	Dioxins/Furans
Chlorine/Hydrogen Chloride (HCL)	Polycyollo Organic Matter (POM) [e.g., Benxo-a-Pyrene (BAP)]
Chromium (Cr)	
Cobalt (Co)	
Fluorine/Hydrogen Fluoride (HF)	
Lead (Pb)	
Manganese (Mn)	
Nickel (Ni)	
Mercury (Hg)	
Selenium (Se)	
Radionuclides	

Plume Blight and Opaqueness

Plume blight is the visual perception of a plume from a large industrial source located at a distance. Because large sources such as coal-fired power plants have elevated stacks, their emissions can sometimes travel great distances before they disperse to the ground. Opacity (or visible emissions) is a measurement of the visibility of a plume. Observations are made at the point of highest opacity in the plume, where condensed water vapor is not present. The visible emissions measure was originally a method for ensuring that the mass emissions from a facility were within the allowable limits. However, at coal-fired power plants, particularly those with flue gas desulfurization, the mass emission rate may be met while exceeding the allowable opacity.

Coal-fired power plants emit fine particles, gases that form fine particles in the atmosphere, and gases that directly absorb light. Fine particles scatter light. Emission controls typically remove more than 95 percent of the mass of fine-particulate matter. Those that escape scatter light and are the primary cause of plume blight and opacity. Secondary sulfate and nitrate particles and acid aerosols can also contribute to plume opacity.

HAZARDOUS AIR POLLUTANTS

Title III of the 1990 Clean Air Act Amendments identified 189 substances as hazardous air pollutants. This greatly expanded the number of chemicals subject to regulation. The Environmental Protection Agency is to develop regulations for each source category (i.e., each type of industrial facility) that emits the listed air toxics. The Environmental Protection Agency was directed to evaluate the hazards to human health and the environment from hazardous air pollutants emitted by electric utilities and to recommend whether emission reductions were warranted for utility plants. The Environmental Protection Agency was given until November 1993 to complete this study, but it is currently behind schedule. The Environmental Protection Agency issued a draft report for review in spring 1995. The final report is expected in November 1995. If the Environmental Protection Agency concludes that emissions reductions are warranted, it must establish necessary and appropriate control requirements. At the earliest, any new regulations would be proposed in 1996 and finalized in 1997. Utilities would have until approximately the year 2000 to bring their plants into compliance.

The Electric Power Research Institute and the Department of Energy have characterized toxic emissions for nearly 100 U.S. utility boilers representing a range of fuels, boiler configurations, and control technologies. Based on these results, the Electric Power Research Institute has estimated emissions and risk to human health from emissions at over 600 utility plants. (EPRI 1994). The Electric Power Research Institute's assessment indicated that no TVA plants and only 3 of the 600 plants posed cancer risks greater than the one-in-one-million identified in the statute and used by the Environmental Protection Agency as an accepted level of minimal risk. Calculated ambient exposures from all plants were below

FIGURE T1-45. **Human Health Risks in the Tennessee Valley Due to Air Concentrations of Heavy Metals**

Metal	Air Concentration at Fort Loudoun, Tennessee Milligram per Cubic Meter	Public Standard Milligram per Cubic Meter	Ratio: Observed to Standard
Arsenic	0.0015	0.3 [1]	1:200
Beryllium	No Data [2]	0.01 [3]	(1:25) [2]
Cadmium	0.007 [2]	50 [4]	(1:7000)
Chromium	0.002 [6]	No Standard [5]	
Copper	Not a Health Hazard by Inhalation Pathway		
Mercury	0.0016	No Standard	

1 State of Washington standard — only agency to date to establish a standard.

2 Survey of U.S. cities indicate the highest recorded level in any city was 0.0004 or about 1/25 of the current provisional Environmental Protection Agency standard.

3 Current standard is a provisional Environmental Protection Agency criterion for a 30-day average (U.S. Public Health Service, 1989)

4 U.S. Public Health Service standard for occupation exposure; no standard has been established for exposure of general public to ambient air.

5 No Environmental Protection Agency standard has been set since hexavalent chromium is a carcinogen by inhalation pathway. Cancer risks have been identified for various exposures to hexavalent chromium.

6 TVA has data only on total chromium, not hexavalent chromium, at the Fort Loudoun site. Approximately 0.2% of power plant emitted chromium is in the hexavalent state. Applying this factor to the measured value for total chromium, and using Environmental Protection Agency data on cancer risk, the cancer risk at this level is estimated to be 1 in 25,000,000.

known threshold levels for human toxicity, even when exposures from multiple sources were considered. TVA is estimating emissions of 19 hazardous air pollutants released from TVA coal-fired plants as part of its reporting requirement under Title V of the 1990 Clean Air Act Amendment *(Figure T1-44)*.

Radionuclides are one of the hazardous air pollutants being evaluated by the Environmental Protection Agency in its study of utility industry hazardous air pollutant emissions. Coal-fired boilers emit trace amounts of radioactive elements (uranium, radium, thorium, and their decay products) found in the fuel. These radionuclides become incorporated into fly ash and are released to the air in the particulate matter emitted from the boilers. Particulate air pollution control equipment, such as electrostatic precipitators limit radionuclide emissions.

Risks to human health due to air concentrations of arsenic, beryllium, cadmium, chromium, and copper in the Tennessee Valley are extremely low. (See discussion under human health impacts section.) *(See Figure T1-45 and T1-46.)* Environmental impacts from heavy metals are largely confined to aquatic ecosystems where concentrations are highest and organisms are often most sensitive. *Figure T1-47* indicates that water concentrations in Fort Loudoun reservoir would have to increase at least a hundredfold to approach thresholds for organism response to arsenic, beryllium, and chromium. Copper and cadmium concentrations measured at Fort Loudoun approach thresholds where some aquatic invertebrates may be affected. TVA is only one contributor to ambient levels of these metals in the Tennessee Valley. Nationally, electric utilities are estimated to contribute about 50 percent of the beryllium, 30-35 percent of the cadmium, 12-16 percent of the chromium, 2-5 percent of the copper, and less than 3 per-

FIGURE T1-46. **Human Health Risks in the Tennessee Valley Due to Water Concentrations of Heavy Metals**

Metal	Water Concentration at Fort Loudoun Reservoir, Tennessee (Milligrams/Liter)	Public Standard (Milligrams/Liter)	Ratio: Observed to Standard
Arsenic	0.034	50 [1]	1:150
Beryllium	Not a Carcinogen by Ingestion Pathway		
Cadmium	0.10	5 [2]	1:50
Chromium	0.46	50 [2]	
Copper	Not a Health Hazard by Ingestion Pathway		
Mercury	0.0058	No Standard [3]	

1 Interim Maximum Contamination Level established by both Environmental Protection Agency and World Health Organization.

2 Environmental Protection Agency drinking water standard.

3 Standard based on fish concentrations for human consumption rather than water concentration.

FIGURE T1-47. **Levels of Metals in Fort Loudoun Reservoir Compared to Threshold Exposures for Environmental Impacts**

Metal	Water Concentration at Fort Loudoun Reservoir, Tennessee (Milligrams/Liter)	EPA Criterion: Biotic Effects (Milligrams/Liter)	Ratio: Observed to Standard
Arsenic	0.34	40[1]	1:100
Beryllium	Not measured (0.02[2])	5.3[3]	(1:250)
Cadmium	0.10	0.05[4]	2:1
Chromium	0.46	100[5]	1:200
Copper	0.8 (0.5 to 5)	5.6[6]	1:7

1 Threshold for embryo and larvae of vertebrates

2 Beryllium level of the highly-polluted Rhine River, demonstrating how low river levels of beryllium generally are.

3 Threshold for crustacean chronic toxicity.

4 Threshold for larvae and embryos of freshwater fish in water of hardness of 200 Milligram per Liter.

5 Threshold for freshwater invertebrates

6 U.S. Environmental Protection Agency criteria for aquatic life.

cent of the arsenic emitted annually to the atmosphere by human sources (Neme 1990).

Mercury

Mercury is used in Energy Vision 2020 as an indicator of hazardous air pollutants. Depending on the degree of concentration and length of exposure, mercury can have toxic effects on humans and wildlife. Organic mercury compounds, such as methyl mercury, are among the most toxic. Mercury salts released into the environment may be converted by bacteria into organic mercury compounds. Mercury accumulates in the environment and is carried through the food chain with ultimate consumption by humans.

Worldwide, approximately 6,000 tons of mercury are released into the air every year. Human activities account for half of this. Estimates vary widely, but United States electric utilities emit about 80 tons per year (EPRI 1993), representing 1.3 percent of the global or 20 percent of United States human-produced emissions. Measurement of the chemical forms of mercury in stacks and in plumes from coal-fired power plants indicate that mercury occurs in both gaseous (elemental) and particulate (oxidized salt) phases.

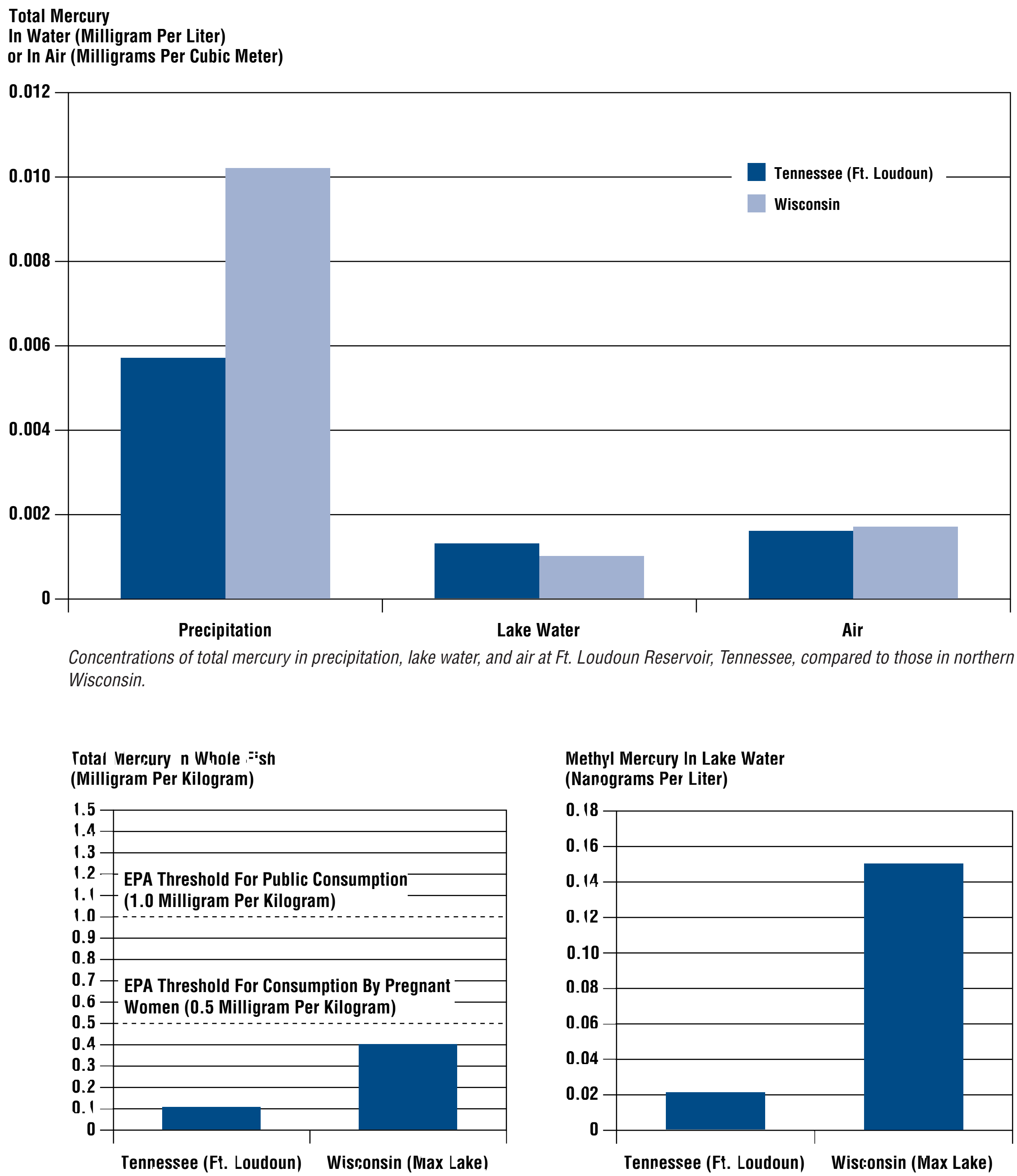
The 1990 Clean Air Act Amendments require the Environmental Protection Agency to study and report on United States mercury emissions. The Environmental Protection Agency's draft mercury study was available for public review in January 1995 with parallel peer reviews and public meetings.

TVA is cooperating in national studies with the Department of Energy and the Electric Power Research Institute to evaluate the efficiency of mercury removal by different control technologies. If the Environmental Protection Agency requires control of mercury emissions, likely controls include wet scrubbers, high efficiency electrostatic precipitators, fabric filters, and/or injection of a sorbent such as activated carbon into the flue gas. Human-produced emission sources are about equally divided among coal combustion, waste incineration, and other facilities.

Globally, impacts of mercury are of concern for sensitive invertebrate and vertebrate species in aquatic ecosystems. Watershed characteristics determine whether atmospherically deposited mercury will accumulate in aquatic ecosystems. Dissolved organic carbon and sulfate ions facilitate mobilization and transport of mercury in aquatic systems. The Tennessee Valley has a higher land-to-surface water ratio and comparatively lower levels of dissolved organic carbon and sulfate than those areas of the country that are experiencing impacts (Joslin 1994). *(See Figure T1-48.)* Impacts of TVA's mercury emissions in the Tennessee Valley are likely to be minor, because the watersheds in the Valley are generally well buffered against mercury accumulation.

TVA emissions could contribute a small percentage to overall mercury loading in watersheds in the upper Midwest and Florida that are sensitive to mercury accumulation. Uncertainty regarding the extent to which mercury is deposited locally, regionally, or globally prevents more quantitative estimates of TVA's contributions to mercury loadings. TVA emissions of mercury are very small compared to its other emissions and compared to mercury emissions from other sources. Mercury emissions under TVA's future energy alternatives are tracked in Volume 2, Document 2, Environmental Consequences, as a surrogate for all toxic emissions from TVA's coal-fired power plants.

FIGURE T1-48. **Comparisons of Environmental Mercury Concentrations**



Concentrations of total mercury in precipitation, lake water, and air at Ft. Loudoun Reservoir, Tennessee, compared to those in northern Wisconsin.

Comparison of total mercury in whole fish and toxic methyl mercury in lake water in Ft. Loudoun Reservoir, Tennessee, and in Max Lake, Wisconsin.

GLOBAL CLIMATE CHANGE

The earth's climate is controlled by the radiative balance of the atmosphere. This refers to the radiant energy received from the sun and emitted by the earth back to space. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFC). With the exception of chlorofluorocarbons, these gases occur naturally. However, human-produced emissions have contributed to the increases in their concentrations. These gases absorb infrared radiation as it passes through the atmosphere and re-emit this energy. This results in a warming of the earth's surface. The greenhouse effect is a natural phenomenon that makes the earth inhabitable. The earth would be cooler by approximately 30 degrees C without the effect of naturally occurring gases. A recent estimate of the contribution by different human-produced activities shows carbon dioxide emissions from energy use and production are the largest contributors to greenhouse gases. The combined effect of the other trace gases presently is equal to that of carbon dioxide.

Globally, atmospheric concentrations of greenhouse gases are believed to have increased dramatically from pre-industrial levels. Atmospheric carbon dioxide has increased from 270 parts per million by volume prior to 1880 to 355 in 1990. The current rate of increase of carbon dioxide is 1.8 parts per million by volume per year or 0.5 percent per year. Fossil fuel combustion and global deforestation are the primary contributors to carbon dioxide buildup. The rate of global increase is projected to accelerate in the next decade as underdeveloped nations, particularly China and India, significantly increase power generation using coal.

Global circulation models predict an average global warming between 1.5 and 4.5 degrees C (2.7 and 8.1 degrees F), changes in precipitation amounts, and distribution (Bretherton et al. 1990; Mitchell et al. 1990) by the middle of the next century. These changes in global precipitation and distribution are also predicted to result in regional changes in crop and forest productivity, land use, water quality and quantity, and possible loss of ecosystems that cannot adapt to these changes. While the general circulation models generally agree that average temperatures in North America will rise, there is a great deal of uncertainty about the magnitude of changes in temperature and whether rainfall will increase or decrease. Current models do not have sufficient spatial resolution to predict magnitude or direction of changes on regional scales. At the current spatial resolutions, the models do not distinguish the southern Appalachian mountains as unique topographic features. Changes in temperature and rainfall within a region such as the Tennessee Valley could have far-reaching impacts on various sectors such as energy, transportation, agriculture, forestry, and socioeconomic factors. However, the science of global warming does not permit reasonable predictions of potential impacts.

The magnitude and scope of the potential climate change impacts are of concern for three areas of TVA operations:

- Those related to power production, including both adjustments to power demand and to power supply operations such as water availability for hydroelectric power production, and water temperature limits for nuclear and coal plant water usage
- Issues related to political or legislative constraints on emissions
- Impacts on the natural resources of the Valley, i.e., forests, water, and agriculture.

Despite the scientific uncertainties, TVA has already agreed, along with some 60 other utilities, to participate in the Department of Energy's Climate Challenge initiative and to voluntarily reduce equivalent TVA carbon dioxide emissions by the year 2000.

Aside from its present activities which seek to reduce equivalent carbon dioxide emissions, TVA is also evaluating how different energy resource options affect greenhouse gas emissions. For example, coal-based technologies emit over 200 pounds of carbon dioxide per million Btu of heat input. Nuclear, wind, solar, and hydroelectric power production essentially emit no carbon dioxide. Biomass fuel options that include burning of wood or herbaceous crops that recycle carbon stored in the vegetation after converting carbon dioxide from the atmosphere have less carbon dioxide emissions than coal-fired options. There may actually be a reduction of carbon dioxide since the root systems of these crops act to store carbon in the soil even after the crop has been harvested for fuel.

The carbon dioxide emissions level is one of the measures used to differentiate among TVA's energy strategies.

Cooperative Research and Assessment Programs

This document summarizes current scientific understanding. Uncertainties in current scientific understanding limit our ability to assess:

- The specific contribution of TVA emissions to regional pollutant loadings
- The relationships between pollutant levels and impacts to human health and the environment
- The expected benefits of specific emission reductions.

TVA is cooperating with several regional air pollution research and assessment programs to improve the scientific

understanding and to design regulatory policy that will be successful in the Tennessee Valley to mitigate present and prevent future impacts. Results of these regional programs will be available between 1995 and 1997. The programs are discussed below.

The Southern Appalachian Mountain Initiative (SAMI) and the Southern Appalachian Assessment (SAA) are two regional assessments being conducted under the public review process to evaluate air pollutant impacts in southern Appalachia. TVA is actively participating in both studies. The assessments summarize existing information on visibility impairment, acid deposition, and ozone impacts in southern Appalachia. The Southern Appalachian Mountain Initiative work is ongoing and may provide information that can be used by TVA. A final report for the Southern Appalachian Assessment is expected early in 1996. TVA's analysis may contribute to the assessments being developed by these groups and to their public information and policy decision-making process.

The Southern Appalachian Assessment considers both ecological and socioeconomic focuses. It is led by seven federal agencies in the southern Appalachian region. The Atmospheric Team of the Southern Appalachian Assessment will report by fall 1995 on visibility impairment, acid deposition, and ozone in southern Appalachia.

The Southern Appalachian Mountain Initiative focuses on policy development and regulatory recommendations for air emissions management. It includes state and federal regulatory agencies, federal land managers, industry, academia, and public interest groups. The Southern Appalachian Mountain Initiative is evaluating emissions management options to mitigate existing or prevent future air quality impacts in Class I areas of southern Appalachia. Existing information on air quality impacts will be evaluated and delivered by the Southern Appalachian Mountain Initiative's Technical Oversight Committee in fall 1995. In its technical assessment of emissions management options, the Southern Appalachian Mountain Initiative's Integrated Assessment Committee is designing a framework to integrate current understanding of relationships among emissions, exposures, and impacts. The technical assessment and recommendations on emissions management options are anticipated to be complete by 1997.

The Southern Oxidants Study is a research partnership between the pubic and private sector to better understand the processes and sources that contribute to regional ozone formation. Several federal agencies, state and local regulatory agencies, industries, and universities are participating in the partnership to study rural ozone exposures and source contributions to urban nonattainment areas in the southeastern United States. In the summer of 1995, the Southern Oxidants Study conducted an extensive field study of rural and urban influences on ozone formation in the Nashville area. TVA is leading the design and implementation of this multi-organizational field study. Results from this field study will allow better understanding of the total biogenic (natural) and human-produced sources contributing to regional ozone formation and the specific contributions of TVA nitrogen oxides emissions to ambient ozone exposures. The North American Research Strategy on Tropospheric Ozone is a national effort to understand why emission control strategies over the past two decades have not been effective in reducing ozone exposures. The Southern Oxidants Study is one component of the larger national program. Results of these studies were not available in time to be evaluated in TVA's analysis of environmental consequences of its future energy supply alternatives.

The Electric Power Research Institute is evaluating risks to human health and the environment due to ozone, fine-particulate, and hazardous air pollutant impacts. The Institute delivers results of its research and risk assessments to the Environmental Protection Agency and regulatory authorities to be considered in developing future emissions regulatory policies. TVA is cooperating with the Electric Power Research Institute, the National Park Service, and several southern utilities to measure visibility and particulate species (i.e. sulfates, nitrates, soil, primary particles, etc.) in the Great Smoky Mountains National Park during summer 1995. Results will not be available in time to be evaluated in TVA's final analysis of environmental consequences of TVA future energy strategies. TVA is also cooperating with the Electric Power Research Institute and the Department of Energy to characterize utility emissions of hazardous air pollutants, the efficiencies of different emissions control strategies, and mercury transport and deposition. The Institute's Air Toxic Risk Assessment will contribute to the Environmental Protection Agency's analysis of utility emissions of mercury and other hazardous air pollutants.

Present Impacts

HEALTH

Introduction

Potential impacts to human health are illustrated in *Figure T1-61*. There are potentially numerous health impacts from environmental air pollutants. Impacts range from temporary eye and lung irritation and headaches to progressive damage to the respiratory, cardiovascular, nervous, and immune systems. United States environmental and health policies are written to protect the general public from the unacceptable risk of adverse effects.

The National Ambient Air Quality Standards for criteria pollutants and the National Emission Standards for Hazardous Air Pollutants are set at levels for ambient outdoor exposure that are intended to protect the public health. These standards are periodically reviewed and revised. Evidence of impacts upon sensitive individuals at ambient levels of ozone and fine particulate matter is being reviewed in 1995 by the Environmental Protection Agency in a draft criteria document.

Health impacts can also occur from air pollutant exposures in indoor environments. Currently, indoor air quality is not regulated by national standards, but several of the same pollutants that occur in the ambient outdoor environment also occur indoors. The Environmental Protection Agency has developed guidelines for levels of other indoor pollutants such as radon.

Risk-Exposure Relationships

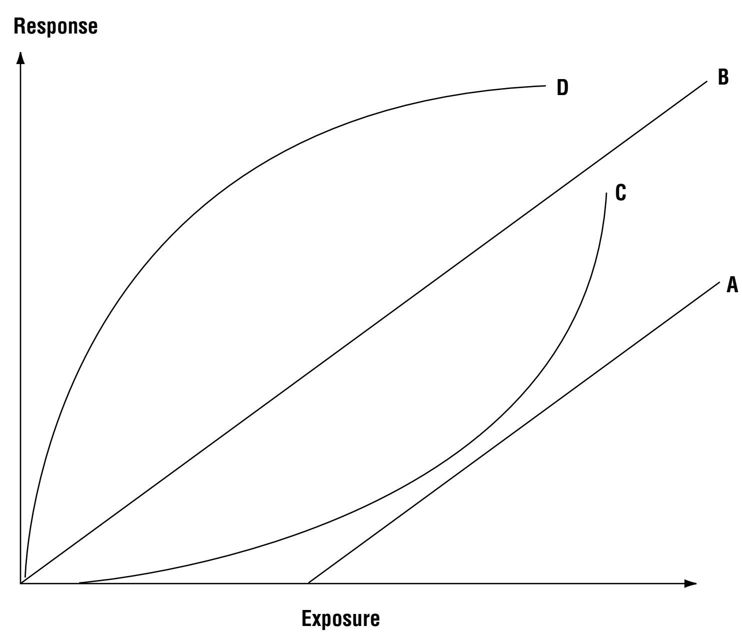
The health risk from exposure to pollutants requires an understanding of the level and duration of exposure. Adverse health effects can come from exposures to high levels for short periods of time and/or prolonged exposures to low levels. The graph in *Figure T1-49* shows examples of theoretical exposure-response relationships. Line A shows a linear relationship with a threshold. For line A, there is no risk for exposures below the threshold. Line B shows a linear relationship without a threshold. For line B, there is some risk at all levels of exposure. Lines C and D are examples of nonlinear relationships. The shape and slope of the exposure-response relationship have substantial implications for assessing the risks from air pollutants and for defining levels sufficient to protect human health. Evaluation of available data has not yielded definitive answers as to which of these curves best fit criteria air pollutants. As a result, the decisions regarding appropriate levels for air quality standards are based in large part on most plausible evaluations and policy goals (Samet et al. 1991). As health effects are better quantified, this evidence is used in reviews and revisions of the National Ambient Air Quality Standards and National Emission Standards for Hazardous Air Pollutants.

Sulfur Dioxide

Depending on concentration, exposure to sulfur dioxide can irritate the eyes, cause respiratory distress, and possibly permanently damage lung tissue. (Durenberger 1991) Under the current ambient standard for the 24-hour average sulfur dioxide concentration, only one group of people might suffer a direct health effect of gaseous sulfur dioxide: People with active asthma who are unmedicated and exercising out of doors might experience an aggravation of asthma symptoms. This occurs infrequently and only in locations near major sulfur dioxide sources (Graham 1990). At locations near major sulfur dioxide sources, short-term sulfur dioxide exposures may be elevated and still meet the 24-hour average standard. These short-term elevated sulfur dioxide exposures may aggravate asthmatics. The Environmental Protection Agency is considering whether a new five-minute sulfur dioxide standard should be set to address this impairment. However, available research indicates that any resulting aggravation is reversible, short-term, and can be avoided with moderation.

Sulfate aerosols that are formed as sulfur dioxide disperses and reacts in the atmosphere also raise concern for human health. The health effects from sulfate aerosols are included in the section that discusses fine-particulate matter. Some epidemiology studies show an association between 24-hour sulfur dioxide concentrations and respiratory illness that may be independent

FIGURE T1-49. **Four Theoretical Exposure-Response Relationships for Health Risks**



Line A = Linear Relationship With a Threshold
Line B = Linear Relationship Without a Threshold
Line C = Non-linear Relationship
Line D = Non-linear Relationships

of particulate concentrations. However, there is uncertainty about whether this is due to sulfur dioxide or the result of another factor correlated with sulfur dioxide (Graham 1990).

Nitrogen Oxides

Depending on its concentration, nitrogen oxides can irritate the eyes, damage the lungs, and lower resistance to respiratory illness and influenza. In its 1994 review of the ambient air quality standard for nitrogen dioxide, the Environmental Protection Agency concluded that the current standard is adequate to protect human health and welfare. The Environmental Protection Agency's annual average standard for nitrogen dioxide is 0.053 parts per million concentration. Current ambient levels of nitrogen dioxide in the Valley are 0.011 parts per million. Evidence from clinical studies suggests that short-term exposures to nitrogen dioxide in the 0.2 to 0.5 parts per million range may cause adverse symptoms for asthmatics. Evidence also suggests that nitrogen oxides from indoor sources such as gas-fired appliances may be associated with greater frequency of respiratory illness in children. This is consistent with some laboratory evidence of reduced resistance to illness. It is difficult at this time to extrapolate health effects from the indoor studies to outdoor levels of nitrogen oxides because the pattern of exposure is quite different. It is uncertain, for example, whether long-term cumulative exposures or peak-level exposures are most important. Some epidemiology studies using measures of outdoor nitrogen oxides have found an association between nitrogen oxides concentrations and acute illness. Other researchers have found no significant relationship (Environmental Protection Agency 1991).

Nitrogen oxides contribute to the formation of two pollutants that are a concern with respect to human health: nitrate aerosols and ozone. Nitrate aerosols are a component of fine-particulate matter and are discussed in that section. Ozone is discussed in the next section.

Ozone

Ozone exposure can cause respiratory tract problems such as difficulty breathing, reduced lung function, asthma, eye irritation, nasal congestion, reduced resistance to infection, and possibly premature aging of lung tissue. (Environmental Protection Agency 1995a.) Ozone levels present in the Tennessee Valley rarely exceed the 1 hour standard of 0.12 parts per million. Epidemiology studies have shown that health effects associated with ozone exposure for the general population include respiratory symptoms, such as acute cough, and minor, restricted activity days. Recent studies in Los Angeles and New York have found small but statistically significant evidence of risk of premature death associated with peak 1-hour ozone exposure at concentrations above 0.20 parts per million (Kinney and Ozkagmak 1990). A study in St. Louis, Missouri, and in Kingston-Harriman, Tennessee, found no increased risk of death at ozone exposure concentrations up to 0.15 parts per million. Extensive evidence exists relating to short term respiratory responses to controlled exposures to ozone in clinical studies. Ozone is also suspected in causing greater susceptibility to chronic respiratory illness, but there is not currently sufficient evidence available to quantify the risk (Krupnik and Kurland 1988; Lippman 1989; U.S. Environmental Protection Agency 1988).

Uncertainty is also associated with the threshold for human health impacts related to ozone. Some evidence indicates effects for certain individuals at levels below the current 1-hour National Ambient Air Quality Standard of 0.12 parts per million. Symptoms have not been observed below 1-hour averages of 0.06 to 0.10 parts per million (Krupnik and Kurland 1988).

Particulate Matter Smaller than 10 Microns

Recent epidemiological studies demonstrate links between particle exposure and respiratory disease in those over age 65 (Fisher et al. 1989). The Environmental Protection Agency standard for particles with diameters of 10 microns or less (PM10), is a concentration of 150 micrograms per cubic meter for 24 hours and 50 micrograms per cubic meter for an annual average. In studies conducted between 1972 and 1980, the Environmental Protection Agency correlated increased death rates with concentrations of PM10 of 100 micrograms per cubic meter. The Agency has also correlated an increase in hospitalizations for respiratory symptoms among people with chronic lung disease with concentrations at this level (Marwick 1991). Some investigators believe the threshold for health effects from particulate matter may be a concentration of 30 micrograms per cubic meter (ORNL 1994).

Some studies have attempted to determine whether the association between particle exposure and respiratory disease is due to sulfates and nitrates associated with fine particles (particles with diameters of 2.5 micron or less), but results have been inconclusive. These smaller particles remain airborne over longer times and distances. It is difficult to separate the potential impacts of sulfate versus acid aerosols because their day-to-day levels tend to be highly correlated. It appears that the association is strongest among the over-65 age group. Those who already suffer from chronic respiratory illness may be at greatest risk (Fisher et al. 1989).

Some studies associate chronic cough and bronchitis symptoms with the level of acidity of aerosols, rather than with sulfate levels or total concentrations of particles. Controlled studies have established a strong relationship between the bronchitis effects on asthmatics and the presence of sulfur dioxide and acidic aerosols at concentrations approaching the ambient standard for

sulfur dioxide (Samet et al.1991). Even so, the evidence to date is inconclusive as to whether acidic aerosols are any more harmful to human health than nonacidic aerosols of similar size (U.S. Environmental Protection Agency 1989).

Epidemiologic studies are limited by the difficulty of measuring exposure and of singling out the effect of acidic aerosols from other factors, particularly for such non-specific health effects as increased symptoms and reduction of lung function. Controlled exposures of volunteer subjects provide information concerning short-term effects. However, this approach cannot fully represent the exposures sustained in a community (Samet et al. 1991).

On a five-year cycle, the Environmental Protection Agency re-evaluates the science on which the National Ambient Air Quality Standards are based. The goal is to either modify or support the current sulfur dioxide and particulate matter standards. The Environmental Protection Agency is currently considering whether standards for acidic aerosols or fine-particulate matter are warranted.

Carbon Monoxide

Carbon monoxide impairs the ability of blood to carry oxygen. Carbon monoxide also affects the cardiovascular, nervous, and pulmonary systems. Carbon monoxide attacks the immune system, especially affecting anyone with heart disease, anemia, and emphysema and other lung diseases. Even at low concentrations, carbon monoxide can affect mental function, vision, and alertness.

Ambient levels of carbon monoxide in the Tennessee Valley are below the level of the National Ambient Air Quality Standards. The Environmental Protection Agency's limit for carbon monoxide is 9 parts per million. At this level, carbon monoxide binds 3 percent of the hemoglobin so that it cannot carry oxygen to body cells and tissues. Toll-booth workers exposed to a 10.8 parts per million level of carbon monoxide had a higher death rate due to heart disease than did toll-booth workers exposed to 6.2 parts per million. There is some question whether a threshold level exists for exposure to carbon monoxide (Marwick 1994). TVA emits less than 1 percent of the regional carbon monoxide emissions.

Air Toxics or Hazardous Air Pollutants

Depending on concentration and duration of exposure, hazardous or toxic air pollutants can increase the risk of cancer. The Environmental Protection Agency has listed 189 chemicals as air toxics. From this list, the air toxics of greatest concern related to coal-fired power plants are arsenic, beryllium, cadmium, chromium, copper, and mercury. Compounds of these toxics are released during combustion of fossil fuels and are ultimately deposited on land and water.

As evidenced in the data outlined in *Figures T1-45* and *T1-46*, the risks to human health appear to be extremely low from air inhalation or water ingestion of arsenic, beryllium, cadmium, chromium, copper, and mercury. Water concentrations of these metals as measured in and around Fort Loudoun, near Knoxville, Tennessee, are compared in *Figure T1-47* with standards set by the U.S. Environmental Protection Agency, the World Health Organization, and other agencies (Joslin 1994). In general, concentrations of these metals would have to increase by at least fiftyfold before established thresholds would be reached. Risk from chromium exposures in the Valley is difficult to evaluate because monitoring data are available only for total levels of chromium while only the hexavalent form of chromium is carcinogenic. Cadmium levels in human diets are considerably below health advisory levels, but levels in human diets have increased (Joslin 1994).

The risk to human health from mercury in the Tennessee Valley is low if one assumes an individual's diet is based on mercury concentrations in local fish and drinking water. High levels of mercury have been reported in fish in Canada, the northern United States, Scandinavia, and Florida. Recent surveys of the Tennessee River system found only one location where mercury in fish was elevated. That location is on the North Fork of the Holston River immediately downstream from Saltville, Virginia. The mercury level, which does not exceed the Environmental Protection Agency guidelines, is from an inactive industrial site unrelated to atmospheric deposition.

Acid Deposition

In addition to those health impacts associated with emissions of sulfur dioxide, nitrogen oxides, acidic aerosols, and fine-particulate matter that have already been discussed, acid deposition can indirectly affect health. Acidic species deposited to surface waters can mobilize metals in the environment. Mercury accumulation in the environment and biological food chains could be increased by acidic deposition under site-specific conditions. These include drinking water systems that use surface ponds or shallow wells and populations that obtain essentially all of their protein in the form of freshwater fish from acidified lakes. Even under these conditions, increased health risk due to increased mercury exposures is low (NAPAP 1991).

Indoor Air Quality

Indoor air quality also raises concern for human health. Exposure to air pollution is determined by the pollutant concentrations and the time that individuals experience those levels. Since Americans spend the majority of their time indoors,

exposures to indoor air pollutant can be a significant component of total personal exposure. Depending on the presence of indoor sources and building ventilation, indoor air pollutant levels can be much higher than outdoor levels. Air pollution advisories, issued when outdoor pollution levels become unhealthy, recommend that sensitive individuals restrict physical activity and time spent outdoors.

There are many kinds and sources of indoor air pollution:

- Combustion gases such as carbon monoxide, carbon dioxide, and nitrogen oxides from indoor combustion sources including wood heaters, unvented kerosene and natural gas space heaters, and other natural gas-fired appliances
- Small particles from smoking, fireplaces, wood heaters, and cooking
- Volatile organic compounds from insecticides, cleaning solvents, stored fuels, paint, vinyl, plastics, adhesives, and furniture and carpet stain repellents
- Biological contaminants such as allergens from pets, insects, and plants; molds and fungi from damp surfaces; and viruses and microorganisms from people and pets
- Radioactive gas (radon) from the earth beneath a structure.

Health complaints associated with poor indoor air quality are varied. They include dizziness, headache, nausea, irritation of the eyes and airways, impaired learning ability, allergies, sleepiness, rashes, abdominal and chest pains, respiratory illness, and cancer. Impacts discussed previously for sulfur dioxide, nitrogen oxides, carbon monoxide, fine-particulate matter, and hazardous air pollutants also apply if these pollutants are elevated in the indoor environment.

Well-designed and maintained heating, ventilating, and air conditioning systems can provide healthy and energy-efficient living spaces. However, indoor air pollution problems can sometimes be aggravated by weatherization or other energy conservation efforts. Reduced ventilation, the existing burden of indoor pollution, and the increased use of alternative heating sources, such as wood heaters and unvented natural gas or kerosene heaters, can lead to elevated indoor air pollutants. Indoor air pollutant levels can exceed regulatory standards for ambient outside air.

Many simple methods may be used to minimize indoor air pollution exposures:

- Use and maintain all appliances according to manufacturers' specifications and recommendations.
- Read the labels on household products such as cleansers, polishes, drain cleaners, and stove cleaners carefully to ensure proper use. Consider switching to "natural" cleaners and polishes.
- Ventilate kitchens and bathrooms during use to remove cooking smoke and excess moisture.
- Store paints, household cleaning products, and fuels in approved containers in well-ventilated areas.
- Avoid smoking indoors.
- In areas with elevated soil radon levels, consider testing to determine levels within the home or office.

Energy Vision 2020 strategies that promote increased conservation and weatherization methods could increase indoor air pollution exposures. It is assumed for this analysis that TVA will continue to provide guidance to minimize indoor pollutant concentrations. Consequently, indoor air quality impacts are not a measure used to differentiate among future TVA strategies.

VISIBILITY IMPAIRMENT

Visibility impairment is of special importance under the Prevention of Significant Deterioration provisions of the 1977 Clean Air Act Amendments. Impacts are discussed in the "Visibility Impairment" section under "Air Quality Concerns Since the 1977 Clean Air Act Amendments" earlier in this section.

CROPS AND FORESTS

Summary

Impacts of gaseous pollutants, including sulfur dioxide, nitrogen oxides, and ozone on crops and forests, have been described in scientific studies and reviewed in numerous reports. The 1990 National Acid Precipitation Assessment Report and the Environmental Protection Agency's Ozone Criteria Document serve as the primary references because they have undergone formal public review. Impacts from primary pollutant emissions (sulfur dioxide, nitrogen oxides, particulate matter) rarely occur at current ambient levels. Historically, acute impacts from gaseous pollutants are most dramatically illustrated by the deforestation and destruction of aquatic and terrestrial ecosystems in the Copper Hill, Tennessee, basin due to emissions from a chemical company. Prior to 1980, incidents of agricultural crop damage have been documented that occurred when TVA coal-fired power plant plumes were intercepted at ground-level (Jones et al. 1988). There was no opportunity for atmospheric mixing to dilute emissions below levels toxic to crops. Impacts of TVA emissions, particularly sulfur dioxide, to crops in the immediate vicinity of TVA power plants were well documented (Jones et al. 1988). Since 1976, TVA sulfur dioxide emissions have been reduced by two-thirds, as shown in the graph in *Figure T1-22*. Direct impacts of sulfur dioxide to crops and forests rarely occur now.

At current ambient exposures, sulfate and nitrate anions in acid deposition and ozone are the pollutants most likely to cause impacts. Such impacts can be cumulative over long-term chronic

(lower level) exposures. Episodes of high ozone exposures can injure foliage of both crops and forest species. Depending on extent and severity, exposure can lead to cumulative impacts to productivity. Impacts from short-term elevated loadings of sulfate and nitrate anions are infrequent but could potentially occur in the undisturbed forests if acid anions in soil solutions mobilized aluminum from soils at levels toxic to plant roots. Forests susceptible to aluminum toxicity are most likely to be in higher elevations of southern Appalachia (Joslin et al. 1992).

Sulfur Dioxide

The effect of sulfur dioxide on crops and other vegetation varies by species and by length and frequency of exposure (Environmental Protection Agency 1982; Shriner et al. 1990). Acute exposures and their associated visual symptoms were once frequently observed in the TVA region. They are very rarely observed today. The current National Ambient Air Quality Standards secondary standard is adequate to protect vegetation from significant negative impacts, based on the literature summarized in the sulfur dioxide criteria document (Environmental Protection Agency 1982) and in the subsequent National Acid Precipitation Assessment Program analysis (Shriner et al. 1990). There may also be a positive contribution of sulfur emissions to the sulfur requirements of agricultural crops (Noggle 1980). Concentrations of sulfur dioxide in most rural areas in the Valley are currently well below the standard and may drop further as the full effects of the 1990 Clean Air Act Amendments are felt.

Nitrogen Oxides

Nitrogen oxides refers to a family of atmospheric pollutants consisting of nitrogen oxide, nitrous oxide, nitrogen dioxide, nitric acid vapor, and various forms of nitrates (Shriner et al. 1990). In contrast to sulfur, which has decreased during the past two decades, the family of nitrogen oxides has increased. The most common phytotoxic (poisonous to plants) form of nitrogen is nitrogen dioxide, followed by the less frequent nitric acid vapor (Shriner et al. 1990). Within the Valley region, the potential impacts of nitrogen dioxide are minimal, since its plant-poisoning threshold concentration of 0.5 parts per million is well above current ambient levels. Nitrogen oxides in the atmosphere are currently a greater concern because they can contribute to acidic deposition impacts or can be utilized in the formation of ozone. The lack of nitrogen frequently limits plant growth in both cultivated and native vegetation. Therefore, nitrogen oxides deposition in many forms has the potential to increase plant growth. This contribution is probably of much greater importance in natural systems than in managed ones where fertilizer additions greatly outweigh other nitrogen sources.

Acidic Deposition–Crops

Impacts on crops attributable to acidic deposition were studied extensively during the last decade. Shriner et al. (1990) summarized the results of most of that work. They concluded that acidic deposition does not cause a reduction in crop yields. Potential reductions in fertility or increases in acidity can be offset by normal management practices. As discussed, the deposition of sulfur and nitrogen associated with acidic deposition in agricultural settings can be a potential benefit to most crop species. Atmospheric sulfur inputs can satisfy much of the crop sulfur need, while nitrogen input is a very small portion of total crop requirements.

Acidic Deposition–Forests

The National Acid Precipitation Assessment Program conducted extensive research to determine the possible impacts of acidic deposition on forests in North America. The results of this research are summarized in the State of the Science Reports, SOS/T-16 (Barnard and Lucier 1990) and SOS/T-18 (Shriner et al. 1990), and in the 1990 National Acid Precipitation Assessment Program Integrated Assessment Report (NAPAP 1991). These studies concluded that, in general, the vast majority of forests in eastern North America are not in decline, either from pollution or other sources. However, atmospheric deposition may be implicated in the premature mortality of high elevation red spruce *(Picea ruben sug.)* in the Northeast.

Evidence of red spruce decline and pollution involvement in the southern Appalachians is less substantial. The red spruce-Fraser fir ecosystem occupies approximately 103 square miles (268 square kilometers) in the southern Appalachian mountains of southwestern Virginia, eastern Tennessee, and western North Carolina. The trees are generally confined to mountain peaks above 5,000 feet (1,525 meters) elevation, as shown in the map in *Figure T1-50*. National Acid Precipitation Assessment Program studies in the southern Appalachians have documented extensive mortality of Fraser fir and decreases in crown vigor and annual growth in red spruce. Fraser fir mortality, frequently pictured in popular publications, is the direct result of an insect, the balsam woolly adelgid.

Although it has been suggested that air pollution may have rendered fir more susceptible to the adelgid, supporting evidence is incomplete. In mixed stands with dying fir, spruce decline can be partially explained by increases in wind damage and soil temperatures (Nicholas et al. 1992). Symptoms of decline in spruce-dominated stands, at elevations with a high frequency of cloud interception, have led scientists to consider impacts of atmospheric deposition. Acid deposition components of sulfate, nitrate, and hydrogen ions at high elevations greatly exceed those at lower elevations. This is primarily due to the increased vol-

ume of precipitation and high ion concentrations in cloud water. Exposure to ambient cloud water with concentrated sulfate and nitrate anions (negatively charged ions) has also been shown to accelerate foliar leaching of essential cations (positively charged ions). In field studies, decreases in foliar calcium and magnesium have corresponded to decreases in foliar biomass. Field surveys and fertilization studies indicate that red spruce in the southern Appalachians are experiencing calcium and zinc deficiencies, while those in the Northeast are generally not.

National Acid Precipitation Assessment Program research, (Barnard and Lucier 1990, Shriner et al. 1990) as well as ongoing studies, (Nodvin et al. In Press) have demonstrated that the high elevation forests appear to be nitrogen-saturated. Nitrogen inputs from rain, snow, and cloud water combined with inputs from natural biological process exceed the capacity of soils and vegetation to immobilize nitrogen. The leaching of excess nitrogen depletes essential base cations from the soil and acidifies soil water. In addition, there is evidence that aluminum is being mobilized into soil water at levels that interfere with plant uptake of calcium, magnesium, and zinc. Soils in the southern Appalachians generally have a large capacity to absorb sulfate, but current sulfate loading rates will likely exceed soil sulfate absorption capacity within a few decades (Johnson and Lindberg 1992).

Exposure to ambient cloud water can reduce the cold tolerance of red spruce. Increases in winter damage to red spruce in the Northeast have contributed to crown damage and increased mortality in that region. This impact occurs infrequently in the southern Appalachians, where temperatures seldom approach the cold tolerance limits for red spruce.

National Acid Precipitation Assessment Program studies did not find a regional decline of southern pines (Barnard and Lucier 1990, Shriner et al. 1990). The U.S.D.A. Forest Service had reported widespread reductions in average tree growth rates in natural pine stands in the Southeast. Similar growth rate reductions have not been observed in tree plantations. Reduction in tree growth in natural pine stands is an anticipated consequence of historical land use patterns, increases in stand longevity and competition, and other natural factors. Available information is not adequate to determine whether the magnitude of reported growth reductions is greater or less than would be expected in the absence of acidic deposition and associated pollutants. The magnitude, extent, and timing of soil chemical changes due to acidic deposition and their long-term implications for forest health and productivity are uncertain. Available evidence does not support a hypothesis that acidic deposition has caused aluminum toxicity or nutrient deficiencies in southern pines.

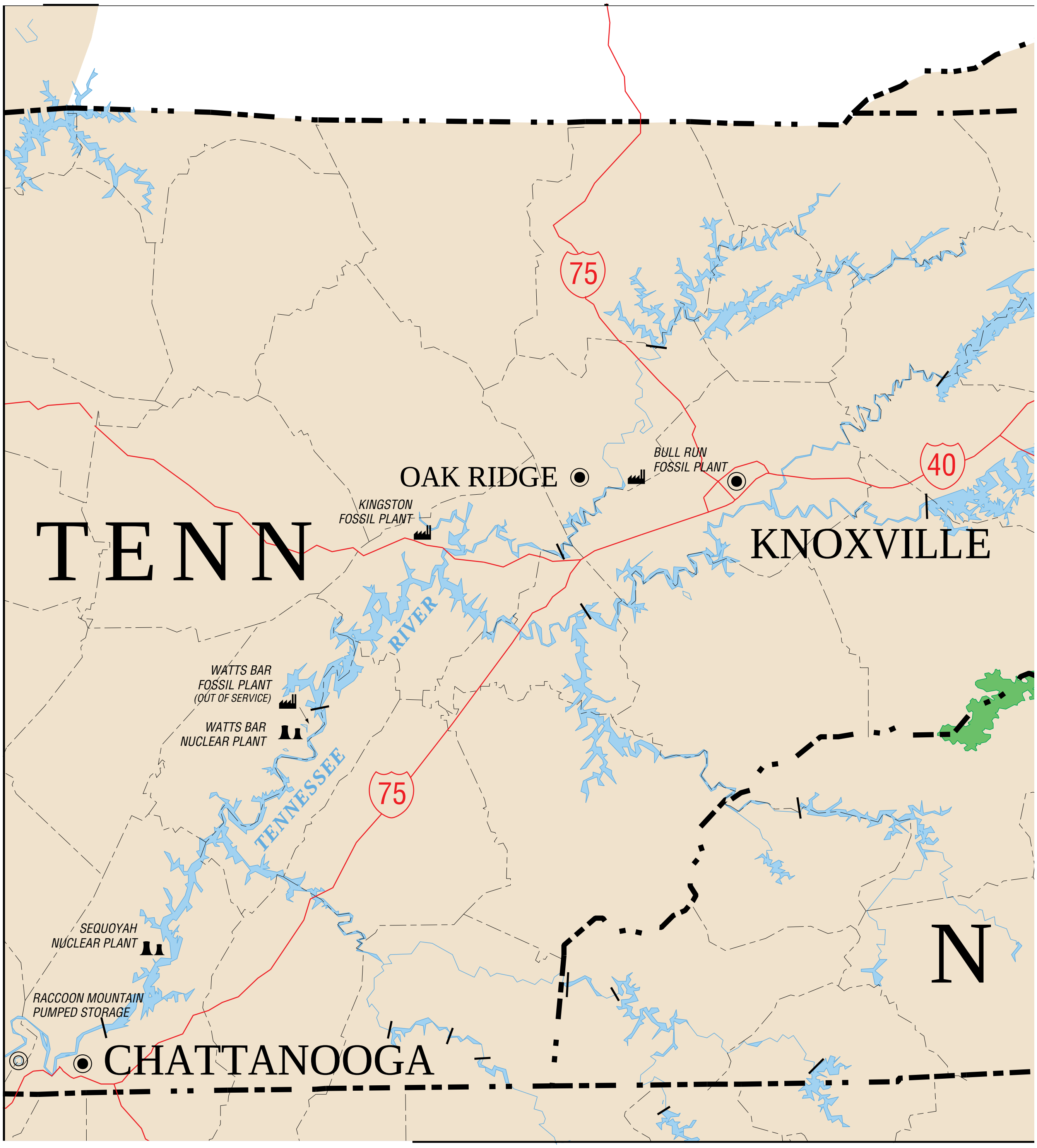
With the possible exception of the spruce-fir forests of southern Appalachia, most Valley forests are receiving acid rain at doses that have not had a serious impact on forest health and productivity. However, the cumulative effects of sulfate and nitrate deposition over several decades could be adverse for some soils. Sulfate and nitrogen oxides deposition increases leaching of nutrient cations from some forest soils and over the long term may reduce the fertility of soils with low buffering capacity or low mineral weathering rate. Nitrogen saturation, a concept currently under discussion in the regulatory arena, could be a long-term impact if nitrogen deposition continues at current rates. Nitrogen saturation is unlikely to occur in Valley forests outside of the high elevation spruce-fir forests or unmanaged old growth wilderness areas.

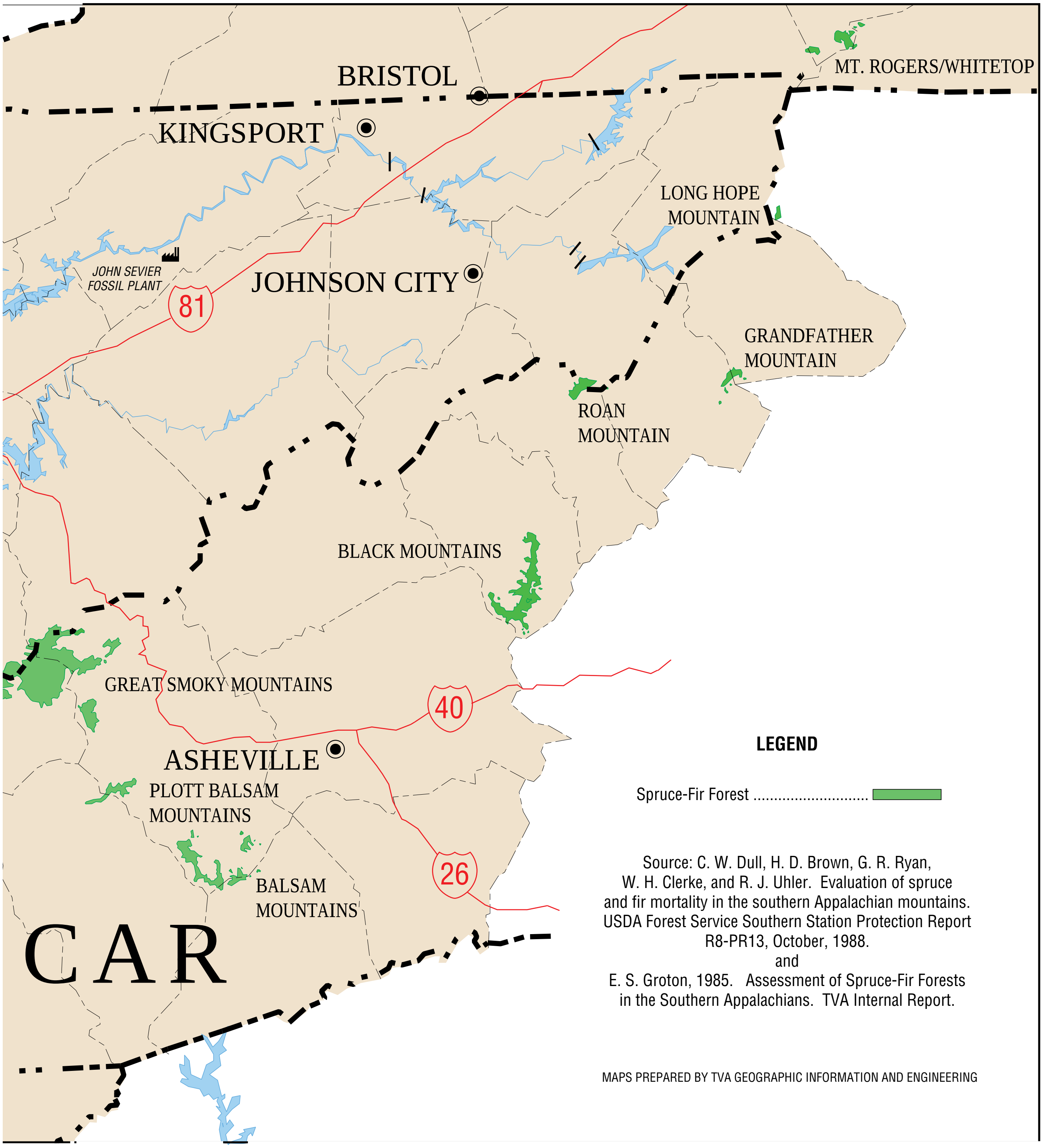
Impacts to forest soils and nutrient cycling are generally considered to be reversible. Decreases in sulfate deposition would ultimately result in decreases in cation leaching once a new soil equilibrium was established. Decreases in nitrate deposition would probably lead to equivalent decreases in cation leaching in high elevation forests thought to be at or near nitrogen saturation. The Nutrient Cycling Model (Liu et al. 1991) is one method to evaluate the potential benefits to forests that could result from reductions in sulfate and nitrate deposition.

The Nutrient Cycling Model accounts for the exchange of essential nutrients from deposition, vegetation, the forest floor, soils, and soil solutions. The model was applied to project nutrient cycling over a 30-year period in a spruce-fir forest at Noland Divide in the Great Smoky Mountains National Park. Levels of sulfate and nitrate in deposition were varied to simulate alternative reductions in sulfur dioxide and nitrogen dioxide emissions. The initial and no change projections reflect deposition levels monitored at Noland divide for the period 1985 to 1988. Reductions in sulfate and nitrate deposition of 20, 30, 40, or 50 percent compared to the 1980s were projected to represent probable benefits achieved from implementation of the 1990 Clean Air Act Amendments or future emissions reductions.

Calcium is an essential plant nutrient that is susceptible to leaching by acid deposition. Aluminum in soil solutions may be toxic to plant roots and may interfere with plant uptake of calcium. The effects of alternative deposition levels on the distribution of calcium in vegetation, forest floor, and soils and on aluminum and calcium in soil solutions are illustrated in *Figures T1-51* and *T1-52*, respectively (Dale Johnson unpublished data). Calcium is not deficient in this spruce-fir stand, and the model projected very small differences after 30 years in calcium in vegetation and the forest floor as a function of deposition levels. Calcium in the exchangeable soil pool is projected to be greater at lower levels of sulfate and nitrate deposition. Calcium and aluminum in soil solutions (an indication of nutrients lost from the ecosystem) are projected to be lower at lower levels of sulfate

FIGURE T1-50. **The Energy Vision 2020 Study Area Includes the Southern Appalachian Spruce-Fir, a Threatened Ecosystem**





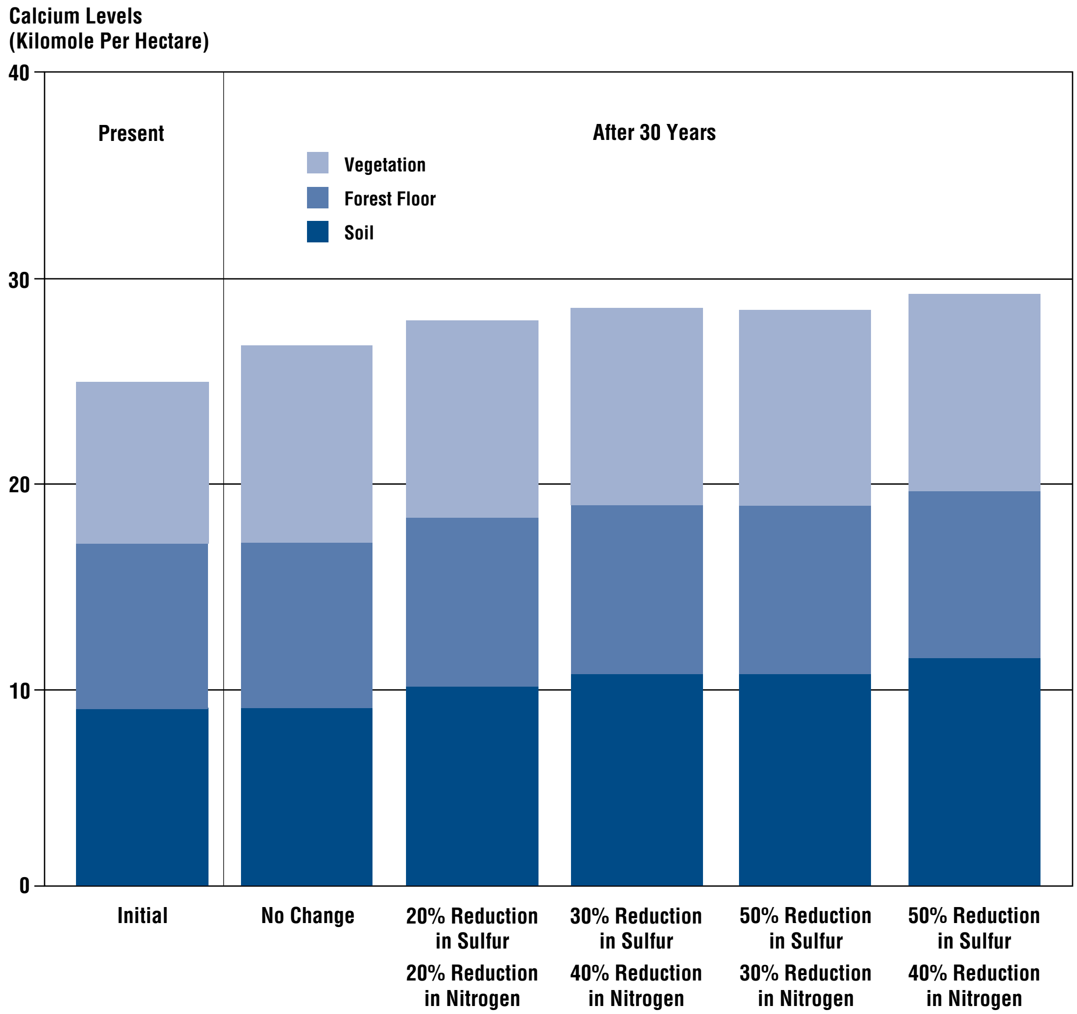
LEGEND

Spruce-Fir Forest ....

Source: C. W. Dull, H. D. Brown, G. R. Ryan, W. H. Clerke, and R. J. Uhler. Evaluation of spruce and fir mortality in the southern Appalachian mountains. USDA Forest Service Southern Station Protection Report R8-PR13, October, 1988.
and
E. S. Groton, 1985. Assessment of Spruce-Fir Forests in the Southern Appalachians. TVA Internal Report.

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-51. **Changes in Calcium Levels in Vegetation, Forest Floor, and Soil Exchangeable Pools in a Spruce-Fir Forest at Noland Divide in the Great Smoky Mountains National Park Based on a 30-Year Simulation Using the Nutrient Cycling Model**



and nitrate. The greatest improvements are projected for the case representing implementation of the 1990 Clean Air Act Amendments compared to the no change (pre-1990 Clean Air Act Amendments) conditions. *Figure T1-52* illustrates that the ratio of aluminum to calcium would improve with reduced deposition levels, particularly during periods of high runoff.

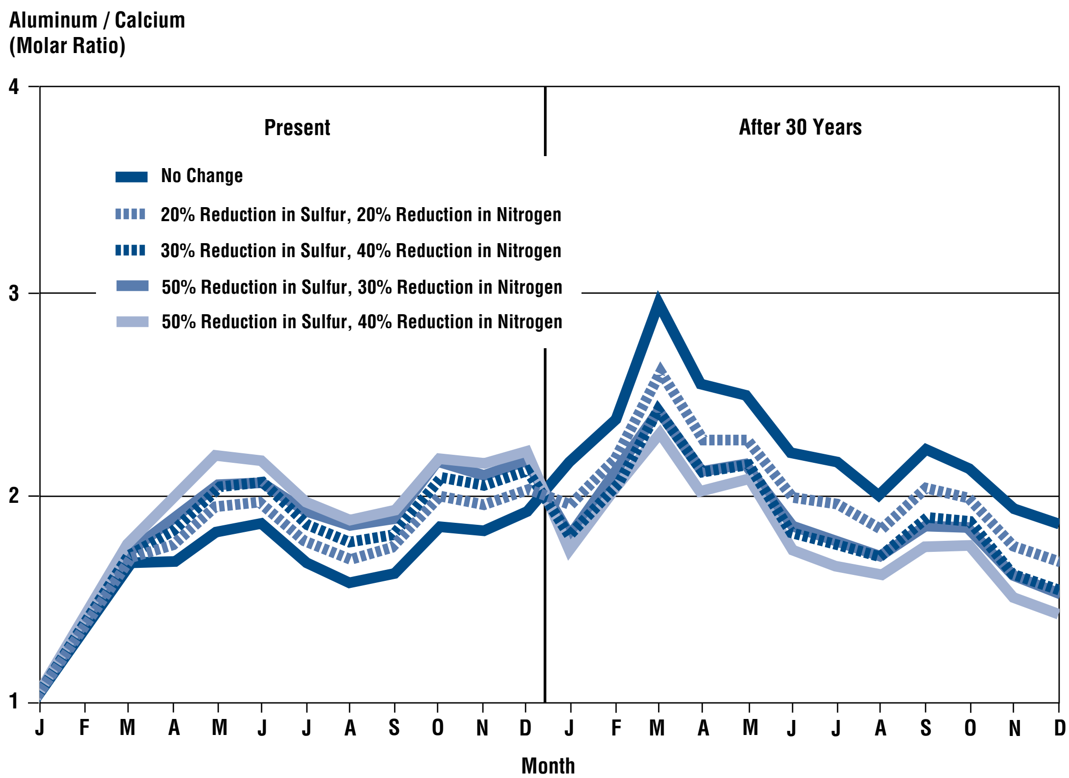
This model application illustrates a potential method to evaluate forest response to reduce deposition levels. Assessments under the Southern appalachian Mountain Initiative will further address methods to evaluate benefits of emissions reductions.

Ozone–Crops

Impacts of ozone are a function of concentration and duration of exposure (external to plants) and plant uptake (internal dose). Ozone is currently the most pervasive air pollutant in rural areas and the pollutant most likely to impact agricultural crops negatively. Impacts to crop productivity, physiology, reproduction, and economic yields have been well documented (Environmental Protection Agency 1995).

Ozone enters plants through the leaf stomates and may disrupt cellular function. High short-term exposures can injure or lead to death of cells in the vicinity of the stomates. The degree of impact increases with the ozone dose received. Visible dis-

FIGURE T1-52. **Changes in Aluminum to Calcium Soil Solution Molar Ratio in a Spruce-Fir Forest at Noland Divide in the Great Smoky Mountains National Park Based on a 30-year Simulation Using the Nutrient Cycling Model**



coloration of foliage may be a result of high short-term exposure to ozone or of the cumulative longer term ozone dose received over the growing season. At frequent, low-level exposures, ozone may inhibit photosynthetic function and reduce plant carbon reserves. Under ozone stress, a greater portion of the carbon fixed through photosynthesis must be used to repair injury to cells rather than contribute to growth. Allocation of carbon from leaves and stems to the root system, which stores carbon for future growth, is frequently limited by chronic ozone exposure. Thus, impacts from ozone can accumulate over the duration of exposure, which can last seasons or years.

At current ambient levels of ozone in the eastern United States, average reductions in crop yield are likely on the order of 10 to 15 percent (Environmental Protection Agency 1995). Some crops, such as tobacco, spinach, and grapes, are very sensitive to ozone and could experience greater than 15 percent reductions in annual yields at current ambient levels. Economic analyses (Kopp et al. 1985; Adams et al. 1989) have considered the economic impacts of yield reductions for major commodity crops such as wheat, corn, soybeans, and cotton. Studies summarized by the Environmental Protection Agency (1995) estimated that net economic losses attributable nationally to current levels of ozone are in the range of 1 to 2 billion dollars per year.

The effects of plant exposure to ozone accumulate over the growing season. Exposures above a threshold value cause greater impacts than lower exposures. Consequently, a cumulative index that sums the hours above a threshold is proposed in the Environmental Protection Agency's 1995 draft ozone criteria document. The Environmental Protection Agency suggests that the sum of hours exceeding a concentration of 0.06 parts per million (SUM06) for the maximum 3-month period between April and October should not exceed 26.4 parts per million-hour. This value was derived from the results of the National Crop Loss Assessment Network (Heck et al. 1990) and is intended to protect 50 percent of crops from 10 percent yield reduction.

Response to ozone can be highly modified by the plant's nutrient and water status. Environmental conditions that limit the extent that leaf stomates are open limit the uptake of ozone.

Consequently, ozone impact is less severe for crops exposed to ozone under low moisture or fertility conditions compared to crops with the same exposure under high moisture and fertility conditions. The table in *Figure T1-53* summarizes the range in ozone exposure at which 10 percent yield reductions were observed for several common crop species in controlled exposure field studies conducted under the National Crop Loss Assessment Network (Heck et al. 1990). Exposure is expressed as the maximum 3-month sum of hours exceeding 0.06 parts per million (SUM06). Plants in these studies were well-watered and fertilized. Yield reductions in unwatered fields may be less than estimated in these studies. In 1992, the maximum 3-month sum of hours greater than 0.06 parts per million exceeded 26.4 parts per million-hour over large areas of the TVA region *(Figure T1-53)*.

FIGURE T1-53. **Crop Response to Ozone Projected by the National Crop Loss Assessment Network Using Controlled Exposure Field Studies**

Crop Species	Maximum 3-Month Sum of Hours Above a Concentration of 0.06 Parts per Million-Hour to Cause a 10% Yield Loss
Corn (2 cultivars)	42-56
Cotton (4 cultivars)	14-95
Kidney Bean (1 cultivar)	15-19
Lettuce (1 cultivar)	37
Peanut (1 cultivar)	36
Potato (1 cultivar)	10-20
Sorghum (1 cultivar)	68
Soybean (7 cultivars)	8-90
Tobacco (1 cultivar)	26
Turnip (4 cultivars)	6-10
Wheat (4 cultivars)	3-35

Source: Environmental Protection Agency 1995 Draft Ozone Criteria Document

Ozone–Forests

Impacts of ozone to forests and natural systems are less well understood than impacts to crops. The bulk of information on ozone impacts to unmanaged vegetation (mainly forest species) has been summarized recently by Barnard and Lucier (1990), Kiester (1990), Shriner et al. (1990), and Environmental Protection Agency (1995). Based on these summaries and other information, it appears that forests in the eastern United States are not in a general state of decline as a consequence of ozone or any other air pollutant. However, ozone has been implicated as the key air pollutant responsible for decreases in productivity in the mountains of southern California and for foliar injury to several forest tree species in the eastern United States. Based on controlled exposure studies with tree seedlings, the table in *Figure T1-54*, summarized from the 1995 draft ozone criteria document, identifies the ozone exposure at which 10 percent losses in biomass are projected for several tree species.

Ozone sensitivity increases in the following order: high elevation conifers, southern pines, late successional hardwoods such as oak, early successional hardwoods such as tulip poplar, black cherry and ash, lichens, and herbaceous forest species (Chappelka et al. 1993; Thornton et al. 1994; Kelly et al. 1993; Samuelson and Edwards 1993; and Samuelson 1994). Species sensitivity to ambient ozone exposures is greatly influenced by site environmental conditions. Species that occur in communities associated with moist sites are generally more sensitive than those species in communities associated with dry sites. While certain varieties of loblolly pine may be negatively impacted by ozone at current ambient levels, the Environmental Protection Agency (1995) concluded that there was no evidence to indicate a general decline in loblolly pine due to ozone in the region.

The National Park Service has documented foliar injury to several sensitive species based both on field surveys in natural forest stands and on controlled chamber exposure studies. (Neufeld and Renfro 1993; Shaver et al. 1994). In natural stands the extent of foliar injury is less than reported from controlled studies. Black cherry is particularly prone to foliar injury. While foliar injury does not necessarily indicate that plant growth has been reduced, it is an indicator of plant sensitivity. Reductions in photosynthesis and growth were documented in the controlled chamber exposures for several of the species sensitive to foliar injury. Results for black cherry and tulip poplar in *Figure T1-54* are from controlled exposure studies in the Great Smoky Mountains National Park (Neufeld and Renfro 1993). Current ambient levels of ozone in the Valley *(Figure T1-37)* exceed levels at which these species experienced biomass losses in controlled chamber studies. Cumulative ozone exposures in the Great Smoky Mountains can actually be greater than in other parts of the Valley because ozone levels in the mountains do not decline as quickly in the late afternoon and evening hours as generally occurs at lower elevations *(Figure T1-35)*. Thus, greater injury to forest species may be occurring in the Great Smoky Mountains than in other areas of the Valley.

Predictions of ozone impacts on forests are still subject to significant scientific uncertainty. The actual ozone dose (uptake) received by a plant is not always a linear function of the ambient exposure because interactions with moisture and fertility can limit stomatal function and ozone uptake. Ozone uptake and plant response to ozone exposures occurring in late afternoon and evening is not well understood. Also, the great bulk of information on tree response to ozone is based on con-

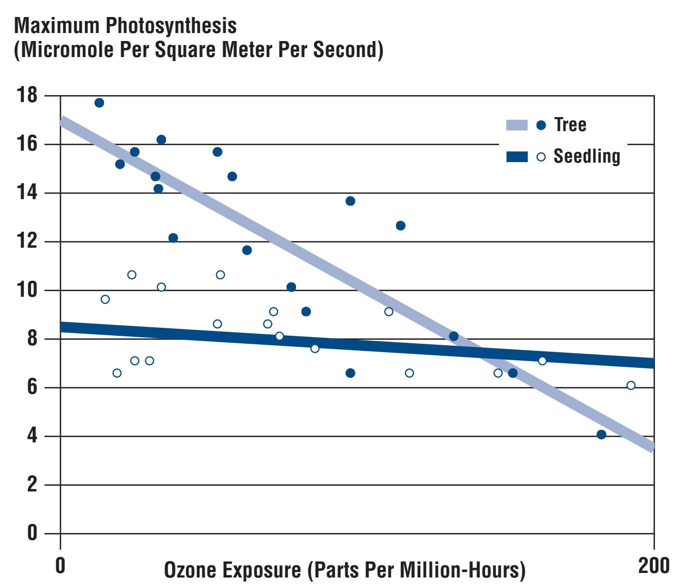
FIGURE T1-54. **Ozone Sensitivity for Several Tree Species Measured as 10 Percent Loss in Seedling Biomass in Controlled Exposure Field Studies**

Tree Species	Maximum 3-Month Sum of Hours Above a Concentration of 0.06 Parts per Million-Hour to Cause 10% Loss in Biomass[1]
Aspen (6 studies)	9-65
Black Cherry (2 studies)	13-17
Tulip Poplar (2 studies)	17-35
Ponderosa Pine (5 studies)	14-65
Red Alder (4 studies)	22-250
Eastern White Pine (1 study)	39-41
Sugar Maple (1 study)	39-105
Red Maple (1 study)	150
Douglas Fir (2 studies)	73-250
Loblolly Pine (1 study)	77-229
Virginia Pine (1 study)	250

[1] Actual ozone exposure in controlled field studies was weighted by duration of exposure to derive maximum 3-month sum of hours greater than 0.06 parts per million-hour. Weighted sum of hours above a concentration of 0.06 parts per million-hour allows sensitivity of tree seedlings to be compared to agricultural crops.

Source: Environmental Protection Agency 1995 Draft Ozone Criteria Document

FIGURE T1-55. **Maximum Photosynthesis of Seedling and Mature Red Oak Under Controlled Ozone Exposures in Chambers in Norris, Tennessee**



trolled exposures of seedlings. Recently completed work has indicated that, at least for northern red oak, mature trees may be more vulnerable to ozone than seedlings (Samuelson and Edwards 1993). *Figure T1-55* indicates that photosynthetical function in mature red oak trees is more sensitive than in seedlings and that ozone impacts increase over that of increased cumulative exposure. Field measures of incremental changes in diameter growth of mature loblolly pines growing on moist and dry sites indicate that ambient levels of ozone may reduce growth of loblolly pine. Site conditions, air temperature, and soil moisture levels were interactive with ambient ozone to affect growth (McLaughlin and Downing, in press).

The Environmental Protection Agency has proposed a new secondary standard that would provide additional protection for crops and forests. This reflects both the possible importance of exposure peaks and the cumulative nature of ozone impacts. The proposed secondary standard suggests a maximum 3-month sum of hours greater than 0.06 parts per million not to exceed 26.4 parts per million-hour. The proposal is based on evidence from agricultural crops, for which there is currently a more complete understanding of plant response to ozone. Because trees are exposed to ozone over several growing seasons, a standard lower than that recommended for annual crops may be necessary to protect sensitive tree species from injury. The next iteration of the ozone criteria document will more fully consider impacts to forests as current studies on mature tree responses provide better scientific evidence to define levels necessary to protect forest species. *(See Figure T1-55.)*

Hazardous Air Pollutants

Terrestrial Impacts

TVA's emissions of hazardous air pollutants primarily involve metals. At current ambient exposures, these metals are not likely to degrade crop and forest productivity. In fact, some vegetation species are very effective at removing metals from the soil and have been used as a biological remediation method to reclaim contaminated sites. The terrestrial ecosystem is a repository for metals deposited from the atmosphere. Soil and vegetation components influence the accumulation or the transport of metals to aquatic ecosystems. Concentrations of metals in tree wood and in lichens have been used as indicators of historical deposition patterns for metals because many of the metals accumulate in vegetation.

Aquatic Impacts

Impacts of metals in aquatic ecosystems are of concern for sensitive invertebrate and vertebrate species. Impacts of regional atmospheric deposition of metals are considered to be minor in

the Tennessee Valley *(Figure T1-47)*. Metals such as mercury or lead are more readily mobilized into soil solutions and transported by acid anions including sulfates, nitrates, and organics. In ecosystems sensitive to acidification, these metals may occur at elevated concentrations. However, the Tennessee Valley watersheds are generally well buffered against acidification, have a high land-to-surface water ratio, and have comparatively lower loadings of dissolved organic carbon than other regions of the country experiencing impacts (Joslin 1994). *Figure T1-48* indicates that levels of mercury in air precipitation, lake water and fish at Fort Loudoun reservoir on the Tennessee River are lower than levels in Wisconsin.

MATERIALS DAMAGE

Sulfur Dioxide

Exposure to gaseous sulfur dioxide at sufficient concentration causes corrosion of the protective zinc coating on galvanized steel and contributes to the erosion and pitting of other metals such as copper and aluminum. Sulfur dioxide forms white deposits called gypsum as it reacts with marble and limestone. It degrades protective paint coatings on steels and exterior wood surfaces and speeds the degradation of wood (Sherwood 1990, Sherwood and Lipfert 1990, Boedecker et al. 1990, Brown and Callaway 1990). Sulfur dioxide is also the major component of acid deposition, which is discussed below. Frequent cleaning reduces the impact of sulfur dioxide on materials. Repainting exposed surfaces as needed can largely mitigate the effects of sulfur dioxide.

Nitrogen Oxides

Exposure to gaseous nitrogen oxides at sufficient concentration causes corrosion of metals and other materials similar to the gaseous sulfur dioxide process described above. The effect is about 75 percent less than that for the same weight concentration of sulfur dioxide (ORNL 1994). The corrosion products are generally soluble, so there are no deposit buildups such as the gypsum associated with corrosion from sulfur dioxide. Nitrogen oxides are a significant component of acid deposition, which is discussed below.

Ozone

Ozone is a strong oxidant that can damage rubber and other elastic substances, textile fibers and dyes, paints, and other materials, including plastics and asphalt. Anti-ozonants and anti-oxidants have been incorporated in paints and other elastic substances to mitigate the effects of ozone. The damage to textile fibers and certain dyes tend to be of secondary effect over product lifetimes when compared with other factors such as abrasion, biological degradation, soiling, and changes in fashion. The studies of dose response are largely empirical, and the Environmental Protection Agency cautions that that they are not reliable (Environmental Protection Agency 1986).

Particulate Matter Smaller than 10 Microns

All exterior surfaces are subject to soiling from particulate matter 10 microns or less in size. Ventilated interior surfaces are also subject to soiling and require more frequent cleaning. Some materials, such as selected fabrics, can be permanently stained. Particulate matter can interact with acid deposits to accelerate the effect from acid deposition.

Acidic Deposition

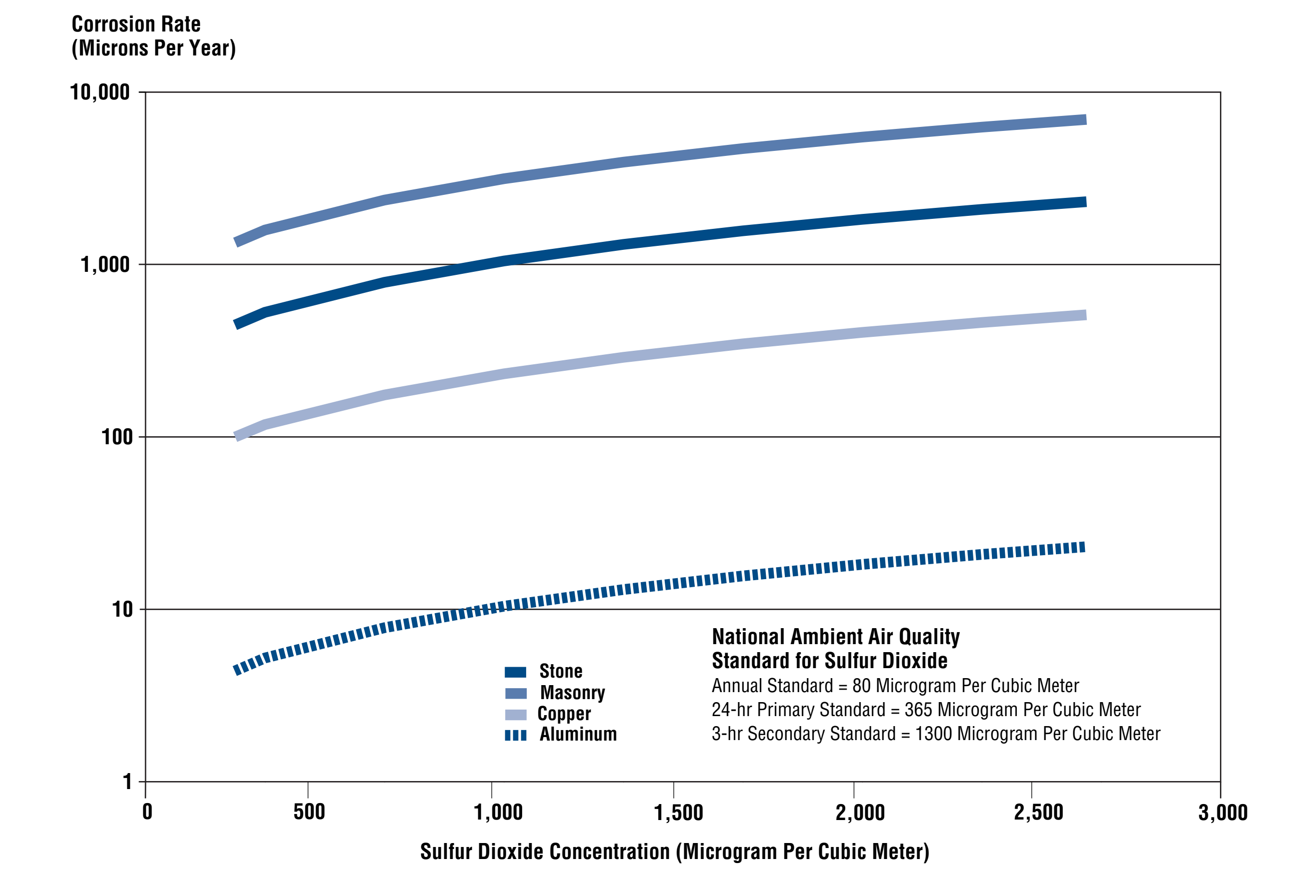
The National Acid Precipitation Assessment Program conducted extensive studies on the effects of acidic deposition on materials (Brown and Callaway 1990). Emissions of sulfur dioxide and nitrogen oxides from power plants are major contributors to acidic deposition. The chemistry of acid deposition involves the oxidation of both sulfur dioxide and nitrogen oxides to form strong acids, sulfuric acid, and nitric acid. These are deposited both directly by dry deposition and by wet deposition with rain, snow, and fog.

Materials that can be damaged from acid deposition include galvanized steel and other metals, painted steel (including automobiles), painted wood, mortar, and carbonate masonry (marble and limestone). Galvanized steel depends on zinc oxides for protection. Over time, these zinc oxides are slowly worn away by clean rain accelerated by acid deposition. Acid deposition corrodes the zinc oxide coating so that it is easily eroded by rain, thus exposing the substrate to corrosion. Copper and bronze develop a natural protective oxide patina that is attacked by acid deposition. As this natural patina is removed, a more porous sulfate patina develops. On copper this sulfate patina has a green color. Painted metals and wood can also be affected by acid deposition. The paints can be damaged, discolored, or spotted. Also, some paints are porous, allowing penetration to the substrate (Brown and Callaway 1990).

Exposures to ambient concentrations of sulfur dioxide can cause marble surfaces to lose 15 to 30 micrometers per year and limestone surfaces, 25 to 45 micrometers per year. Reactions to acidic deposition tend to accumulate as gypsum on the sheltered surfaces of carbonate stone buildings and monuments. Even small material losses can cause significant loss of artistic detail in statues and cultural or historic structures (Brown and Callaway 1990).

National Acid Precipitation Assessment Program corrosion studies in the 1980s have correlated decreased corrosion rates in the eastern United States with diminished sulfur dioxide concentrations. The graphs in *Figure T1-56* shows the

FIGURE T1-56. **Dose-Response Functions for Materials Exposed to Acidic Deposition**



dose-response relationship between sulfur dioxide levels and the corrosion rate on common materials (ORNL 1994).

While a correlation exists, caution should be taken in assuming a cause-and-effect relationship. The level of nitrogen oxides, ozone, acid deposition, and particulates also tended to track with sulfur dioxide, so the investigators could not isolate effects of individual pollutants. Therefore, this table is best viewed as showing the composite effect of acid deposition with sulfur dioxide acting as the marker.

The effects of acidic depositions can be reduced by frequent cleaning and repainting as needed. Paints and protective coatings that are more resistant to attack from acidic deposition need to be developed.

Air Indices and Rationale for Weightings

TVA's existing energy resources and many of the resource options considered for Energy Vision 2020 can affect air quality in different ways. Several air quality issues were identified as concerns in the scoping phase of the Energy Vision 2020 process. Air indices were developed to help characterize how TVA power system operations and alternative energy strategies might affect air quality impact areas. *Figure T1-57* contains the weightings used in Energy Vision 2020 for air emissions. The values in the index are weighted by the relative importance among TVA emissions in contributing to pollutant loadings that could affect human health and the environment. The index allows the emissions of greater concern for impacts to be given greater emphasis in multi-attribute analysis of alternative energy strategies.

To understand how the index translates to differences in impacts, it is necessary to understand how TVA emissions contribute to pollutant exposures and how changes in expo-

FIGURE T1-57. **Weighting Factors for Air Quality Evaluation Measures Used in Four Impact Area Indices**

	IMPACT AREAS			
Measure	Health-Inhalation	Visibility Impairment	Forest and Crop Productivity	Materials Damage
Sulfur Dioxide Emission	0.40	0.70	0.25	0.60
Nitrogen Oxides Emission	0.50	0.25	0.75	0.40
Total Suspended Particulate Emission	0.05	0.05		
Mercury Emission	0.05			

sures result in changes in impacts. Uncertainty in scientific understanding limits the ability to quantify the relationships among emissions, exposures, and impacts. In applying this index to multi-attribute analysis, percentile differences in the weights among strategies can be interpreted as differences in TVA contributions to the air pollutant loadings that cause impacts. The air index, as presented, does not provide a weighting of TVA's contribution to the total pollutant loading in the area of concern.

RELATIONSHIPS

Energy Vision 2020 defines TVA's future energy options as alternative energy supply strategies and does not define specific sites where TVA air emissions might increase. To understand impacts of specific TVA sources to specific receptors of concern, it is necessary to use atmospheric models to project the transformation and delivery of emissions under specific meteorologic conditions. This analysis does not attempt to model delivery of emissions from specific TVA sites to specific receptors. In TVA siting decisions for future energy supply, atmospheric modeling can be used to better project site-specific impacts from TVA emissions.

General relationships between pollutant loadings and impacts are illustrated in *Figures T1-58* through *T1-60* for acid deposition, ozone, and visibility. In these diagrams, factors that can be controlled, e.g. emissions management decisions, are illustrated in a box. Arrows illustrate dependencies between variables and end results. Impacts to human health, crop and forest productivity, materials, and visibility are the end results of decisions on levels of emissions from human activity and the many environmental variables that influence pollutant formation, transport, and exposure. The variables in these diagrams must be considered to evaluate what changes in impacts will occur as a result of changes in emissions under different TVA energy supply strategies. As can be seen from these figures, utility emissions are just one category of emissions that contribute to air pollution impacts.

TVA's contribution to total pollutant loadings can be estimated by using predominant wind speeds and directions for seasonal or annual time periods to define the general source area for the Tennessee Valley. (See discussions under ozone, acid deposition, and visibility impairment sections.) TVA's emissions within the source area are projected from 1996 to 2020, and changes in impacts are considered as a function of changes in loadings. Analyses assume that emissions from non-TVA sources will remain level over this period, and any changes in loadings will be a function only of changes in TVA's contribution.

Potential changes in impacts have been considered for the region and for sensitive receptors. For human health impacts, any reduction in loadings will have positive benefit. Environmental and material damages can be episodic (hours or days) or cumulative (seasonal, annual, or over decades) and can vary as a function of the site conditions. Reductions in pollutant loadings below a threshold level may be required before benefits are measurable.

WEIGHTINGS ASSIGNED TO EMISSIONS IN AIR INDICES

Weightings of key pollutants in the indices are given in *Figure T1-57*.

Human Health–Inhalation

Figure T1-61 contains a summary of possible health effects associated with various types of pollutants. Any TVA contributions to health impacts associated with inhalation of pollutants are primarily related to ozone and fine-particulate matter on respiratory functions of sensitive individuals. Ambient levels of sulfur dioxide associated with TVA's emissions are below levels that impact lung function directly. However, sulfur dioxide can be converted to sulfate particles that are of the size most irritating to lung function (particles less than 2.5 microns). Increased health risk has also been associated with elevated levels of the fine particles.

TVA's nitrogen oxides emissions contribute to ozone formation. Ambient levels of ozone are estimated to have slightly greater risks of respiratory impacts than fine particles. Because of the importance of ozone, nitrogen oxides were weighted slightly more than sulfur dioxide (0.5 versus 0.4).

TVA's emissions of hazardous air pollutants are estimated to have less risk than the Environmental Protection Agency's one-in-one million health risk threshold. Therefore, a low weighting of 0.05 was applied. TVA mercury emissions are tracked in the air index as a surrogate for other metals emitted in trace quantities from coal combustion because more quantitative data is available for mercury emissions than for other hazardous air pol-

FIGURE T1-58. **Acid Deposition: Relationships Among Emissions, Exposures, and Impacts**

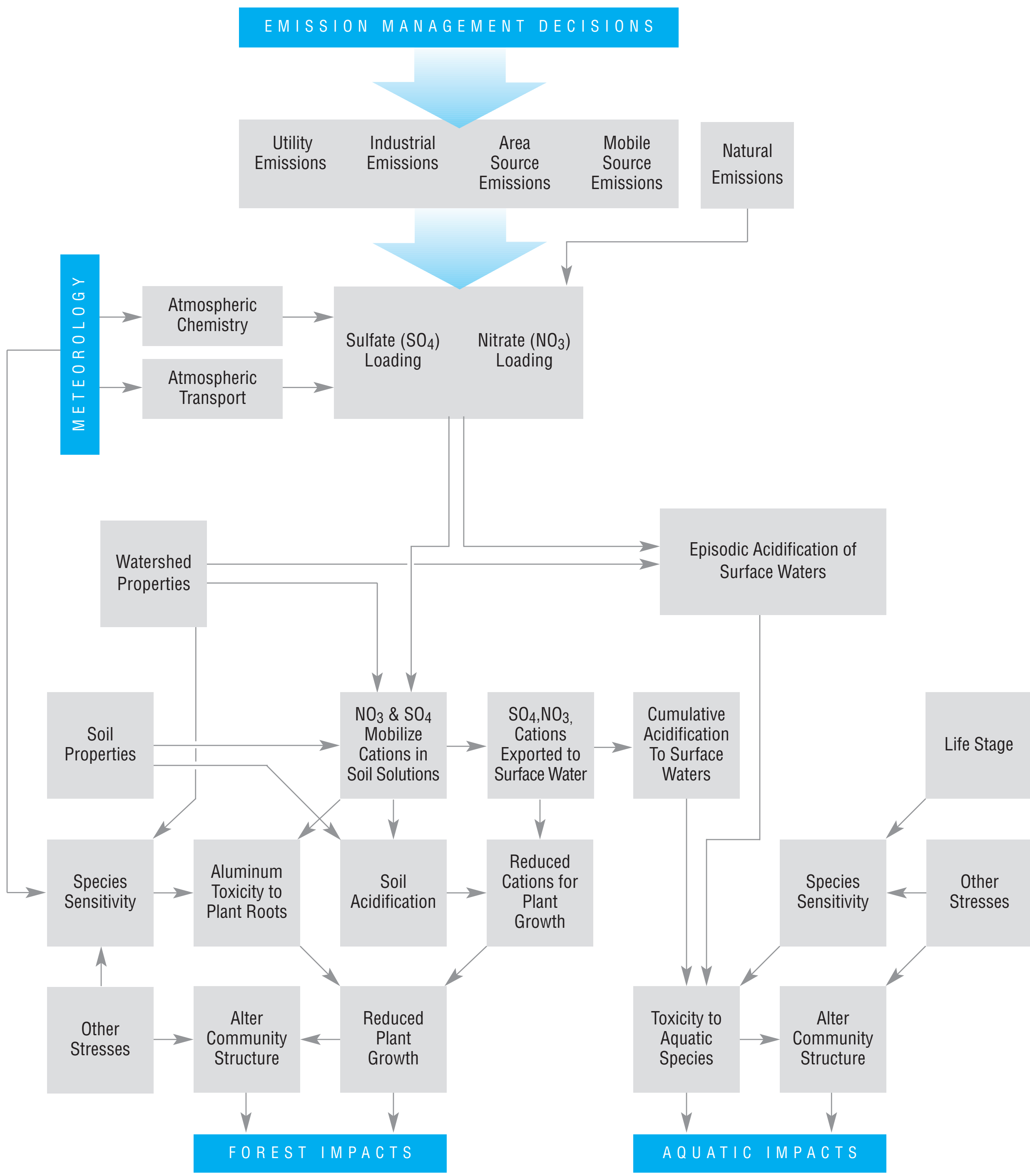


FIGURE T1-59. **Ozone: Relationships Among Emissions, Exposures, and Impacts**

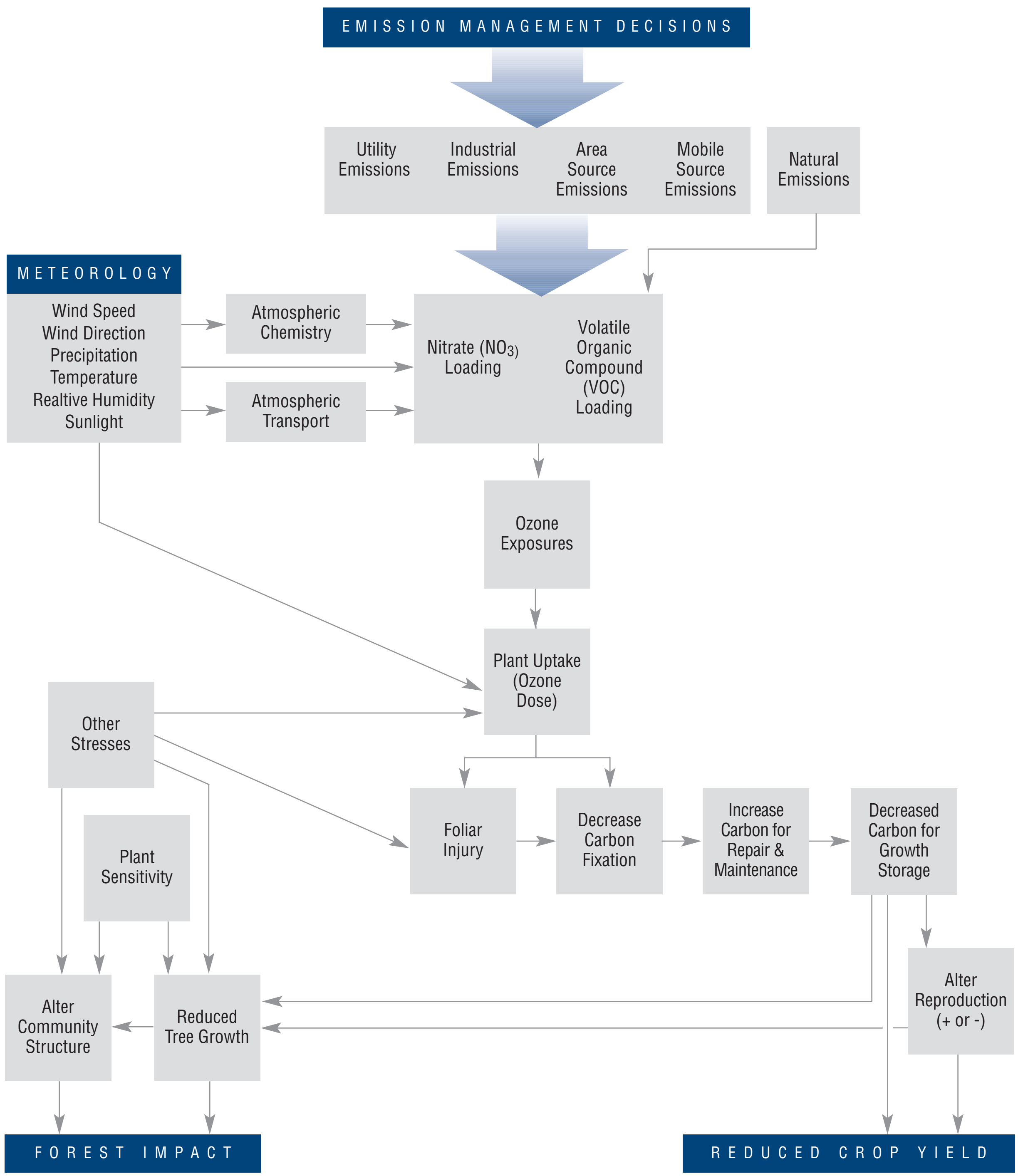
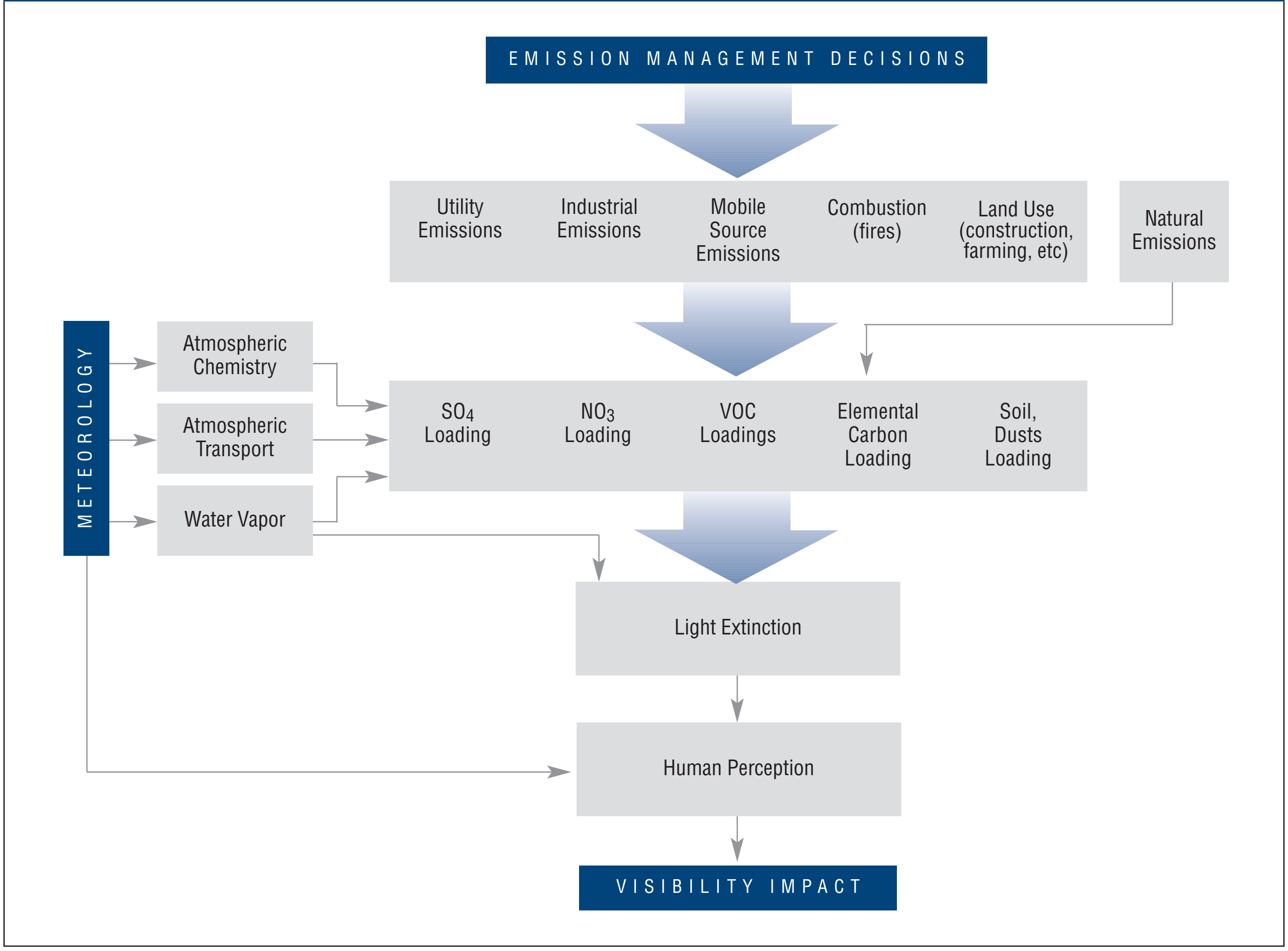


FIGURE T1-60. **Visibility: Relationships Among Emissions of Particulate Matter, Gaseous Pollutants, and Visibility Impairment**



lutants. Mercury effects are discussed in the water resources section of this section.

TVA's emissions of primary particulates are a minor component of the fine-particulate size contributing to health risk. For this reason, total suspended particulates received a weight of only 0.05.

Any reduction in emissions is assumed to have positive benefits for human health.

Visibility Impairment

TVA's contribution to regional visibility impairment is primarily associated with fine sulfate particles. Because sulfate production from sulfur dioxide in the atmosphere is slow, TVA sulfur dioxide emissions contribute very little to visibility impairment in the Great Smoky Mountains National Park.

TVA's nitrogen oxides emissions contribute only indirectly to visibility impairment through their role in ozone formation and the conversion of sulfate particles to organic aerosols. As a result, sulfur dioxide was weighted as almost three times more significant than nitrogen oxides (0.70 versus 0.25).

TVA's emissions of primary particles are a minor component of the fine-particulate size most responsible for scattering light in the atmosphere and thus impairing visibility. Because of this minor role, total suspended particulates received a weight of only 0.05.

Forests and Crops

Any TVA contributions to crop and forest impacts are primarily associated with ozone and with nitrate and sulfate in acid deposition. TVA's sulfur dioxide emissions contribute to sulfate in acid deposition, and nitrogen oxides emissions contribute to both ozone and nitrate in acid deposition. At ambient ozone levels, several crop and forest species in the Tennessee Valley are sensitive and exhibit foliar injury and reduced productivity. Sulfate in acid deposition is not thought to have adverse impacts to vegetation and

may have slight positive benefits as a plant nutrient where soils are low in native sulfur. For crops and many forests growing on nitrogen-deficient soils, nitrate in deposition has positive benefits. However, loadings of sulfate and nitrate from wet, dry, and cloud deposition are greatest at high elevation, and high-elevation spruce and fir forests in the southern Appalachians are sensitive to acidification.

Nitrate in deposition has greater impact than sulfate for high elevation forests because soils in the southern Appalachians generally are able to absorb sulfate. Biological processes that use nitrogen are slower at high elevation. When nitrogen deposition exceeds the biological demand for nitrogen, nitrates in soil water can combine with and remove nutrients such as calcium and magnesium that are essential for plant growth. Nitrate can acidify soil waters, leading to aluminum toxicity for sensitive plants. Due to its contributions to ozone and nitrate in acid deposition, nitrogen oxides emissions have been weighted three times greater for their impact to crop and forest productivity than sulfur dioxide emissions (0.75 versus 0.25).

Materials (Structural and Cultural)

Any TVA contribution to damage of materials is associated with both acid deposition and ozone. Acid deposition can erode surfaces of paint, limestone, and metals. Ozone can oxidize some materials such as rubber. Sulfate is considered more corrosive than nitrate in acid deposition, and acid deposition can damage a greater variety of surfaces than ozone, including cultural resources such as historic buildings and tombstones. Therefore, sulfur dioxide emissions are weighted as more significant than nitrogen oxides emissions for material damage (0.60 versus 0.40). Material damage is cumulative, so any reductions in current ambient exposures will likely reduce the rate of material degradation.

FIGURE T1-61. **Summary of Possible Health Effects Associated with Certain Types of Pollutants**

Emission	Pollutant	Health Effect	Air Quality Index [1] Weighting Factor
Sulfur Dioxide	Sulfur Dioxide Sulfate Aerosols Sulfate Fine Particulate (PM10)	Eye Irritation Respiratory Distress Lung Damage	0.40
Nitrogen Oxides	Nitrogen Oxides Nitrate Aerosols Nitrate Fine Particulate (PM10) Ozone	Respiratory Distress Lung Damage Eye Irritation	0.50
Carbon Monoxide	Carbon Monoxide	Headaches Reduced Mental Alertness Heart Damage	0.00
Primary Particulates	PM10	Respiratory Distress Lung Damage Eye Irritation	0.05
Mercury	Mercury	Neurotoxin Brain Damage	0.05

[1] Weighting of the relative importance among TVA air emissions is qualitative, based on estimated magnitude of health impact in the Tennessee Valley and TVA's relative contribution to loadings in that pollutant category. Weightings do not attempt to estimate TVA contribution to health impacts outside the Tennessee Valley.

FIGURE T1-62. **Weighting Factors for Greenhouse Gases**

Environmental Measure	Units [1]	Total Equivalent Carbon Dioxide (Millions of Tons)
Carbon Dioxide Emissions	Annual Average Thousands of Tons	1
Coalbed Methane Emissions Avoided	Annual Average Tons	-21
Nat. Gas Methane Emissions	Annual Average Tons	21
Landfill Methane Recovered	Annual Average Tons	-21
Wood Waste Methane Avoided	Annual Average Tons	-21
Wood Waste Carbon Dioxide Avoided	Annual Average Tons	-1
Short Rotation Woody Crops Carbon Dioxide Avoided	Annual Average Thousands of Tons	-1

[1] Annual Average Equivalent TVA Carbon Dioxide Emissions

Greenhouse Gases

A separate measure was also developed to sum the net greenhouse gas emissions for alternative future energy supply strategies. The measure is expressed in equivalent tons of carbon dioxide, the most common greenhouse gas. Other greenhouse gases, principally methane, are converted to equivalent carbon dioxide by multiplying emissions by the radiative forcing potential. *(See Figure T1-62.)* The radiative forcing potential for any greenhouse gas is an indication of the relative effect of the gas on the global warming potential compared to carbon dioxide, which has a radiative forcing potential of one. For example, methane has a radiate forcing potential of 21, which means its effect on global warming is 21 times greater than that of an equivalent weight of carbon dioxide.

An explanation of the process used to develop measures for environmental evaluation criteria and the calculations for indices can be found in Volume 1, Chapter 5, Evaluation Criteria, and Volume 2, Technical Document 4, Evaluation Criteria.

GLOBAL CLIMATE CHANGE

The earth's climate is controlled by the radiative balance of the atmosphere. This refers to the radiant energy received from the sun and emitted by the earth back to space. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFC). With the exception of chlorofluorocarbons, these gases occur naturally. However, human-produced emissions have contributed to the increases in their concentrations. These gases absorb infrared radiation as it passes through the atmosphere and re-emit this energy. This results in a warming of the earth's surface. The greenhouse effect is a natural phenomenon that makes the earth inhabitable. The earth would be cooler by approximately 30 degrees C without the effect of naturally occurring gases. A recent estimate of the contribution by different human-produced activities shows carbon dioxide emissions from energy use and production are the largest contributors to greenhouse gases. The combined effect of the other trace gases presently is equal to that of carbon dioxide.

Globally, atmospheric concentrations of greenhouse gases are believed to have increased dramatically from pre-industrial levels. Atmospheric carbon dioxide has increased from 270 parts per million by volume prior to 1880 to 355 in 1990. The current rate of increase of carbon dioxide is 1.8 parts per million by volume per year or 0.5 percent per year. Fossil fuel combustion and global deforestation are the primary contributors to carbon dioxide buildup. The rate of global increase is projected to accelerate in the next decade as underdeveloped nations, particularly China and India, significantly increase power generation using coal.

Global circulation models predict an average global warming between 1.5 and 4.5 degrees C (2.7 and 8.1 degrees F), changes in precipitation amounts, and distribution (Bretherton et al. 1990; Mitchell et al. 1990) by the middle of the next century. These changes in global precipitation and distribution are also predicted to result in regional changes in crop and forest productivity, land use, water quality and quantity, and possible loss of ecosystems that cannot adapt to these changes. While the general circulation models generally agree that average temperatures in North America will rise, there is a great deal of uncertainty about the magnitude of changes in temperature and whether rainfall will increase or decrease. Current models do not have sufficient spatial resolution to predict magnitude or direction of changes on regional scales. At the current spatial resolutions, the models do not distinguish the southern Appalachian mountains as unique topographic features. Changes in temperature and rainfall within a region such as the Tennessee Valley could have far-reaching impacts on various sectors such as energy, transportation, agriculture, forestry, and socioeconomic factors. However, the science of global warming does not permit reasonable predictions of potential impacts.

The magnitude and scope of the potential climate change impacts are of concern for three areas of TVA operations:

- Those related to power production, including both adjustments to power demand and to power supply operations such as water availability for hydroelectric power production, and water temperature limits for nuclear and coal plant water usage
- Issues related to political or legislative constraints on emissions
- Impacts on the natural resources of the Valley, i.e., forests, water, and agriculture.

Despite the scientific uncertainties, TVA has already agreed, along with some 60 other utilities, to participate in the Department of Energy's Climate Challenge initiative and to voluntarily reduce equivalent TVA carbon dioxide emissions by the year 2000.

Aside from its present activities which seek to reduce equivalent carbon dioxide emissions, TVA is also evaluating how different energy resource options affect greenhouse gas emissions. For example, coal-based technologies emit over 200 pounds of carbon dioxide per million Btu of heat input. Nuclear, wind, solar, and hydroelectric power production essentially emit no carbon dioxide. Biomass fuel options that include burning of wood or herbaceous crops that recycle carbon stored in the vegetation after converting carbon dioxide from the atmosphere have less carbon dioxide emissions than coal-fired options. There may actually be a reduction of carbon dioxide since the root systems of these crops act to store carbon in the soil even after the crop has been harvested for fuel.

The carbon dioxide emissions level is one of the measures used to differentiate among TVA's energy strategies.

Cooperative Research and Assessment Programs

This document summarizes current scientific understanding. Uncertainties in current scientific understanding limit our ability to assess:

- The specific contribution of TVA emissions to regional pollutant loadings
- The relationships between pollutant levels and impacts to human health and the environment
- The expected benefits of specific emission reductions.

TVA is cooperating with several regional air pollution research and assessment programs to improve the scientific

understanding and to design regulatory policy that will be successful in the Tennessee Valley to mitigate present and prevent future impacts. Results of these regional programs will be available between 1995 and 1997. The programs are discussed below.

The Southern Appalachian Mountain Initiative (SAMI) and the Southern Appalachian Assessment (SAA) are two regional assessments being conducted under the public review process to evaluate air pollutant impacts in southern Appalachia. TVA is actively participating in both studies. The assessments summarize existing information on visibility impairment, acid deposition, and ozone impacts in southern Appalachia. The Southern Appalachian Mountain Initiative work is ongoing and may provide information that can be used by TVA. A final report for the Southern Appalachian Assessment is expected early in 1996. TVA's analysis may contribute to the assessments being developed by these groups and to their public information and policy decision-making process.

The Southern Appalachian Assessment considers both ecological and socioeconomic focuses. It is led by seven federal agencies in the southern Appalachian region. The Atmospheric Team of the Southern Appalachian Assessment will report by fall 1995 on visibility impairment, acid deposition, and ozone in southern Appalachia.

The Southern Appalachian Mountain Initiative focuses on policy development and regulatory recommendations for air emissions management. It includes state and federal regulatory agencies, federal land managers, industry, academia, and public interest groups. The Southern Appalachian Mountain Initiative is evaluating emissions management options to mitigate existing or prevent future air quality impacts in Class I areas of southern Appalachia. Existing information on air quality impacts will be evaluated and delivered by the Southern Appalachian Mountain Initiative's Technical Oversight Committee in fall 1995. In its technical assessment of emissions management options, the Southern Appalachian Mountain Initiative's Integrated Assessment Committee is designing a framework to integrate current understanding of relationships among emissions, exposures, and impacts. The technical assessment and recommendations on emissions management options are anticipated to be complete by 1997.

The Southern Oxidants Study is a research partnership between the pubic and private sector to better understand the processes and sources that contribute to regional ozone formation. Several federal agencies, state and local regulatory agencies, industries, and universities are participating in the partnership to study rural ozone exposures and source contributions to urban nonattainment areas in the southeastern United States. In the summer of 1995, the Southern Oxidants Study conducted an extensive field study of rural and urban influences on ozone formation in the Nashville area. TVA is leading the design and implementation of this multi-organizational field study. Results from this field study will allow better understanding of the total biogenic (natural) and human-produced sources contributing to regional ozone formation and the specific contributions of TVA nitrogen oxides emissions to ambient ozone exposures. The North American Research Strategy on Tropospheric Ozone is a national effort to understand why emission control strategies over the past two decades have not been effective in reducing ozone exposures. The Southern Oxidants Study is one component of the larger national program. Results of these studies were not available in time to be evaluated in TVA's analysis of environmental consequences of its future energy supply alternatives.

The Electric Power Research Institute is evaluating risks to human health and the environment due to ozone, fine-particulate, and hazardous air pollutant impacts. The Institute delivers results of its research and risk assessments to the Environmental Protection Agency and regulatory authorities to be considered in developing future emissions regulatory policies. TVA is cooperating with the Electric Power Research Institute, the National Park Service, and several southern utilities to measure visibility and particulate species (i.e. sulfates, nitrates, soil, primary particles, etc.) in the Great Smoky Mountains National Park during summer 1995. Results will not be available in time to be evaluated in TVA's final analysis of environmental consequences of TVA future energy strategies. TVA is also cooperating with the Electric Power Research Institute and the Department of Energy to characterize utility emissions of hazardous air pollutants, the efficiencies of different emissions control strategies, and mercury transport and deposition. The Institute's Air Toxic Risk Assessment will contribute to the Environmental Protection Agency's analysis of utility emissions of mercury and other hazardous air pollutants.

Present Impacts

HEALTH

Introduction

Potential impacts to human health are illustrated in *Figure T1-61*. There are potentially numerous health impacts from environmental air pollutants. Impacts range from temporary eye and lung irritation and headaches to progressive damage to the respiratory, cardiovascular, nervous, and immune systems. United States environmental and health policies are written to protect the general public from the unacceptable risk of adverse effects.

The National Ambient Air Quality Standards for criteria pollutants and the National Emission Standards for Hazardous Air Pollutants are set at levels for ambient outdoor exposure that are intended to protect the public health. These standards are periodically reviewed and revised. Evidence of impacts upon sensitive individuals at ambient levels of ozone and fine particulate matter is being reviewed in 1995 by the Environmental Protection Agency in a draft criteria document.

Health impacts can also occur from air pollutant exposures in indoor environments. Currently, indoor air quality is not regulated by national standards, but several of the same pollutants that occur in the ambient outdoor environment also occur indoors. The Environmental Protection Agency has developed guidelines for levels of other indoor pollutants such as radon.

Risk-Exposure Relationships

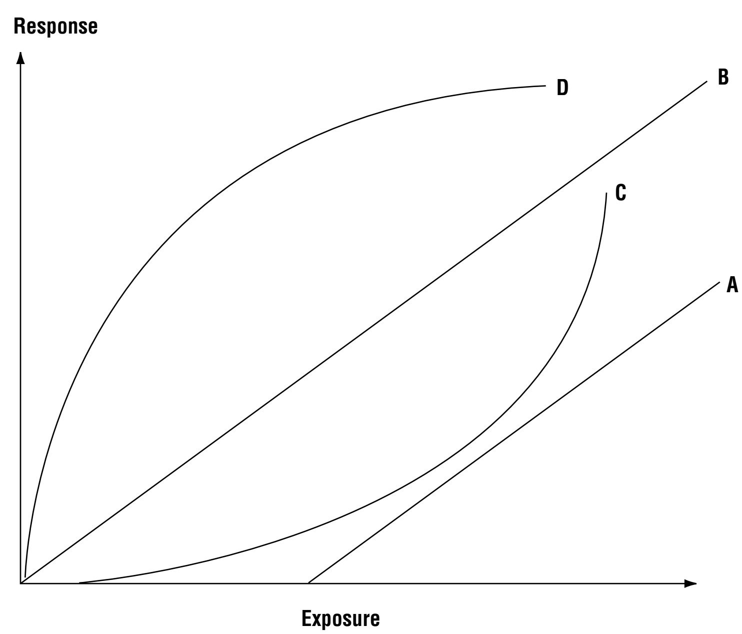
The health risk from exposure to pollutants requires an understanding of the level and duration of exposure. Adverse health effects can come from exposures to high levels for short periods of time and/or prolonged exposures to low levels. The graph in *Figure T1-49* shows examples of theoretical exposure-response relationships. Line A shows a linear relationship with a threshold. For line A, there is no risk for exposures below the threshold. Line B shows a linear relationship without a threshold. For line B, there is some risk at all levels of exposure. Lines C and D are examples of nonlinear relationships. The shape and slope of the exposure-response relationship have substantial implications for assessing the risks from air pollutants and for defining levels sufficient to protect human health. Evaluation of available data has not yielded definitive answers as to which of these curves best fit criteria air pollutants. As a result, the decisions regarding appropriate levels for air quality standards are based in large part on most plausible evaluations and policy goals (Samet et al. 1991). As health effects are better quantified, this evidence is used in reviews and revisions of the National Ambient Air Quality Standards and National Emission Standards for Hazardous Air Pollutants.

Sulfur Dioxide

Depending on concentration, exposure to sulfur dioxide can irritate the eyes, cause respiratory distress, and possibly permanently damage lung tissue. (Durenberger 1991) Under the current ambient standard for the 24-hour average sulfur dioxide concentration, only one group of people might suffer a direct health effect of gaseous sulfur dioxide: People with active asthma who are unmedicated and exercising out of doors might experience an aggravation of asthma symptoms. This occurs infrequently and only in locations near major sulfur dioxide sources (Graham 1990). At locations near major sulfur dioxide sources, short-term sulfur dioxide exposures may be elevated and still meet the 24-hour average standard. These short-term elevated sulfur dioxide exposures may aggravate asthmatics. The Environmental Protection Agency is considering whether a new five-minute sulfur dioxide standard should be set to address this impairment. However, available research indicates that any resulting aggravation is reversible, short-term, and can be avoided with moderation.

Sulfate aerosols that are formed as sulfur dioxide disperses and reacts in the atmosphere also raise concern for human health. The health effects from sulfate aerosols are included in the section that discusses fine-particulate matter. Some epidemiology studies show an association between 24-hour sulfur dioxide concentrations and respiratory illness that may be independent

FIGURE T1-49. **Four Theoretical Exposure-Response Relationships for Health Risks**



Line A = Linear Relationship With a Threshold
Line B = Linear Relationship Without a Threshold
Line C = Non-linear Relationship
Line D = Non-linear Relationships

of particulate concentrations. However, there is uncertainty about whether this is due to sulfur dioxide or the result of another factor correlated with sulfur dioxide (Graham 1990).

Nitrogen Oxides

Depending on its concentration, nitrogen oxides can irritate the eyes, damage the lungs, and lower resistance to respiratory illness and influenza. In its 1994 review of the ambient air quality standard for nitrogen dioxide, the Environmental Protection Agency concluded that the current standard is adequate to protect human health and welfare. The Environmental Protection Agency's annual average standard for nitrogen dioxide is 0.053 parts per million concentration. Current ambient levels of nitrogen dioxide in the Valley are 0.011 parts per million. Evidence from clinical studies suggests that short-term exposures to nitrogen dioxide in the 0.2 to 0.5 parts per million range may cause adverse symptoms for asthmatics. Evidence also suggests that nitrogen oxides from indoor sources such as gas-fired appliances may be associated with greater frequency of respiratory illness in children. This is consistent with some laboratory evidence of reduced resistance to illness. It is difficult at this time to extrapolate health effects from the indoor studies to outdoor levels of nitrogen oxides because the pattern of exposure is quite different. It is uncertain, for example, whether long-term cumulative exposures or peak-level exposures are most important. Some epidemiology studies using measures of outdoor nitrogen oxides have found an association between nitrogen oxides concentrations and acute illness. Other researchers have found no significant relationship (Environmental Protection Agency 1991).

Nitrogen oxides contribute to the formation of two pollutants that are a concern with respect to human health: nitrate aerosols and ozone. Nitrate aerosols are a component of fine-particulate matter and are discussed in that section. Ozone is discussed in the next section.

Ozone

Ozone exposure can cause respiratory tract problems such as difficulty breathing, reduced lung function, asthma, eye irritation, nasal congestion, reduced resistance to infection, and possibly premature aging of lung tissue. (Environmental Protection Agency 1995a.) Ozone levels present in the Tennessee Valley rarely exceed the 1 hour standard of 0.12 parts per million. Epidemiology studies have shown that health effects associated with ozone exposure for the general population include respiratory symptoms, such as acute cough, and minor, restricted activity days. Recent studies in Los Angeles and New York have found small but statistically significant evidence of risk of premature death associated with peak 1-hour ozone exposure at concentrations above 0.20 parts per million (Kinney and Ozkagmak 1990). A study in St. Louis, Missouri, and in Kingston-Harriman, Tennessee, found no increased risk of death at ozone exposure concentrations up to 0.15 parts per million. Extensive evidence exists relating to short term respiratory responses to controlled exposures to ozone in clinical studies. Ozone is also suspected in causing greater susceptibility to chronic respiratory illness, but there is not currently sufficient evidence available to quantify the risk (Krupnik and Kurland 1988; Lippman 1989; U.S. Environmental Protection Agency 1988).

Uncertainty is also associated with the threshold for human health impacts related to ozone. Some evidence indicates effects for certain individuals at levels below the current 1-hour National Ambient Air Quality Standard of 0.12 parts per million. Symptoms have not been observed below 1-hour averages of 0.06 to 0.10 parts per million (Krupnik and Kurland 1988).

Particulate Matter Smaller than 10 Microns

Recent epidemiological studies demonstrate links between particle exposure and respiratory disease in those over age 65 (Fisher et al. 1989). The Environmental Protection Agency standard for particles with diameters of 10 microns or less (PM10), is a concentration of 150 micrograms per cubic meter for 24 hours and 50 micrograms per cubic meter for an annual average. In studies conducted between 1972 and 1980, the Environmental Protection Agency correlated increased death rates with concentrations of PM10 of 100 micrograms per cubic meter. The Agency has also correlated an increase in hospitalizations for respiratory symptoms among people with chronic lung disease with concentrations at this level (Marwick 1991). Some investigators believe the threshold for health effects from particulate matter may be a concentration of 30 micrograms per cubic meter (ORNL 1994).

Some studies have attempted to determine whether the association between particle exposure and respiratory disease is due to sulfates and nitrates associated with fine particles (particles with diameters of 2.5 micron or less), but results have been inconclusive. These smaller particles remain airborne over longer times and distances. It is difficult to separate the potential impacts of sulfate versus acid aerosols because their day-to-day levels tend to be highly correlated. It appears that the association is strongest among the over-65 age group. Those who already suffer from chronic respiratory illness may be at greatest risk (Fisher et al. 1989).

Some studies associate chronic cough and bronchitis symptoms with the level of acidity of aerosols, rather than with sulfate levels or total concentrations of particles. Controlled studies have established a strong relationship between the bronchitis effects on asthmatics and the presence of sulfur dioxide and acidic aerosols at concentrations approaching the ambient standard for

sulfur dioxide (Samet et al.1991). Even so, the evidence to date is inconclusive as to whether acidic aerosols are any more harmful to human health than nonacidic aerosols of similar size (U.S. Environmental Protection Agency 1989).

Epidemiologic studies are limited by the difficulty of measuring exposure and of singling out the effect of acidic aerosols from other factors, particularly for such non-specific health effects as increased symptoms and reduction of lung function. Controlled exposures of volunteer subjects provide information concerning short-term effects. However, this approach cannot fully represent the exposures sustained in a community (Samet et al. 1991).

On a five-year cycle, the Environmental Protection Agency re-evaluates the science on which the National Ambient Air Quality Standards are based. The goal is to either modify or support the current sulfur dioxide and particulate matter standards. The Environmental Protection Agency is currently considering whether standards for acidic aerosols or fine-particulate matter are warranted.

Carbon Monoxide

Carbon monoxide impairs the ability of blood to carry oxygen. Carbon monoxide also affects the cardiovascular, nervous, and pulmonary systems. Carbon monoxide attacks the immune system, especially affecting anyone with heart disease, anemia, and emphysema and other lung diseases. Even at low concentrations, carbon monoxide can affect mental function, vision, and alertness.

Ambient levels of carbon monoxide in the Tennessee Valley are below the level of the National Ambient Air Quality Standards. The Environmental Protection Agency's limit for carbon monoxide is 9 parts per million. At this level, carbon monoxide binds 3 percent of the hemoglobin so that it cannot carry oxygen to body cells and tissues. Toll-booth workers exposed to a 10.8 parts per million level of carbon monoxide had a higher death rate due to heart disease than did toll-booth workers exposed to 6.2 parts per million. There is some question whether a threshold level exists for exposure to carbon monoxide (Marwick 1994). TVA emits less than 1 percent of the regional carbon monoxide emissions.

Air Toxics or Hazardous Air Pollutants

Depending on concentration and duration of exposure, hazardous or toxic air pollutants can increase the risk of cancer. The Environmental Protection Agency has listed 189 chemicals as air toxics. From this list, the air toxics of greatest concern related to coal-fired power plants are arsenic, beryllium, cadmium, chromium, copper, and mercury. Compounds of these toxics are released during combustion of fossil fuels and are ultimately deposited on land and water.

As evidenced in the data outlined in *Figures T1-45* and *T1-46*, the risks to human health appear to be extremely low from air inhalation or water ingestion of arsenic, beryllium, cadmium, chromium, copper, and mercury. Water concentrations of these metals as measured in and around Fort Loudoun, near Knoxville, Tennessee, are compared in *Figure T1-47* with standards set by the U.S. Environmental Protection Agency, the World Health Organization, and other agencies (Joslin 1994). In general, concentrations of these metals would have to increase by at least fiftyfold before established thresholds would be reached. Risk from chromium exposures in the Valley is difficult to evaluate because monitoring data are available only for total levels of chromium while only the hexavalent form of chromium is carcinogenic. Cadmium levels in human diets are considerably below health advisory levels, but levels in human diets have increased (Joslin 1994).

The risk to human health from mercury in the Tennessee Valley is low if one assumes an individual's diet is based on mercury concentrations in local fish and drinking water. High levels of mercury have been reported in fish in Canada, the northern United States, Scandinavia, and Florida. Recent surveys of the Tennessee River system found only one location where mercury in fish was elevated. That location is on the North Fork of the Holston River immediately downstream from Saltville, Virginia. The mercury level, which does not exceed the Environmental Protection Agency guidelines, is from an inactive industrial site unrelated to atmospheric deposition.

Acid Deposition

In addition to those health impacts associated with emissions of sulfur dioxide, nitrogen oxides, acidic aerosols, and fine-particulate matter that have already been discussed, acid deposition can indirectly affect health. Acidic species deposited to surface waters can mobilize metals in the environment. Mercury accumulation in the environment and biological food chains could be increased by acidic deposition under site-specific conditions. These include drinking water systems that use surface ponds or shallow wells and populations that obtain essentially all of their protein in the form of freshwater fish from acidified lakes. Even under these conditions, increased health risk due to increased mercury exposures is low (NAPAP 1991).

Indoor Air Quality

Indoor air quality also raises concern for human health. Exposure to air pollution is determined by the pollutant concentrations and the time that individuals experience those levels. Since Americans spend the majority of their time indoors,

exposures to indoor air pollutant can be a significant component of total personal exposure. Depending on the presence of indoor sources and building ventilation, indoor air pollutant levels can be much higher than outdoor levels. Air pollution advisories, issued when outdoor pollution levels become unhealthy, recommend that sensitive individuals restrict physical activity and time spent outdoors.

There are many kinds and sources of indoor air pollution:

- Combustion gases such as carbon monoxide, carbon dioxide, and nitrogen oxides from indoor combustion sources including wood heaters, unvented kerosene and natural gas space heaters, and other natural gas-fired appliances
- Small particles from smoking, fireplaces, wood heaters, and cooking
- Volatile organic compounds from insecticides, cleaning solvents, stored fuels, paint, vinyl, plastics, adhesives, and furniture and carpet stain repellents
- Biological contaminants such as allergens from pets, insects, and plants; molds and fungi from damp surfaces; and viruses and microorganisms from people and pets
- Radioactive gas (radon) from the earth beneath a structure.

Health complaints associated with poor indoor air quality are varied. They include dizziness, headache, nausea, irritation of the eyes and airways, impaired learning ability, allergies, sleepiness, rashes, abdominal and chest pains, respiratory illness, and cancer. Impacts discussed previously for sulfur dioxide, nitrogen oxides, carbon monoxide, fine-particulate matter, and hazardous air pollutants also apply if these pollutants are elevated in the indoor environment.

Well-designed and maintained heating, ventilating, and air conditioning systems can provide healthy and energy-efficient living spaces. However, indoor air pollution problems can sometimes be aggravated by weatherization or other energy conservation efforts. Reduced ventilation, the existing burden of indoor pollution, and the increased use of alternative heating sources, such as wood heaters and unvented natural gas or kerosene heaters, can lead to elevated indoor air pollutants. Indoor air pollutant levels can exceed regulatory standards for ambient outside air.

Many simple methods may be used to minimize indoor air pollution exposures:

- Use and maintain all appliances according to manufacturers' specifications and recommendations.
- Read the labels on household products such as cleansers, polishes, drain cleaners, and stove cleaners carefully to ensure proper use. Consider switching to "natural" cleaners and polishes.
- Ventilate kitchens and bathrooms during use to remove cooking smoke and excess moisture.
- Store paints, household cleaning products, and fuels in approved containers in well-ventilated areas.
- Avoid smoking indoors.
- In areas with elevated soil radon levels, consider testing to determine levels within the home or office.

Energy Vision 2020 strategies that promote increased conservation and weatherization methods could increase indoor air pollution exposures. It is assumed for this analysis that TVA will continue to provide guidance to minimize indoor pollutant concentrations. Consequently, indoor air quality impacts are not a measure used to differentiate among future TVA strategies.

VISIBILITY IMPAIRMENT

Visibility impairment is of special importance under the Prevention of Significant Deterioration provisions of the 1977 Clean Air Act Amendments. Impacts are discussed in the "Visibility Impairment" section under "Air Quality Concerns Since the 1977 Clean Air Act Amendments" earlier in this section.

CROPS AND FORESTS

Summary

Impacts of gaseous pollutants, including sulfur dioxide, nitrogen oxides, and ozone on crops and forests, have been described in scientific studies and reviewed in numerous reports. The 1990 National Acid Precipitation Assessment Report and the Environmental Protection Agency's Ozone Criteria Document serve as the primary references because they have undergone formal public review. Impacts from primary pollutant emissions (sulfur dioxide, nitrogen oxides, particulate matter) rarely occur at current ambient levels. Historically, acute impacts from gaseous pollutants are most dramatically illustrated by the deforestation and destruction of aquatic and terrestrial ecosystems in the Copper Hill, Tennessee, basin due to emissions from a chemical company. Prior to 1980, incidents of agricultural crop damage have been documented that occurred when TVA coal-fired power plant plumes were intercepted at ground-level (Jones et al. 1988). There was no opportunity for atmospheric mixing to dilute emissions below levels toxic to crops. Impacts of TVA emissions, particularly sulfur dioxide, to crops in the immediate vicinity of TVA power plants were well documented (Jones et al. 1988). Since 1976, TVA sulfur dioxide emissions have been reduced by two-thirds, as shown in the graph in *Figure T1-22*. Direct impacts of sulfur dioxide to crops and forests rarely occur now.

At current ambient exposures, sulfate and nitrate anions in acid deposition and ozone are the pollutants most likely to cause impacts. Such impacts can be cumulative over long-term chronic

(lower level) exposures. Episodes of high ozone exposures can injure foliage of both crops and forest species. Depending on extent and severity, exposure can lead to cumulative impacts to productivity. Impacts from short-term elevated loadings of sulfate and nitrate anions are infrequent but could potentially occur in the undisturbed forests if acid anions in soil solutions mobilized aluminum from soils at levels toxic to plant roots. Forests susceptible to aluminum toxicity are most likely to be in higher elevations of southern Appalachia (Joslin et al. 1992).

Sulfur Dioxide

The effect of sulfur dioxide on crops and other vegetation varies by species and by length and frequency of exposure (Environmental Protection Agency 1982; Shriner et al. 1990). Acute exposures and their associated visual symptoms were once frequently observed in the TVA region. They are very rarely observed today. The current National Ambient Air Quality Standards secondary standard is adequate to protect vegetation from significant negative impacts, based on the literature summarized in the sulfur dioxide criteria document (Environmental Protection Agency 1982) and in the subsequent National Acid Precipitation Assessment Program analysis (Shriner et al. 1990). There may also be a positive contribution of sulfur emissions to the sulfur requirements of agricultural crops (Noggle 1980). Concentrations of sulfur dioxide in most rural areas in the Valley are currently well below the standard and may drop further as the full effects of the 1990 Clean Air Act Amendments are felt.

Nitrogen Oxides

Nitrogen oxides refers to a family of atmospheric pollutants consisting of nitrogen oxide, nitrous oxide, nitrogen dioxide, nitric acid vapor, and various forms of nitrates (Shriner et al. 1990). In contrast to sulfur, which has decreased during the past two decades, the family of nitrogen oxides has increased. The most common phytotoxic (poisonous to plants) form of nitrogen is nitrogen dioxide, followed by the less frequent nitric acid vapor (Shriner et al. 1990). Within the Valley region, the potential impacts of nitrogen dioxide are minimal, since its plant-poisoning threshold concentration of 0.5 parts per million is well above current ambient levels. Nitrogen oxides in the atmosphere are currently a greater concern because they can contribute to acidic deposition impacts or can be utilized in the formation of ozone. The lack of nitrogen frequently limits plant growth in both cultivated and native vegetation. Therefore, nitrogen oxides deposition in many forms has the potential to increase plant growth. This contribution is probably of much greater importance in natural systems than in managed ones where fertilizer additions greatly outweigh other nitrogen sources.

Acidic Deposition–Crops

Impacts on crops attributable to acidic deposition were studied extensively during the last decade. Shriner et al. (1990) summarized the results of most of that work. They concluded that acidic deposition does not cause a reduction in crop yields. Potential reductions in fertility or increases in acidity can be offset by normal management practices. As discussed, the deposition of sulfur and nitrogen associated with acidic deposition in agricultural settings can be a potential benefit to most crop species. Atmospheric sulfur inputs can satisfy much of the crop sulfur need, while nitrogen input is a very small portion of total crop requirements.

Acidic Deposition–Forests

The National Acid Precipitation Assessment Program conducted extensive research to determine the possible impacts of acidic deposition on forests in North America. The results of this research are summarized in the State of the Science Reports, SOS/T-16 (Barnard and Lucier 1990) and SOS/T-18 (Shriner et al. 1990), and in the 1990 National Acid Precipitation Assessment Program Integrated Assessment Report (NAPAP 1991). These studies concluded that, in general, the vast majority of forests in eastern North America are not in decline, either from pollution or other sources. However, atmospheric deposition may be implicated in the premature mortality of high elevation red spruce *(Picea ruben sug.)* in the Northeast.

Evidence of red spruce decline and pollution involvement in the southern Appalachians is less substantial. The red spruce-Fraser fir ecosystem occupies approximately 103 square miles (268 square kilometers) in the southern Appalachian mountains of southwestern Virginia, eastern Tennessee, and western North Carolina. The trees are generally confined to mountain peaks above 5,000 feet (1,525 meters) elevation, as shown in the map in *Figure T1-50*. National Acid Precipitation Assessment Program studies in the southern Appalachians have documented extensive mortality of Fraser fir and decreases in crown vigor and annual growth in red spruce. Fraser fir mortality, frequently pictured in popular publications, is the direct result of an insect, the balsam woolly adelgid.

Although it has been suggested that air pollution may have rendered fir more susceptible to the adelgid, supporting evidence is incomplete. In mixed stands with dying fir, spruce decline can be partially explained by increases in wind damage and soil temperatures (Nicholas et al. 1992). Symptoms of decline in spruce-dominated stands, at elevations with a high frequency of cloud interception, have led scientists to consider impacts of atmospheric deposition. Acid deposition components of sulfate, nitrate, and hydrogen ions at high elevations greatly exceed those at lower elevations. This is primarily due to the increased vol-

ume of precipitation and high ion concentrations in cloud water. Exposure to ambient cloud water with concentrated sulfate and nitrate anions (negatively charged ions) has also been shown to accelerate foliar leaching of essential cations (positively charged ions). In field studies, decreases in foliar calcium and magnesium have corresponded to decreases in foliar biomass. Field surveys and fertilization studies indicate that red spruce in the southern Appalachians are experiencing calcium and zinc deficiencies, while those in the Northeast are generally not.

National Acid Precipitation Assessment Program research, (Barnard and Lucier 1990, Shriner et al. 1990) as well as ongoing studies, (Nodvin et al. In Press) have demonstrated that the high elevation forests appear to be nitrogen-saturated. Nitrogen inputs from rain, snow, and cloud water combined with inputs from natural biological process exceed the capacity of soils and vegetation to immobilize nitrogen. The leaching of excess nitrogen depletes essential base cations from the soil and acidifies soil water. In addition, there is evidence that aluminum is being mobilized into soil water at levels that interfere with plant uptake of calcium, magnesium, and zinc. Soils in the southern Appalachians generally have a large capacity to absorb sulfate, but current sulfate loading rates will likely exceed soil sulfate absorption capacity within a few decades (Johnson and Lindberg 1992).

Exposure to ambient cloud water can reduce the cold tolerance of red spruce. Increases in winter damage to red spruce in the Northeast have contributed to crown damage and increased mortality in that region. This impact occurs infrequently in the southern Appalachians, where temperatures seldom approach the cold tolerance limits for red spruce.

National Acid Precipitation Assessment Program studies did not find a regional decline of southern pines (Barnard and Lucier 1990, Shriner et al. 1990). The U.S.D.A. Forest Service had reported widespread reductions in average tree growth rates in natural pine stands in the Southeast. Similar growth rate reductions have not been observed in tree plantations. Reduction in tree growth in natural pine stands is an anticipated consequence of historical land use patterns, increases in stand longevity and competition, and other natural factors. Available information is not adequate to determine whether the magnitude of reported growth reductions is greater or less than would be expected in the absence of acidic deposition and associated pollutants. The magnitude, extent, and timing of soil chemical changes due to acidic deposition and their long-term implications for forest health and productivity are uncertain. Available evidence does not support a hypothesis that acidic deposition has caused aluminum toxicity or nutrient deficiencies in southern pines.

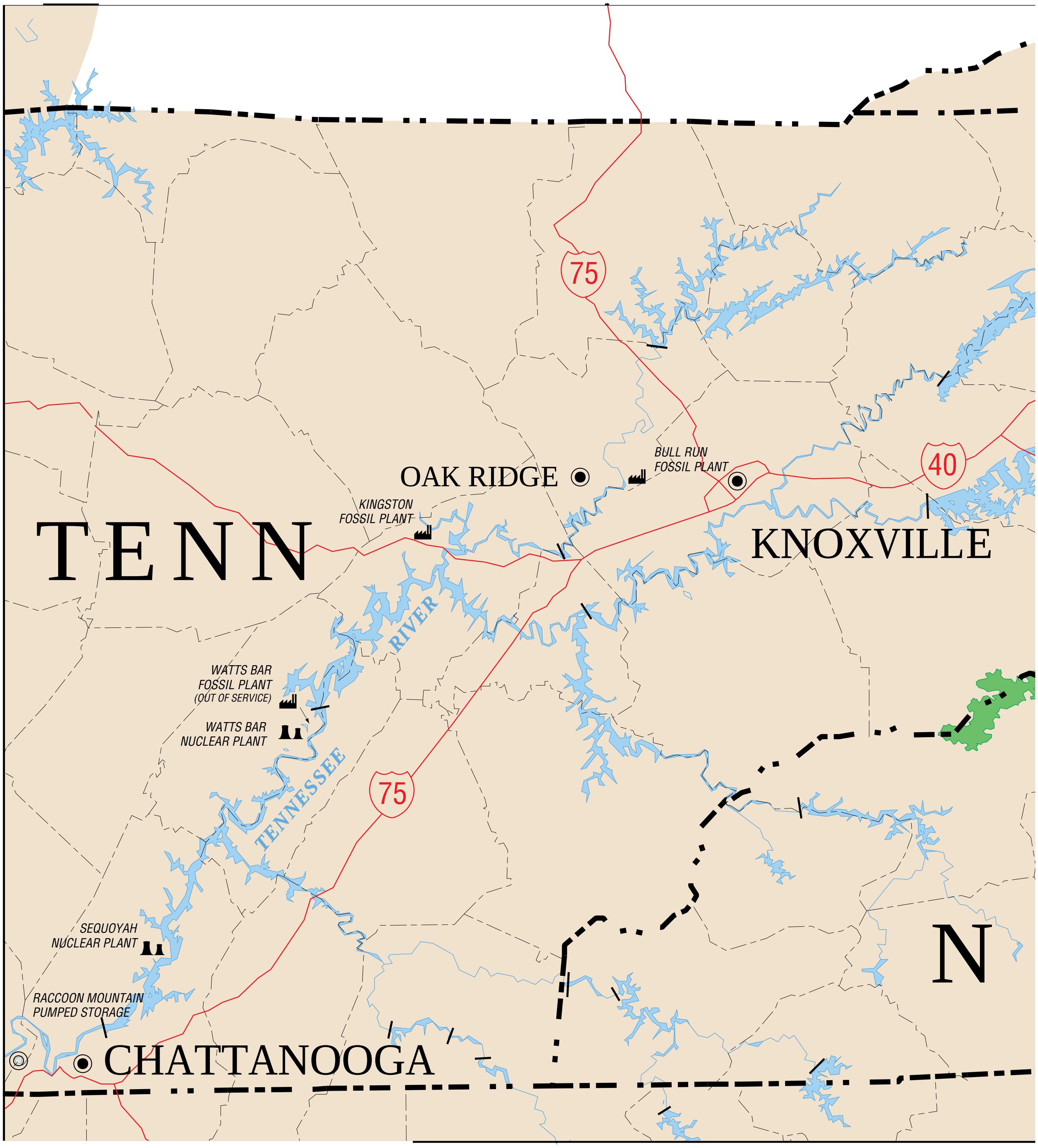
With the possible exception of the spruce-fir forests of southern Appalachia, most Valley forests are receiving acid rain at doses that have not had a serious impact on forest health and productivity. However, the cumulative effects of sulfate and nitrate deposition over several decades could be adverse for some soils. Sulfate and nitrogen oxides deposition increases leaching of nutrient cations from some forest soils and over the long term may reduce the fertility of soils with low buffering capacity or low mineral weathering rate. Nitrogen saturation, a concept currently under discussion in the regulatory arena, could be a long-term impact if nitrogen deposition continues at current rates. Nitrogen saturation is unlikely to occur in Valley forests outside of the high elevation spruce-fir forests or unmanaged old growth wilderness areas.

Impacts to forest soils and nutrient cycling are generally considered to be reversible. Decreases in sulfate deposition would ultimately result in decreases in cation leaching once a new soil equilibrium was established. Decreases in nitrate deposition would probably lead to equivalent decreases in cation leaching in high elevation forests thought to be at or near nitrogen saturation. The Nutrient Cycling Model (Liu et al. 1991) is one method to evaluate the potential benefits to forests that could result from reductions in sulfate and nitrate deposition.

The Nutrient Cycling Model accounts for the exchange of essential nutrients from deposition, vegetation, the forest floor, soils, and soil solutions. The model was applied to project nutrient cycling over a 30-year period in a spruce-fir forest at Noland Divide in the Great Smoky Mountains National Park. Levels of sulfate and nitrate in deposition were varied to simulate alternative reductions in sulfur dioxide and nitrogen dioxide emissions. The initial and no change projections reflect deposition levels monitored at Noland divide for the period 1985 to 1988. Reductions in sulfate and nitrate deposition of 20, 30, 40, or 50 percent compared to the 1980s were projected to represent probable benefits achieved from implementation of the 1990 Clean Air Act Amendments or future emissions reductions.

Calcium is an essential plant nutrient that is susceptible to leaching by acid deposition. Aluminum in soil solutions may be toxic to plant roots and may interfere with plant uptake of calcium. The effects of alternative deposition levels on the distribution of calcium in vegetation, forest floor, and soils and on aluminum and calcium in soil solutions are illustrated in *Figures T1-51* and *T1-52*, respectively (Dale Johnson unpublished data). Calcium is not deficient in this spruce-fir stand, and the model projected very small differences after 30 years in calcium in vegetation and the forest floor as a function of deposition levels. Calcium in the exchangeable soil pool is projected to be greater at lower levels of sulfate and nitrate deposition. Calcium and aluminum in soil solutions (an indication of nutrients lost from the ecosystem) are projected to be lower at lower levels of sulfate

FIGURE T1-50. **The Energy Vision 2020 Study Area Includes the Southern Appalachian Spruce-Fir, a Threatened Ecosystem**



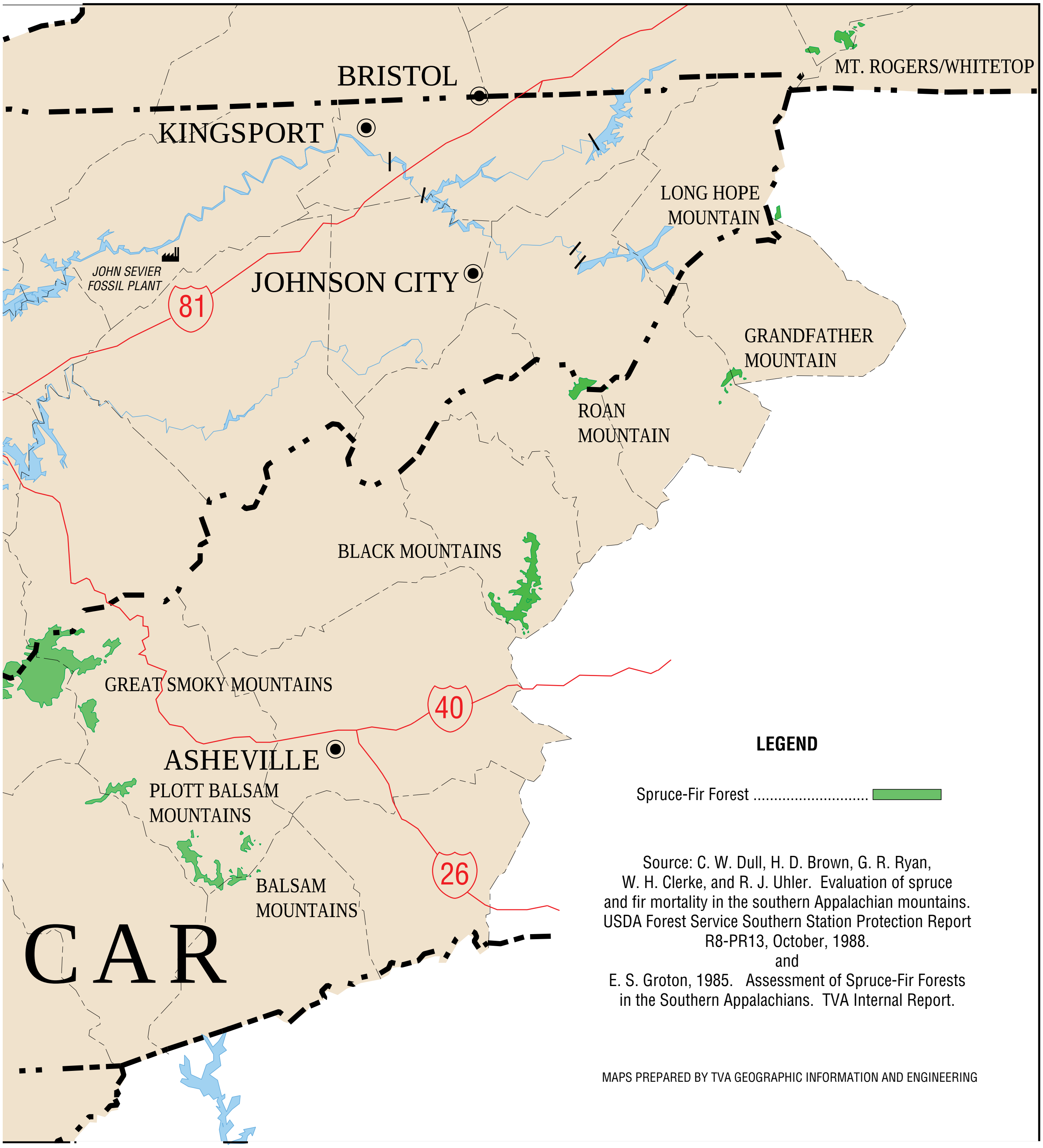
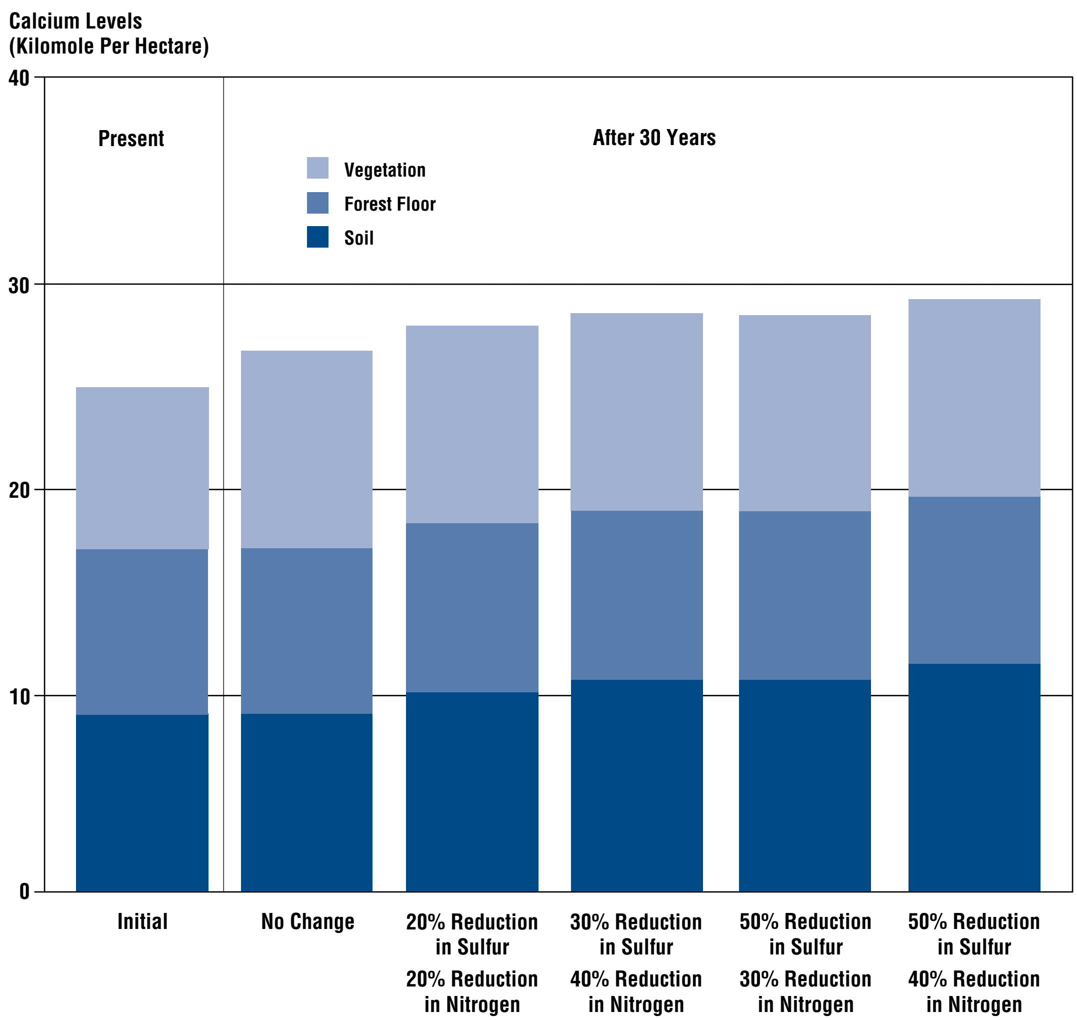

BRISTOL
MT. ROGERS/WHITETOP
KINGSPORT
LONG HOPE MOUNTAIN
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
81
GRANDFATHER MOUNTAIN
ROAN MOUNTAIN
BLACK MOUNTAINS
GREAT SMOKY MOUNTAINS
40
ASHEVILLE
PLOTT BALSAM MOUNTAINS
BALSAM MOUNTAINS
26
CAR
LEGEND
Spruce-Fir Forest ....
Source: C. W. Dull, H. D. Brown, G. R. Ryan, W. H. Clerke, and R. J. Uhler. Evaluation of spruce and fir mortality in the southern Appalachian mountains. USDA Forest Service Southern Station Protection Report R8-PR13, October, 1988.
and
E. S. Groton, 1985. Assessment of Spruce-Fir Forests in the Southern Appalachians. TVA Internal Report.
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-51. **Changes in Calcium Levels in Vegetation, Forest Floor, and Soil Exchangeable Pools in a Spruce-Fir Forest at Noland Divide in the Great Smoky Mountains National Park Based on a 30-Year Simulation Using the Nutrient Cycling Model**



and nitrate. The greatest improvements are projected for the case representing implementation of the 1990 Clean Air Act Amendments compared to the no change (pre-1990 Clean Air Act Amendments) conditions. *Figure T1-52* illustrates that the ratio of aluminum to calcium would improve with reduced deposition levels, particularly during periods of high runoff.

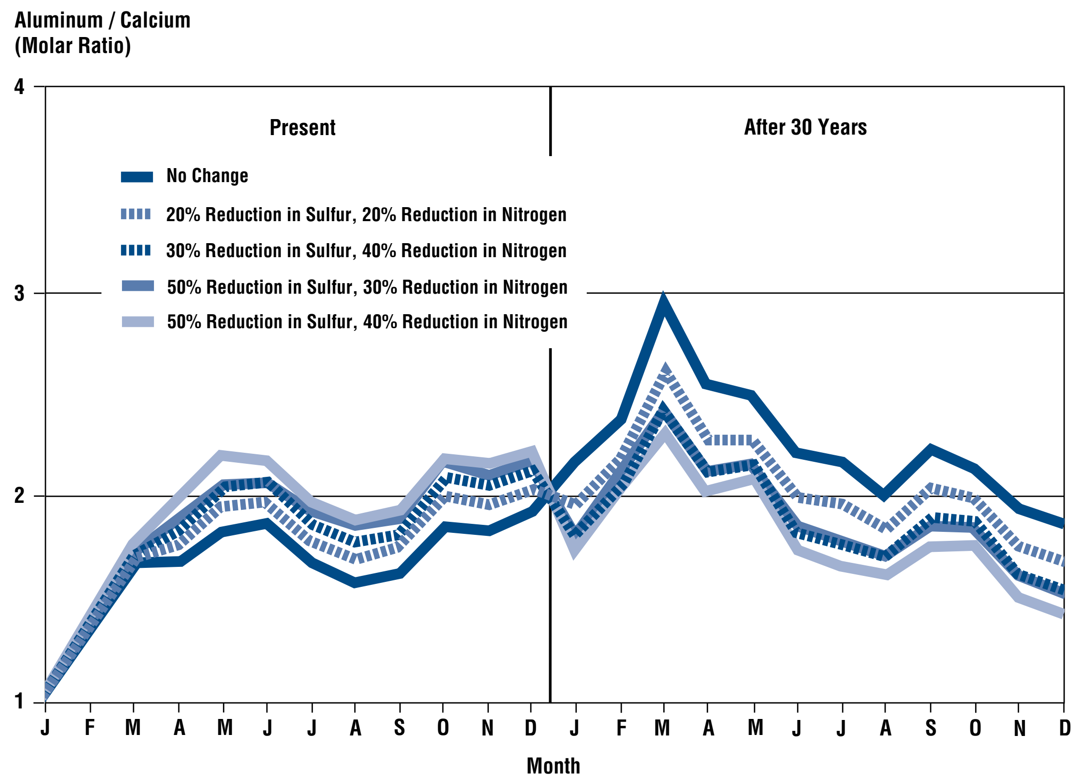
This model application illustrates a potential method to evaluate forest response to reduce deposition levels. Assessments under the Southern appalachian Mountain Initiative will further address methods to evaluate benefits of emissions reductions.

Ozone–Crops

Impacts of ozone are a function of concentration and duration of exposure (external to plants) and plant uptake (internal dose). Ozone is currently the most pervasive air pollutant in rural areas and the pollutant most likely to impact agricultural crops negatively. Impacts to crop productivity, physiology, reproduction, and economic yields have been well documented (Environmental Protection Agency 1995).

Ozone enters plants through the leaf stomates and may disrupt cellular function. High short-term exposures can injure or lead to death of cells in the vicinity of the stomates. The degree of impact increases with the ozone dose received. Visible dis-

FIGURE T1-52. **Changes in Aluminum to Calcium Soil Solution Molar Ratio in a Spruce-Fir Forest at Noland Divide in the Great Smoky Mountains National Park Based on a 30-year Simulation Using the Nutrient Cycling Model**



coloration of foliage may be a result of high short-term exposure to ozone or of the cumulative longer term ozone dose received over the growing season. At frequent, low-level exposures, ozone may inhibit photosynthetic function and reduce plant carbon reserves. Under ozone stress, a greater portion of the carbon fixed through photosynthesis must be used to repair injury to cells rather than contribute to growth. Allocation of carbon from leaves and stems to the root system, which stores carbon for future growth, is frequently limited by chronic ozone exposure. Thus, impacts from ozone can accumulate over the duration of exposure, which can last seasons or years.

At current ambient levels of ozone in the eastern United States, average reductions in crop yield are likely on the order of 10 to 15 percent (Environmental Protection Agency 1995). Some crops, such as tobacco, spinach, and grapes, are very sensitive to ozone and could experience greater than 15 percent reductions in annual yields at current ambient levels. Economic analyses (Kopp et al. 1985; Adams et al. 1989) have considered the economic impacts of yield reductions for major commodity crops such as wheat, corn, soybeans, and cotton. Studies summarized by the Environmental Protection Agency (1995) estimated that net economic losses attributable nationally to current levels of ozone are in the range of 1 to 2 billion dollars per year.

The effects of plant exposure to ozone accumulate over the growing season. Exposures above a threshold value cause greater impacts than lower exposures. Consequently, a cumulative index that sums the hours above a threshold is proposed in the Environmental Protection Agency's 1995 draft ozone criteria document. The Environmental Protection Agency suggests that the sum of hours exceeding a concentration of 0.06 parts per million (SUM06) for the maximum 3-month period between April and October should not exceed 26.4 parts per million-hour. This value was derived from the results of the National Crop Loss Assessment Network (Heck et al. 1990) and is intended to protect 50 percent of crops from 10 percent yield reduction.

Response to ozone can be highly modified by the plant's nutrient and water status. Environmental conditions that limit the extent that leaf stomates are open limit the uptake of ozone.

Consequently, ozone impact is less severe for crops exposed to ozone under low moisture or fertility conditions compared to crops with the same exposure under high moisture and fertility conditions. The table in *Figure T1-53* summarizes the range in ozone exposure at which 10 percent yield reductions were observed for several common crop species in controlled exposure field studies conducted under the National Crop Loss Assessment Network (Heck et al. 1990). Exposure is expressed as the maximum 3-month sum of hours exceeding 0.06 parts per million (SUM06). Plants in these studies were well-watered and fertilized. Yield reductions in unwatered fields may be less than estimated in these studies. In 1992, the maximum 3-month sum of hours greater than 0.06 parts per million exceeded 26.4 parts per million-hour over large areas of the TVA region *(Figure T1-53)*.

FIGURE T1-53. **Crop Response to Ozone Projected by the National Crop Loss Assessment Network Using Controlled Exposure Field Studies**

Crop Species	Maximum 3-Month Sum of Hours Above a Concentration of 0.06 Parts per Million-Hour to Cause a 10% Yield Loss
Corn (2 cultivars)	42-56
Cotton (4 cultivars)	14-95
Kidney Bean (1 cultivar)	15-19
Lettuce (1 cultivar)	37
Peanut (1 cultivar)	36
Potato (1 cultivar)	10-20
Sorghum (1 cultivar)	68
Soybean (7 cultivars)	8-90
Tobacco (1 cultivar)	26
Turnip (4 cultivars)	6-10
Wheat (4 cultivars)	3-35

Source: Environmental Protection Agency 1995 Draft Ozone Criteria Document

Ozone–Forests

Impacts of ozone to forests and natural systems are less well understood than impacts to crops. The bulk of information on ozone impacts to unmanaged vegetation (mainly forest species) has been summarized recently by Barnard and Lucier (1990), Kiester (1990), Shriner et al. (1990), and Environmental Protection Agency (1995). Based on these summaries and other information, it appears that forests in the eastern United States are not in a general state of decline as a consequence of ozone or any other air pollutant. However, ozone has been implicated as the key air pollutant responsible for decreases in productivity in the mountains of southern California and for foliar injury to several forest tree species in the eastern United States. Based on controlled exposure studies with tree seedlings, the table in *Figure T1-54*, summarized from the 1995 draft ozone criteria document, identifies the ozone exposure at which 10 percent losses in biomass are projected for several tree species.

Ozone sensitivity increases in the following order: high elevation conifers, southern pines, late successional hardwoods such as oak, early successional hardwoods such as tulip poplar, black cherry and ash, lichens, and herbaceous forest species (Chappelka et al. 1993; Thornton et al. 1994; Kelly et al. 1993; Samuelson and Edwards 1993; and Samuelson 1994). Species sensitivity to ambient ozone exposures is greatly influenced by site environmental conditions. Species that occur in communities associated with moist sites are generally more sensitive than those species in communities associated with dry sites. While certain varieties of loblolly pine may be negatively impacted by ozone at current ambient levels, the Environmental Protection Agency (1995) concluded that there was no evidence to indicate a general decline in loblolly pine due to ozone in the region.

The National Park Service has documented foliar injury to several sensitive species based both on field surveys in natural forest stands and on controlled chamber exposure studies. (Neufeld and Renfro 1993; Shaver et al. 1994). In natural stands the extent of foliar injury is less than reported from controlled studies. Black cherry is particularly prone to foliar injury. While foliar injury does not necessarily indicate that plant growth has been reduced, it is an indicator of plant sensitivity. Reductions in photosynthesis and growth were documented in the controlled chamber exposures for several of the species sensitive to foliar injury. Results for black cherry and tulip poplar in *Figure T1-54* are from controlled exposure studies in the Great Smoky Mountains National Park (Neufeld and Renfro 1993). Current ambient levels of ozone in the Valley *(Figure T1-37)* exceed levels at which these species experienced biomass losses in controlled chamber studies. Cumulative ozone exposures in the Great Smoky Mountains can actually be greater than in other parts of the Valley because ozone levels in the mountains do not decline as quickly in the late afternoon and evening hours as generally occurs at lower elevations *(Figure T1-35)*. Thus, greater injury to forest species may be occurring in the Great Smoky Mountains than in other areas of the Valley.

Predictions of ozone impacts on forests are still subject to significant scientific uncertainty. The actual ozone dose (uptake) received by a plant is not always a linear function of the ambient exposure because interactions with moisture and fertility can limit stomatal function and ozone uptake. Ozone uptake and plant response to ozone exposures occurring in late afternoon and evening is not well understood. Also, the great bulk of information on tree response to ozone is based on con-

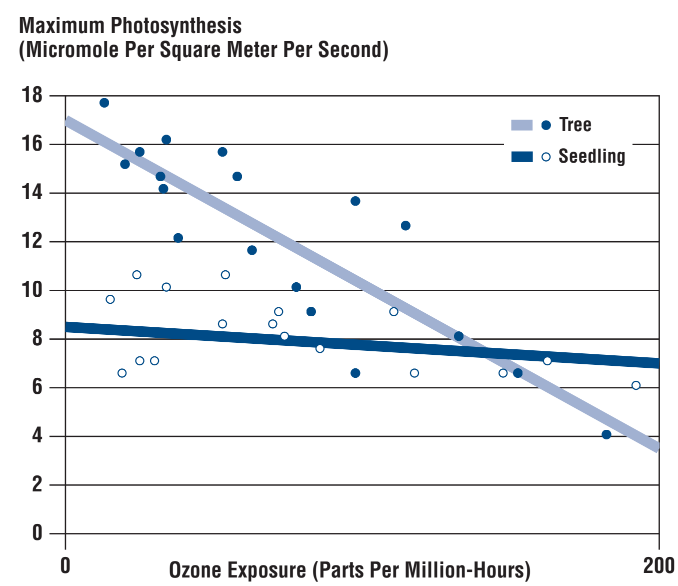
FIGURE T1-54. **Ozone Sensitivity for Several Tree Species Measured as 10 Percent Loss in Seedling Biomass in Controlled Exposure Field Studies**

Tree Species	Maximum 3-Month Sum of Hours Above a Concentration of 0.06 Parts per Million-Hour to Cause 10% Loss in Biomass[1]
Aspen (6 studies)	9-65
Black Cherry (2 studies)	13-17
Tulip Poplar (2 studies)	17-35
Ponderosa Pine (5 studies)	14-65
Red Alder (4 studies)	22-250
Eastern White Pine (1 study)	39-41
Sugar Maple (1 study)	39-105
Red Maple (1 study)	150
Douglas Fir (2 studies)	73-250
Loblolly Pine (1 study)	77-229
Virginia Pine (1 study)	250

[1] Actual ozone exposure in controlled field studies was weighted by duration of exposure to derive maximum 3-month sum of hours greater than 0.06 parts per million-hour. Weighted sum of hours above a concentration of 0.06 parts per million-hour allows sensitivity of tree seedlings to be compared to agricultural crops.

Source: Environmental Protection Agency 1995 Draft Ozone Criteria Document

FIGURE T1-55. **Maximum Photosynthesis of Seedling and Mature Red Oak Under Controlled Ozone Exposures in Chambers in Norris, Tennessee**



trolled exposures of seedlings. Recently completed work has indicated that, at least for northern red oak, mature trees may be more vulnerable to ozone than seedlings (Samuelson and Edwards 1993). *Figure T1-55* indicates that photosynthetical function in mature red oak trees is more sensitive than in seedlings and that ozone impacts increase over that of increased cumulative exposure. Field measures of incremental changes in diameter growth of mature loblolly pines growing on moist and dry sites indicate that ambient levels of ozone may reduce growth of loblolly pine. Site conditions, air temperature, and soil moisture levels were interactive with ambient ozone to affect growth (McLaughlin and Downing, in press).

The Environmental Protection Agency has proposed a new secondary standard that would provide additional protection for crops and forests. This reflects both the possible importance of exposure peaks and the cumulative nature of ozone impacts. The proposed secondary standard suggests a maximum 3-month sum of hours greater than 0.06 parts per million not to exceed 26.4 parts per million-hour. The proposal is based on evidence from agricultural crops, for which there is currently a more complete understanding of plant response to ozone. Because trees are exposed to ozone over several growing seasons, a standard lower than that recommended for annual crops may be necessary to protect sensitive tree species from injury. The next iteration of the ozone criteria document will more fully consider impacts to forests as current studies on mature tree responses provide better scientific evidence to define levels necessary to protect forest species. *(See Figure T1-55.)*

Hazardous Air Pollutants

Terrestrial Impacts

TVA's emissions of hazardous air pollutants primarily involve metals. At current ambient exposures, these metals are not likely to degrade crop and forest productivity. In fact, some vegetation species are very effective at removing metals from the soil and have been used as a biological remediation method to reclaim contaminated sites. The terrestrial ecosystem is a repository for metals deposited from the atmosphere. Soil and vegetation components influence the accumulation or the transport of metals to aquatic ecosystems. Concentrations of metals in tree wood and in lichens have been used as indicators of historical deposition patterns for metals because many of the metals accumulate in vegetation.

Aquatic Impacts

Impacts of metals in aquatic ecosystems are of concern for sensitive invertebrate and vertebrate species. Impacts of regional atmospheric deposition of metals are considered to be minor in

the Tennessee Valley *(Figure T1-47)*. Metals such as mercury or lead are more readily mobilized into soil solutions and transported by acid anions including sulfates, nitrates, and organics. In ecosystems sensitive to acidification, these metals may occur at elevated concentrations. However, the Tennessee Valley watersheds are generally well buffered against acidification, have a high land-to-surface water ratio, and have comparatively lower loadings of dissolved organic carbon than other regions of the country experiencing impacts (Joslin 1994). *Figure T1-48* indicates that levels of mercury in air precipitation, lake water and fish at Fort Loudoun reservoir on the Tennessee River are lower than levels in Wisconsin.

MATERIALS DAMAGE

Sulfur Dioxide

Exposure to gaseous sulfur dioxide at sufficient concentration causes corrosion of the protective zinc coating on galvanized steel and contributes to the erosion and pitting of other metals such as copper and aluminum. Sulfur dioxide forms white deposits called gypsum as it reacts with marble and limestone. It degrades protective paint coatings on steels and exterior wood surfaces and speeds the degradation of wood (Sherwood 1990, Sherwood and Lipfert 1990, Boedecker et al. 1990, Brown and Callaway 1990). Sulfur dioxide is also the major component of acid deposition, which is discussed below. Frequent cleaning reduces the impact of sulfur dioxide on materials. Repainting exposed surfaces as needed can largely mitigate the effects of sulfur dioxide.

Nitrogen Oxides

Exposure to gaseous nitrogen oxides at sufficient concentration causes corrosion of metals and other materials similar to the gaseous sulfur dioxide process described above. The effect is about 75 percent less than that for the same weight concentration of sulfur dioxide (ORNL 1994). The corrosion products are generally soluble, so there are no deposit buildups such as the gypsum associated with corrosion from sulfur dioxide. Nitrogen oxides are a significant component of acid deposition, which is discussed below.

Ozone

Ozone is a strong oxidant that can damage rubber and other elastic substances, textile fibers and dyes, paints, and other materials, including plastics and asphalt. Anti-ozonants and anti-oxidants have been incorporated in paints and other elastic substances to mitigate the effects of ozone. The damage to textile fibers and certain dyes tend to be of secondary effect over product lifetimes when compared with other factors such as abrasion, biological degradation, soiling, and changes in fashion. The studies of dose response are largely empirical, and the Environmental Protection Agency cautions that that they are not reliable (Environmental Protection Agency 1986).

Particulate Matter Smaller than 10 Microns

All exterior surfaces are subject to soiling from particulate matter 10 microns or less in size. Ventilated interior surfaces are also subject to soiling and require more frequent cleaning. Some materials, such as selected fabrics, can be permanently stained. Particulate matter can interact with acid deposits to accelerate the effect from acid deposition.

Acidic Deposition

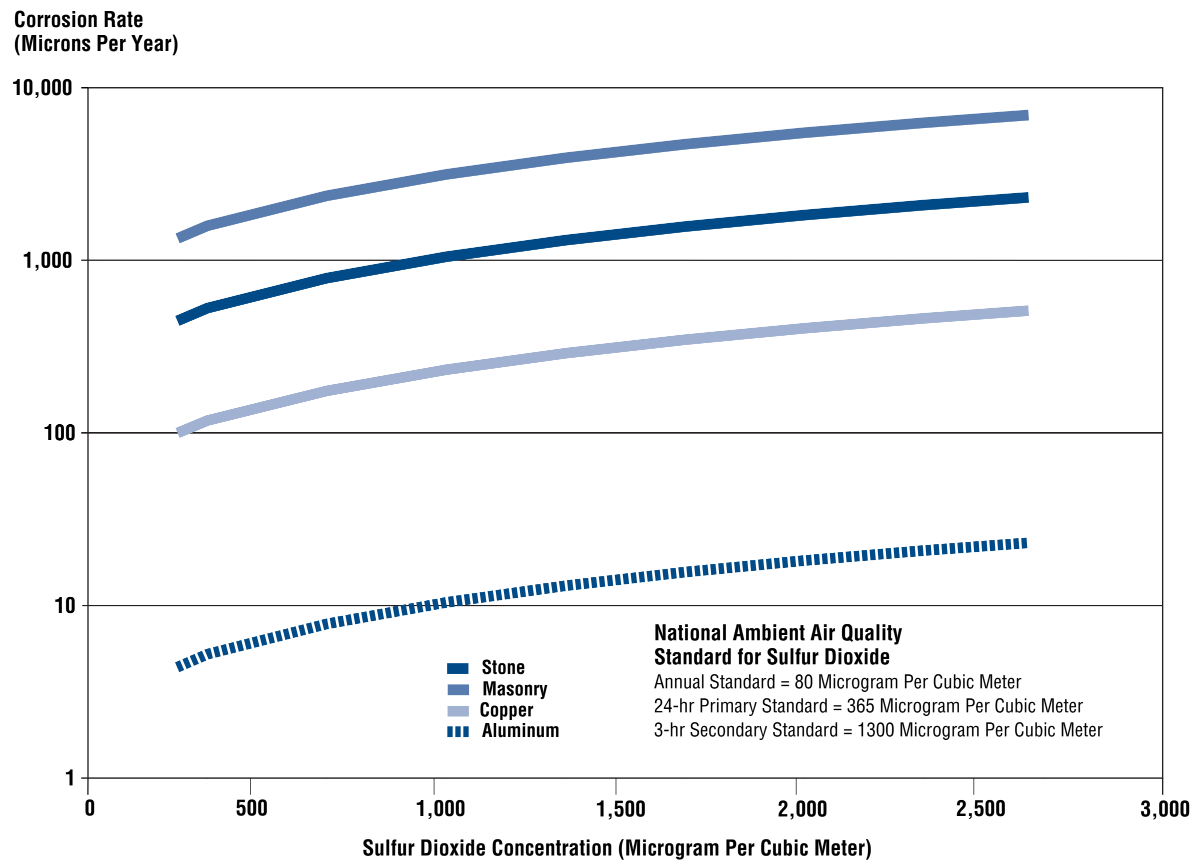
The National Acid Precipitation Assessment Program conducted extensive studies on the effects of acidic deposition on materials (Brown and Callaway 1990). Emissions of sulfur dioxide and nitrogen oxides from power plants are major contributors to acidic deposition. The chemistry of acid deposition involves the oxidation of both sulfur dioxide and nitrogen oxides to form strong acids, sulfuric acid, and nitric acid. These are deposited both directly by dry deposition and by wet deposition with rain, snow, and fog.

Materials that can be damaged from acid deposition include galvanized steel and other metals, painted steel (including automobiles), painted wood, mortar, and carbonate masonry (marble and limestone). Galvanized steel depends on zinc oxides for protection. Over time, these zinc oxides are slowly worn away by clean rain accelerated by acid deposition. Acid deposition corrodes the zinc oxide coating so that it is easily eroded by rain, thus exposing the substrate to corrosion. Copper and bronze develop a natural protective oxide patina that is attacked by acid deposition. As this natural patina is removed, a more porous sulfate patina develops. On copper this sulfate patina has a green color. Painted metals and wood can also be affected by acid deposition. The paints can be damaged, discolored, or spotted. Also, some paints are porous, allowing penetration to the substrate (Brown and Callaway 1990).

Exposures to ambient concentrations of sulfur dioxide can cause marble surfaces to lose 15 to 30 micrometers per year and limestone surfaces, 25 to 45 micrometers per year. Reactions to acidic deposition tend to accumulate as gypsum on the sheltered surfaces of carbonate stone buildings and monuments. Even small material losses can cause significant loss of artistic detail in statues and cultural or historic structures (Brown and Callaway 1990).

National Acid Precipitation Assessment Program corrosion studies in the 1980s have correlated decreased corrosion rates in the eastern United States with diminished sulfur dioxide concentrations. The graphs in *Figure T1-56* shows the

FIGURE T1-56. **Dose-Response Functions for Materials Exposed to Acidic Deposition**



dose-response relationship between sulfur dioxide levels and the corrosion rate on common materials (ORNL 1994).

While a correlation exists, caution should be taken in assuming a cause-and-effect relationship. The level of nitrogen oxides, ozone, acid deposition, and particulates also tended to track with sulfur dioxide, so the investigators could not isolate effects of individual pollutants. Therefore, this table is best viewed as showing the composite effect of acid deposition with sulfur dioxide acting as the marker.

The effects of acidic depositions can be reduced by frequent cleaning and repainting as needed. Paints and protective coatings that are more resistant to attack from acidic deposition need to be developed.

Air Indices and Rationale for Weightings

TVA's existing energy resources and many of the resource options considered for Energy Vision 2020 can affect air quality in different ways. Several air quality issues were identified as concerns in the scoping phase of the Energy Vision 2020 process. Air indices were developed to help characterize how TVA power system operations and alternative energy strategies might affect air quality impact areas. *Figure T1-57* contains the weightings used in Energy Vision 2020 for air emissions. The values in the index are weighted by the relative importance among TVA emissions in contributing to pollutant loadings that could affect human health and the environment. The index allows the emissions of greater concern for impacts to be given greater emphasis in multi-attribute analysis of alternative energy strategies.

To understand how the index translates to differences in impacts, it is necessary to understand how TVA emissions contribute to pollutant exposures and how changes in expo-

FIGURE T1-57. **Weighting Factors for Air Quality Evaluation Measures Used in Four Impact Area Indices**

Measure	IMPACT AREAS Health-Inhalation	Visibility Impairment	Forest and Crop Productivity	Materials Damage
Sulfur Dioxide Emission	0.40	0.70	0.25	0.60
Nitrogen Oxides Emission	0.50	0.25	0.75	0.40
Total Suspended Particulate Emission	0.05	0.05		
Mercury Emission	0.05			

sures result in changes in impacts. Uncertainty in scientific understanding limits the ability to quantify the relationships among emissions, exposures, and impacts. In applying this index to multi-attribute analysis, percentile differences in the weights among strategies can be interpreted as differences in TVA contributions to the air pollutant loadings that cause impacts. The air index, as presented, does not provide a weighting of TVA's contribution to the total pollutant loading in the area of concern.

RELATIONSHIPS

Energy Vision 2020 defines TVA's future energy options as alternative energy supply strategies and does not define specific sites where TVA air emissions might increase. To understand impacts of specific TVA sources to specific receptors of concern, it is necessary to use atmospheric models to project the transformation and delivery of emissions under specific meteorologic conditions. This analysis does not attempt to model delivery of emissions from specific TVA sites to specific receptors. In TVA siting decisions for future energy supply, atmospheric modeling can be used to better project site-specific impacts from TVA emissions.

General relationships between pollutant loadings and impacts are illustrated in *Figures T1-58* through *T1-60* for acid deposition, ozone, and visibility. In these diagrams, factors that can be controlled, e.g. emissions management decisions, are illustrated in a box. Arrows illustrate dependencies between variables and end results. Impacts to human health, crop and forest productivity, materials, and visibility are the end results of decisions on levels of emissions from human activity and the many environmental variables that influence pollutant formation, transport, and exposure. The variables in these diagrams must be considered to evaluate what changes in impacts will occur as a result of changes in emissions under different TVA energy supply strategies. As can be seen from these figures, utility emissions are just one category of emissions that contribute to air pollution impacts.

TVA's contribution to total pollutant loadings can be estimated by using predominant wind speeds and directions for seasonal or annual time periods to define the general source area for the Tennessee Valley. (See discussions under ozone, acid deposition, and visibility impairment sections.) TVA's emissions within the source area are projected from 1996 to 2020, and changes in impacts are considered as a function of changes in loadings. Analyses assume that emissions from non-TVA sources will remain level over this period, and any changes in loadings will be a function only of changes in TVA's contribution.

Potential changes in impacts have been considered for the region and for sensitive receptors. For human health impacts, any reduction in loadings will have positive benefit. Environmental and material damages can be episodic (hours or days) or cumulative (seasonal, annual, or over decades) and can vary as a function of the site conditions. Reductions in pollutant loadings below a threshold level may be required before benefits are measurable.

WEIGHTINGS ASSIGNED TO EMISSIONS IN AIR INDICES

Weightings of key pollutants in the indices are given in *Figure T1-57*.

Human Health–Inhalation

Figure T1-61 contains a summary of possible health effects associated with various types of pollutants. Any TVA contributions to health impacts associated with inhalation of pollutants are primarily related to ozone and fine-particulate matter on respiratory functions of sensitive individuals. Ambient levels of sulfur dioxide associated with TVA's emissions are below levels that impact lung function directly. However, sulfur dioxide can be converted to sulfate particles that are of the size most irritating to lung function (particles less than 2.5 microns). Increased health risk has also been associated with elevated levels of the fine particles.

TVA's nitrogen oxides emissions contribute to ozone formation. Ambient levels of ozone are estimated to have slightly greater risks of respiratory impacts than fine particles. Because of the importance of ozone, nitrogen oxides were weighted slightly more than sulfur dioxide (0.5 versus 0.4).

TVA's emissions of hazardous air pollutants are estimated to have less risk than the Environmental Protection Agency's one-in-one million health risk threshold. Therefore, a low weighting of 0.05 was applied. TVA mercury emissions are tracked in the air index as a surrogate for other metals emitted in trace quantities from coal combustion because more quantitative data is available for mercury emissions than for other hazardous air pol-

FIGURE T1-58. **Acid Deposition: Relationships Among Emissions, Exposures, and Impacts**

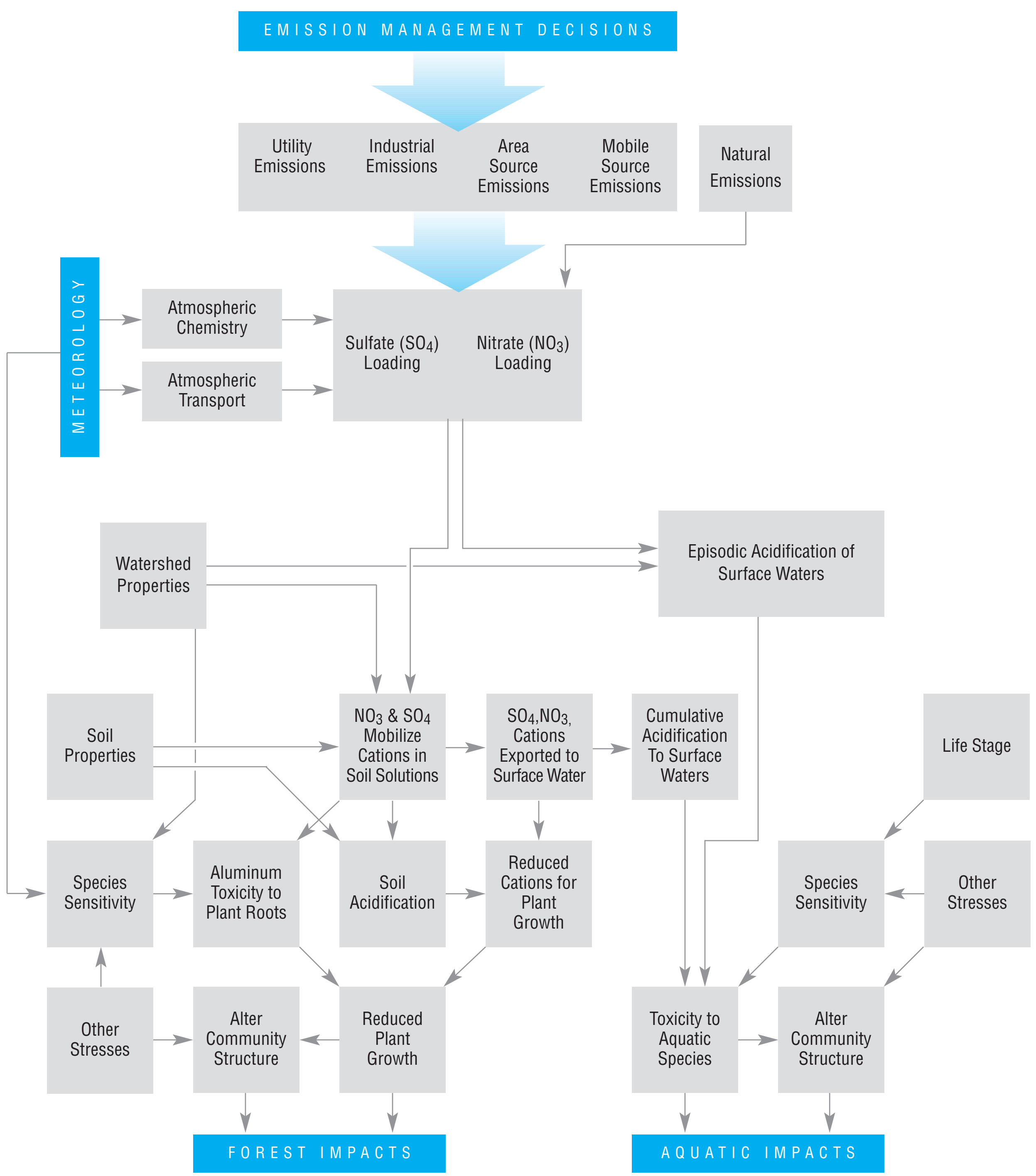


FIGURE T1-59. **Ozone: Relationships Among Emissions, Exposures, and Impacts**

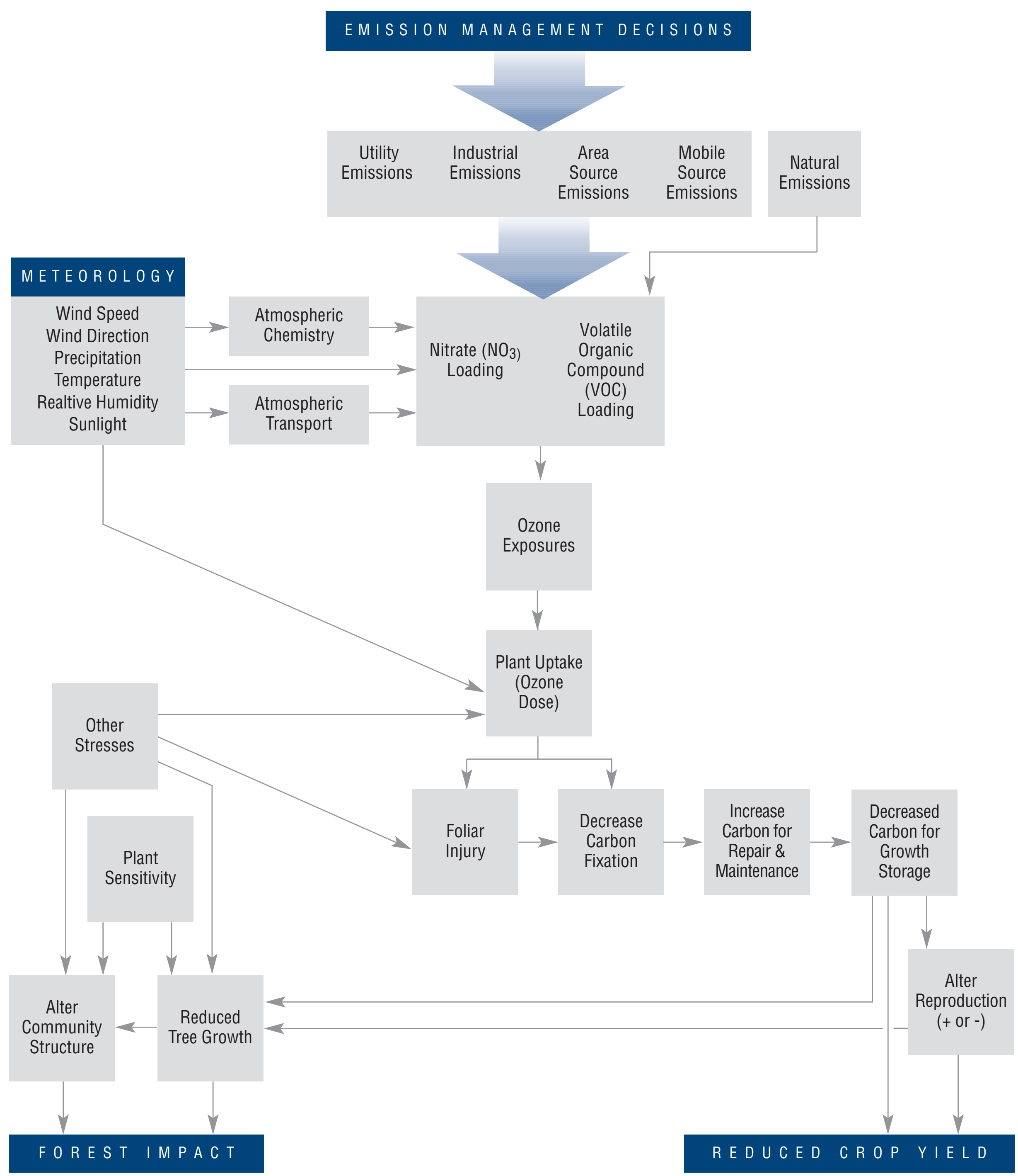
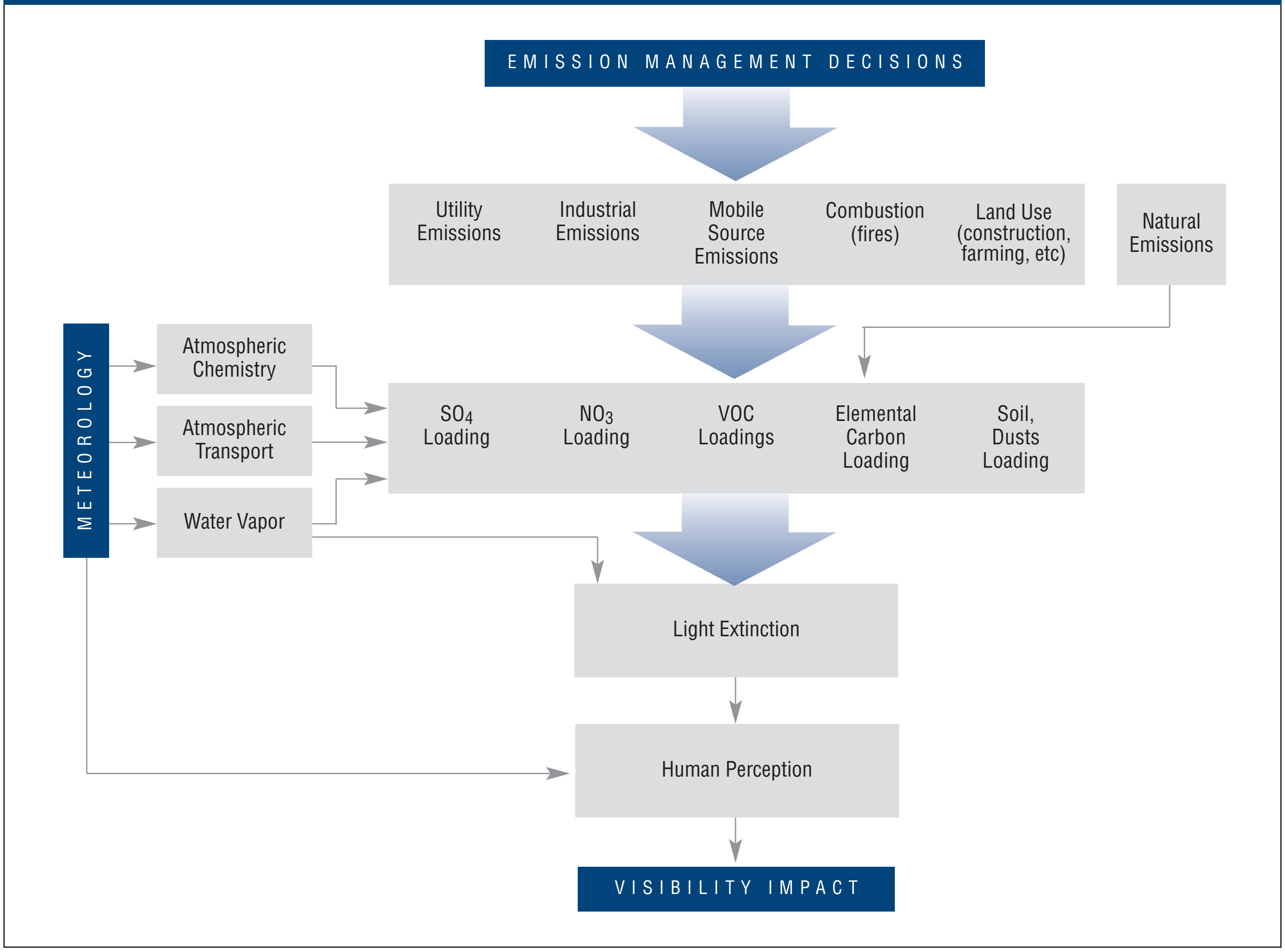


FIGURE T1-60. **Visibility: Relationships Among Emissions of Particulate Matter, Gaseous Pollutants, and Visibility Impairment**



lutants. Mercury effects are discussed in the water resources section of this section.

TVA's emissions of primary particulates are a minor component of the fine-particulate size contributing to health risk. For this reason, total suspended particulates received a weight of only 0.05.

Any reduction in emissions is assumed to have positive benefits for human health.

Visibility Impairment

TVA's contribution to regional visibility impairment is primarily associated with fine sulfate particles. Because sulfate production from sulfur dioxide in the atmosphere is slow, TVA sulfur dioxide emissions contribute very little to visibility impairment in the Great Smoky Mountains National Park.

TVA's nitrogen oxides emissions contribute only indirectly to visibility impairment through their role in ozone formation and the conversion of sulfate particles to organic aerosols. As a result, sulfur dioxide was weighted as almost three times more significant than nitrogen oxides (0.70 versus 0.25).

TVA's emissions of primary particles are a minor component of the fine-particulate size most responsible for scattering light in the atmosphere and thus impairing visibility. Because of this minor role, total suspended particulates received a weight of only 0.05.

Forests and Crops

Any TVA contributions to crop and forest impacts are primarily associated with ozone and with nitrate and sulfate in acid deposition. TVA's sulfur dioxide emissions contribute to sulfate in acid deposition, and nitrogen oxides emissions contribute to both ozone and nitrate in acid deposition. At ambient ozone levels, several crop and forest species in the Tennessee Valley are sensitive and exhibit foliar injury and reduced productivity. Sulfate in acid deposition is not thought to have adverse impacts to vegetation and

may have slight positive benefits as a plant nutrient where soils are low in native sulfur. For crops and many forests growing on nitrogen-deficient soils, nitrate in deposition has positive benefits. However, loadings of sulfate and nitrate from wet, dry, and cloud deposition are greatest at high elevation, and high-elevation spruce and fir forests in the southern Appalachians are sensitive to acidification.

Nitrate in deposition has greater impact than sulfate for high elevation forests because soils in the southern Appalachians generally are able to absorb sulfate. Biological processes that use nitrogen are slower at high elevation. When nitrogen deposition exceeds the biological demand for nitrogen, nitrates in soil water can combine with and remove nutrients such as calcium and magnesium that are essential for plant growth. Nitrate can acidify soil waters, leading to aluminum toxicity for sensitive plants. Due to its contributions to ozone and nitrate in acid deposition, nitrogen oxides emissions have been weighted three times greater for their impact to crop and forest productivity than sulfur dioxide emissions (0.75 versus 0.25).

Materials (Structural and Cultural)

Any TVA contribution to damage of materials is associated with both acid deposition and ozone. Acid deposition can erode surfaces of paint, limestone, and metals. Ozone can oxidize some materials such as rubber. Sulfate is considered more corrosive than nitrate in acid deposition, and acid deposition can damage a greater variety of surfaces than ozone, including cultural resources such as historic buildings and tombstones. Therefore, sulfur dioxide emissions are weighted as more significant than nitrogen oxides emissions for material damage (0.60 versus 0.40). Material damage is cumulative, so any reductions in current ambient exposures will likely reduce the rate of material degradation.

FIGURE T1-61. **Summary of Possible Health Effects Associated with Certain Types of Pollutants**

Emission	Pollutant	Health Effect	Air Quality Index [1] Weighting Factor
Sulfur Dioxide	Sulfur Dioxide Sulfate Aerosols Sulfate Fine Particulate (PM10)	Eye Irritation Respiratory Distress Lung Damage	0.40
Nitrogen Oxides	Nitrogen Oxides Nitrate Aerosols Nitrate Fine Particulate (PM10) Ozone	Respiratory Distress Lung Damage Eye Irritation	0.50
Carbon Monoxide	Carbon Monoxide	Headaches Reduced Mental Alertness Heart Damage	0.00
Primary Particulates	PM10	Respiratory Distress Lung Damage Eye Irritation	0.05
Mercury	Mercury	Neurotoxin Brain Damage	0.05

[1] Weighting of the relative importance among TVA air emissions is qualitative, based on estimated magnitude of health impact in the Tennessee Valley and TVA's relative contribution to loadings in that pollutant category. Weightings do not attempt to estimate TVA contribution to health impacts outside the Tennessee Valley.

FIGURE T1-62. **Weighting Factors for Greenhouse Gases**

Environmental Measure	Units [1]	Total Equivalent Carbon Dioxide (Millions of Tons)
Carbon Dioxide Emissions	Annual Average Thousands of Tons	1
Coalbed Methane Emissions Avoided	Annual Average Tons	-21
Nat. Gas Methane Emissions	Annual Average Tons	21
Landfill Methane Recovered	Annual Average Tons	-21
Wood Waste Methane Avoided	Annual Average Tons	-21
Wood Waste Carbon Dioxide Avoided	Annual Average Tons	-1
Short Rotation Woody Crops Carbon Dioxide Avoided	Annual Average Thousands of Tons	-1

[1] Annual Average Equivalent TVA Carbon Dioxide Emissions

Greenhouse Gases

A separate measure was also developed to sum the net greenhouse gas emissions for alternative future energy supply strategies. The measure is expressed in equivalent tons of carbon dioxide, the most common greenhouse gas. Other greenhouse gases, principally methane, are converted to equivalent carbon dioxide by multiplying emissions by the radiative forcing potential. *(See Figure T1-62.)* The radiative forcing potential for any greenhouse gas is an indication of the relative effect of the gas on the global warming potential compared to carbon dioxide, which has a radiative forcing potential of one. For example, methane has a radiate forcing potential of 21, which means its effect on global warming is 21 times greater than that of an equivalent weight of carbon dioxide.

An explanation of the process used to develop measures for environmental evaluation criteria and the calculations for indices can be found in Volume 1, Chapter 5, Evaluation Criteria, and Volume 2, Technical Document 4, Evaluation Criteria.

SECTION 4: WATER RESOURCES

Introduction

The scope of the Energy Vision 2020 water resources study covers the entire Tennessee River basins and portions of the Cumberland, lower Ohio, lower Mississippi, and Green River basins, as shown in the map in *Figure T1-63*. Fresh water abounds in this area and generally supports most beneficial uses, including fish and aquatic life, public water supply, industrial water supply, waste assimilation, agriculture, and water contact recreation such as swimming.

Water quality concerns in the region include the following:

- Point sources of pollution such as wastes from sewage treatment facilities and industrial plants
- Non-point sources of pollution such as agricultural and urban runoff
- Toxic substances found both in sediment and fish in some reservoirs
- Occurrences of low dissolved oxygen levels in tailwaters downstream of certain dams. (A tailwater is the water immediately downstream from a dam, including water released from the dam.)

Principal water quality concerns in TVA reservoirs are shown in the table in *Figure T1-64*. Principal water quality concerns in Tennessee Valley watersheds are shown in the table in *Figure T1-65*.

Water quality and aquatic habitats differ substantially according to the type of aquatic environment. Aquatic environments in the region can be characterized as follows:

- Unregulated streams and stream reaches sufficiently far downstream of dams to have returned to "stream-like" conditions
- Mainstream reservoirs (reservoirs on large rivers such as the Tennessee River)
- Tributary reservoirs and associated tailwaters.

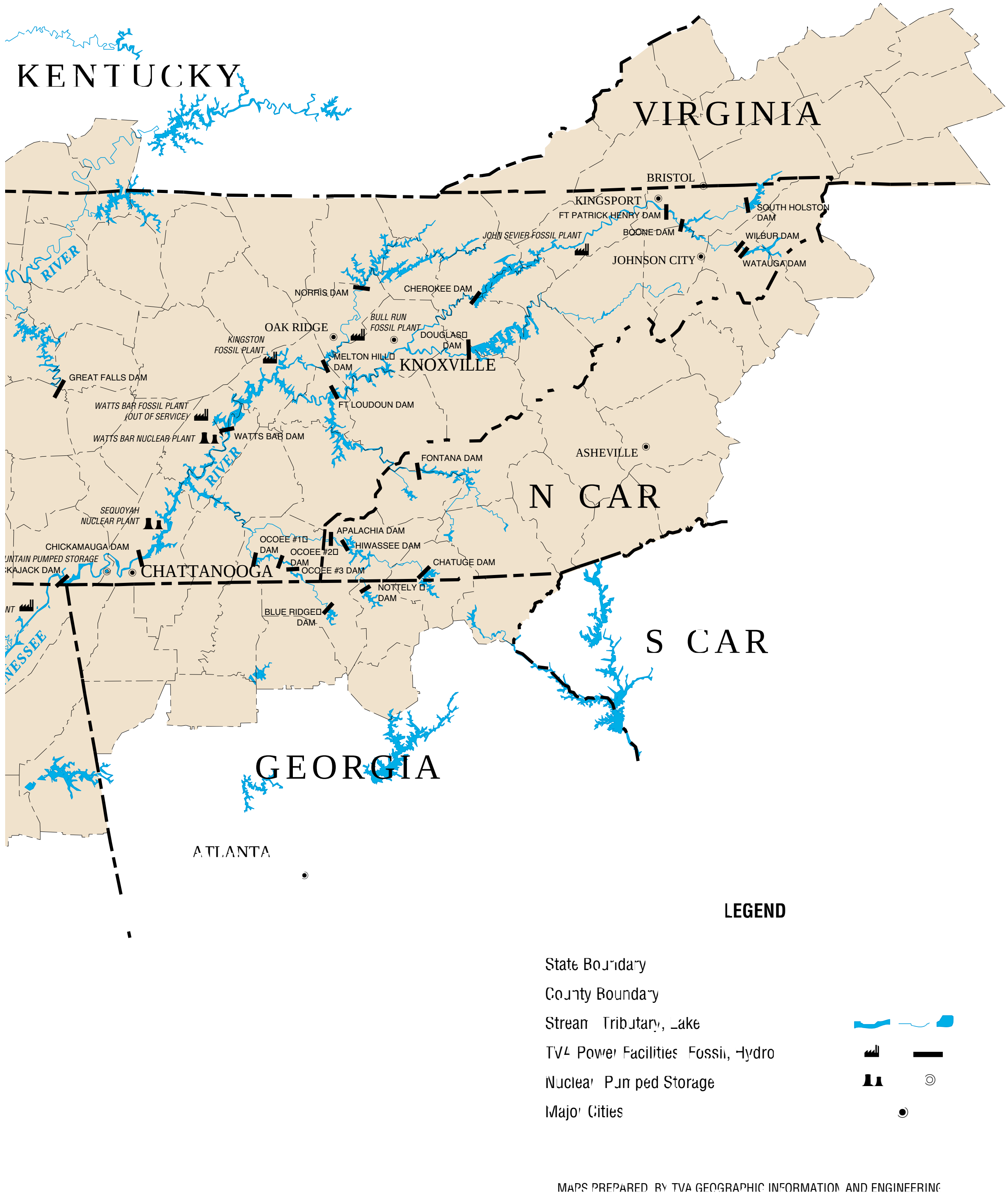
For the most part, smaller streams and some reaches of larger streams in the region are unregulated or free-flowing. Stream habitats vary from cold water mountain streams to lowland warm water creeks and small rivers. The water quality and aquatic life in these streams are affected by the characteristics of the watershed (the area draining into a stream or river), as well as human activities. Many small streams are susceptible to impacts from runoff, waste discharges, and contaminated groundwater seepage. The small streams that form in the Appalachian mountains have a low buffering capacity (ability to absorb acids and bases without altering the stream pH). This makes them particularly vulnerable to the effects of acid mine drainage and acid precipitation. Mining produces coal for many TVA power plants, and emissions from TVA coal-fired power plants contribute to acid precipitation.

Mainstream dams on the Tennessee River are operated primarily for navigation, flood control, and hydroelectric power production. They form relatively shallow, run-of-the-river reservoirs that exhibit characteristics of both lakes and rivers. The upstream portions of the reservoirs are more riverine with a gradual downstream transition to lake-like conditions. The relatively higher flow rates in these mainstream reservoirs aid in maintaining adequate dissolved oxygen levels. Thermal stratification (layering of water with different temperatures—warmer near the surface and colder near the bottom) occurs to some extent in the downstream, lake-like portions of the reservoirs but generally does not occur in the upstream portions.

Tributary reservoirs are operated for flood control, hydroelectric power production, and to a lesser extent, augmentation of downstream water supplies. They are relatively deep, lake-like reservoirs that thermally stratify during the summer and fall. Releases from the lower levels of stratified reservoirs are often low in dissolved oxygen and may have elevated concentrations of metals such as iron and manganese. Also, operation of hydro power units to meet peak power demands often results in low or intermittent downstream water flows. Therefore, the quality of the water released intermittently from the reservoirs during the summer may be characterized by low dissolved oxygen levels and elevated concentrations of some metals.

TVA, through its Lake Improvement Plan, is reaerating reservoir releases and providing minimum continuous water flows downstream of most of its tributary reservoirs. The establishment of minimum flows and aeration of releases will recover over 170 miles of aquatic habitat lost from intermittent drying of the river bed below TVA tributary dams and improve levels of dissolved oxygen in over 300 miles of river where water quality is now impaired in the late summer and fall by releases through TVA dams. Proposed summer lake levels in tributary reservoirs will also improve, as will reservoir fisheries, by increasing survival of young fish.

Figure T1-63. **Water Resources Considered in Energy Vision 2020 Include the Entire Tennessee River Basin and Portions of the Cumberland, Ohio, Mississippi, and Green River Basins**



KENTUCKY
VIRGINIA
N CAR
S CAR
GEORGIA
RIVER
RIVER
NESSEE
BRISTOL
KINGSPORT
FT PATRICK HENRY DAM
BOONE DAM
SOUTH HOLSTON DAM
WILBUR DAM
WATAUGA DAM
JOHNSON CITY
JOHN SEVIER FOSSIL PLANT
CHEROKEE DAM
NORRIS DAM
OAK RIDGE
BULL RUN FOSSIL PLANT
KINGSTON FOSSIL PLANT
DOUGLAS DAM
MELTON HILL DAM
KNOXVILLE
GREAT FALLS DAM
FT LOUDOUN DAM
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
WATTS BAR DAM
FONTANA DAM
ASHEVILLE
SEQUOYAH NUCLEAR PLANT
CHICKAMAUGA DAM
OCOEE #1 DAM
OCOEE #2 DAM
OCOEE #3 DAM
APALACHIA DAM
HIWASSEE DAM
CHATUGE DAM
NOTTELY DAM
BLUE RIDGE DAM
CHATTANOOGA
ATLANTA
LEGEND
State Boundary
County Boundary
Stream, Tributary, Lake
TVA Power Facilities: Fossil, Hydro
Nuclear, Pumped Storage
Major Cities
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

Tennessee River

The Tennessee River basin contains all but one of TVA's dams and covers most of the TVA region.

The Tennessee River is formed by the Holston and French Broad Rivers joining at Knoxville, Tennessee, 652 river miles from where it empties into the Ohio River near Paducah, Kentucky. The entire length of the Tennessee River is regulated by a series of nine locks and dams built mostly in the 1930s and 40s that allow navigation to Knoxville. Virtually all the major tributaries have at least one dam, creating 14 multi-purpose storage reservoirs and 7 single-purpose power reservoirs. *Figure T1-63* is a map of the basin, showing dams and reservoirs. This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries.

SURFACE WATER

Major water quality concerns within the Tennessee River drainage basin include point and non-point sources of pollution that degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs. Toxic substances have also been found in sediment and fish in reservoirs that oth-

FIGURE T1-64. **Principal Water Quality Concerns in TVA Reservoirs**

Navigation & West Tributary Reservoirs	USES AFFECTED				SOURCE	
	Aquatic Life	Fish Consumption	Recreation	Water Supply	Point	Non-Point
Kentucky			Aquatic Plants			
Normandy	Low Dissolved Oxygen			Taste, Odor, Iron, Manganese	X	
Pickwick				Algae		X
Wilson	Low Dissolved Oxygen			Taste, Odor		X
Wheeler	Low Dissolved Oxygen	DDT			X	X
Tims Ford	Low Dissolved Oxygen					X
Guntersville			Aquatic Plants			X
Nickajack		PCBs, Chlordane			X	X
Chickamauga	Low Dissolved Oxygen				X	X
Watts Bar	Low Dissolved Oxygen	PCBs			X	X
Melton Hill		PCBs				X
Ft. Loudoun		PCBs	Bacteria		X	X
Tellico	Low Dissolved Oxygen	PCBs				X
East Tributary Reservoirs						
Norris	Low Dissolved Oxygen					X
Cherokee	Low Dissolved Oxygen				X	X
Ft. Patrick Henry						
Boone	Low Dissolved Oxygen	Metals, Toxics			X	X
South Holston	Low Dissolved Oxygen					X
Wilbur						
Watauga						
Douglas	Low Dissolved Oxygen			Color	X	X
Nolichucky	Siltation		Siltation	Siltation		X
Fontana	Low Dissolved Oxygen					X
Ocoee 1-3	Metals, Siltation	PCBs	Siltation		X	X
Blue Ridge						
Appalachia						
Hiwassee	Low Dissolved Oxygen					X
Nottely	Low Dissolved Oxygen				X	X
Chatuge	Low Dissolved Oxygen					X

erwise have good water quality. Other water quality concerns include occurrences of low dissolved oxygen levels downstream of dams, which stresses aquatic life and limits the ability of the water to assimilate wastes.

The principal water quality concerns in TVA reservoirs and watersheds are summarized in *Figures T1-64* and *T1-65*. This information was derived primarily using data and analysis generated through TVA's comprehensive ecological health and use suitability monitoring program as well as other TVA aquatic monitoring and assessment activities. The criteria used in making the determinations were state water quality standards and fish consumption advisories. This summary reflects the current understanding of the causes and effects of point and non-point sources of pollution on water quality.

Point and Non-Point Sources of Pollution

Point and non-point sources of pollution include:

- Heat-release – Utility and industrial plants may release water into streams or lakes that has been heated above the temperature of the body of water.
- Wastewater – Sewage treatment systems, utilities, industry, and others dispose of waste into streams and lakes.
- Runoff from agriculture, urban uses, and mined land.
- Air pollution – Pollutant concentrations in the air can affect surface waters through rain and deposition.

Heat Releases

Power plants use water from streams or lakes for various purposes. The water returned to the streams or lakes is often heated above the temperature of the body of water. When the Clean Water Act was first considered, little was known about the effects of waste heat on freshwater ecosystems. Many possible consequences were postulated, including direct mortality, blockage, or interruption of fish spawning migrations; advanced spawning of fish or hatching of aquatic insects; increased toxicity of certain pollutants; and shift of phytoplankton populations to less desirable species. Because of the uncertainty surrounding this issue, extremely conservative thermal water quality criteria and permit limitations were established based primarily on laboratory studies of these potential effects. To provide relief to dischargers from the unnecessarily stringent limitations that would in many cases likely be imposed , the Act provided for alternative thermal limits where dischargers could demonstrate to regulators that the waste heat limits imposed were more stringent than necessary to protect indigenous aquatic communities. Many of TVA's power plants are now operating under alternative thermal limits granted as a result of such demonstrations.

TVA conducts extensive aquatic monitoring programs to ensure that thermal and other discharges do not cause adverse impacts even at permitted levels. Recently, programs have focused primarily on potential effects on spawning and development of coolwater fish species such as sauger (*Stizostedion canadense*) and walleye (*Stizostedion vitreum*), but have also included attraction of fish to thermal plumes from power plants and possible increases in undesirable aquatic microorganisms, such as blue-green algae. In general, these monitoring programs have failed to detect significant negative effects resulting from release of heated water from TVA facilities.

There are presently 2 operating nuclear plants and 11 operating coal-fired plants in the TVA power system. A third nuclear plant is scheduled to begin operating in 1996. Each of these plants withdraws process cooling water from the river upon which it is located. The heated water is then discharged back into the river at or below the temperature necessary to meet the thermal discharge limitations stated in each plant's discharge permit. Permits normally state a maximum allowable temperature after mixing of the thermal discharge with the receiving stream, as well as a maximum temperature change relative to upstream conditions and a maximum rate of temperature change.

Various measures are used by TVA to ensure compliance with thermal limits. All three nuclear plants and one fossil plant have cooling towers that

FIGURE T1-65. **Principal Water Quality Concerns in Tennessee Valley Watersheds**[1]

Aquatic Watershed	Fish Life	USES AFFECTED [2] Consumption	Recreation	SOURCE Point	Non-Point
Chickamauga-Nickajack		PCBs	Bacteria		X
Pickwick-Wilson	Toxics				X
Watts Bar-Melton Hill	Siltation	PCBs	Bacteria		X
Duck River	Siltation		Bacteria		X
Guntersville-Sequatchie	Siltation		Bacteria		X
Clinch-Powell	Siltation				X
Wheeler-Elk		DDT, PCBs	Bacteria		X
Holston	Toxics	Mercury	Bacteria	X	X
French Broad	Siltation	Dioxin	Bacteria	X	X
Little Tennessee	Siltation	PCBs		X	X
Hiwassee	Metals, Siltation			X	X

1 As designated by TVA's Clean Water Initiative
2 Uses are affected by the problem noted on at least one stream in the watershed.

may be used as appropriate to dissipate heat to the atmosphere before water is discharged. Depending on conditions and permit requirements, these plants may continually recirculate cooling water through the towers, they may pass the heated water through the towers once before discharging, or they may bypass the towers altogether and discharge the heated water directly to the river. Heated water at nuclear plants is discharged to the river through diffusers that extend well out into the river to produce rapid mixing.

Three coal-fired plants that do not have cooling towers may experience conditions during certain times of some years when they cannot operate at full power and still meet thermal limits. During those times, electricity generation is cut back to reduce the amount of waste heat released to the river. A few plants can discharge once-through cooling water without either cooling towers or operational cut backs because of their location on large water bodies that quickly assimilate waste heat discharges.

Wastewater

Discharges of pollutants from point sources, such as sewage treatment facilities and industrial plants, are regulated by the U.S. Environmental Protection Agency and the states to achieve a certain level of water quality. As a result, impacts from these sources have been greatly reduced.

Nuclear Plant Wastewater

Nuclear power plants have non-complex wastewaters that are subjected to various levels of treatment and usually discharged to surface waters. These releases are controlled through state-issued National Pollutant Discharge Elimination System permits, which are part of Federal Clean Water Act statutes. Wastewater (discharged cooling tower and steam generator recirculation water, turbine building sump, sanitary wastewater, intake screen and strainer backwash, water treatment neutralization wastes, etc.) from various plant systems is normally mixed with heated condenser cooling water before being discharged to surface water. Periodic toxicity testing is performed on this discharge as part of the National Pollutant Discharge Elimination System permit to ensure that plant effluents do not contain chemicals at deleterious levels that could affect aquatic life. In addition, storm water runoff is monitored at regular intervals as part of the National Pollutant Discharge Elimination System.

Radiological wastewater releases to surface waters are controlled by the U.S. Nuclear Regulatory Commission and plant Technical Specifications, as well as the state-issued National Pollutant Discharge Elimination System permit. A radiological monitoring program is also conducted on the body of water receiving the wastewater, fish, intake water, river sediment, and aquatic invertebrates on a routine basis.

Coal-Fired Plant Wastewater

Coal-fired plants have several liquid waste streams that are treated and released to surface waters. These releases are permitted by each state environmental agency under the National Pollutant Discharge Elimination System. Biomonitoring of wastewater is required to ensure that there are no acute toxic effects to aquatic life.

At many plants, fly ash is sluiced to an ash storage pond. The sluicing water, which is drawn from the river or reservoir serving the plant, flows continuously. Metal cleaning waste is a waste stream that may be acidic or basic. After treatment for neutralization, these wastes are also typically discharged to the ash pond for mixing with the pond water and, potentially, additional treatment. On-site treatment of domestic sewage occurs at some plants that are not connected to a local community sewage collection and treatment system. After treatment, the wastewater is typically discharged to the ash storage pond for mixing with the pond water and possible further treatment. Stormwater runoff from the plant site is also typically routed to the ash ponds, where it mixes with the ash pond water.

Rainfall and Runoff Pollutants

Non-point sources of pollution have not been subjected to government regulations or control in most cases. They contribute as much as five times more dissolved oxygen-consuming wastes than point sources. Principal causes of non-point source pollution are agriculture, including runoff from fertilizer and pesticide applications, erosion, and animal wastes; mining, including erosion and acid mine drainage; and urban runoff. Mining is necessary to extract coal and uranium used as fuel by power plants.

Air Pollution

Atmospheric deposition of air pollutants is another source of pollution affecting water quality, particularly in relation to acid rain and fallout of toxic metals, especially mercury. Section 3 in this document (Volume 2, Technical Document 1, Comprehensive Affected Environment) discusses air pollution, its effects, and TVA's contribution in some detail.

Low Dissolved Oxygen Levels

Another major water quality concern in the Tennessee River is low dissolved oxygen levels in streams below TVA dams on tributary rivers. When rivers are dammed, organic material from normal runoff, upstream pollution sources, and fallout from living organisms in the upper water levels tends to accumulate in sediments behind the dams. As this organic material decomposes, it uses up the oxygen in the overlying deep water layer. When turbines in the dam are operated to generate electricity, this low-oxygen water is released downstream, creating poor habitat for

aquatic life. TVA addressed this issue in its 1990 environmental impact statement, “Tennessee River and Reservoir System Operation and Planning Review” (TVA 1990). As a result, TVA has initiated a program to improve dissolved oxygen levels in water discharged from its dams based on this study.

To understand the causes of low dissolved oxygen levels in water released through TVA dams, it is necessary to understand the changes in temperature and dissolved oxygen content that occur in deep tributary reservoirs during a typical year. Tributary reservoirs begin to stratify (layering of the water with warmer water near the surface and cooler water near the bottom) during the spring as a result of surface heating and reduced stream flows. The dissolved oxygen content of the upper 10 to 20 feet usually remains at an acceptable level due to surface reaeration and exposure to the atmosphere and to light. Planktonic algae absorb the light and through photosynthesis produce oxygen in the water. However, oxygen levels in the lower portion decline because there is no photosynthesis in the bottom waters due to a lack of light, and they are isolated from surface reaeration. The existing oxygen is used by decaying algae and other organic matter as it settles in the water column.

Hydroelectric plants at TVA dams were designed to withdraw water from near the reservoir bottom to provide maximum flexibility for operation and maintenance of the turbines. These low level intakes maximize generating potential, and allow the hydroelectric plant turbines to operate during the winter season when reservoir levels are kept low to provide flood storage capacity, or during other times of the year under drought conditions. As a result, the water released through TVA dams in the process of hydroelectric power generation from mid-summer to early fall can contain no or low concentrations of dissolved oxygen.

In some reservoirs, discharge from the deep water layer also contributes to the release of dissolved sulfides, iron, and manganese in the tailwaters below the dams affecting water supplies and aquatic life. The presence of sulfides has been documented in the tailwaters of upper Bear Creek and Douglas Reservoirs. The presence of iron and manganese has been documented at these and other projects.

Temperatures in deep tributary reservoirs follow an annual cycle that begins with large amounts of cold, well-mixed water in storage at the beginning of spring. During the spring, surface water in the reservoir is heated, while deeper water remains at a relatively constant winter temperature. As spring and summer progress, flows enter the reservoir at an intermediate depth. Three layers form:

- The warm, stagnant surface layer
- The spring and summer interflow layer
- The cold winter layer on the bottom.

Turbine operation during the summer gradually draws off the cold water at the bottom of the reservoir. At some point in late summer or early fall, withdrawal of the colder water and gradual reduction in air temperature act in concert to again cause mixing of surface and bottom water. Completely mixed conditions last through the winter while the temperature of the reservoir is gradually lowered. The annual cycle then begins to repeat during the next spring season, when reservoirs are again filled.

GROUNDWATER

Power plants often use fuels such as coal, natural gas, and uranium. Extracting these fuels from the ground can affect the quality of groundwater. Also, ash ponds at coal-fired plants can potentially affect groundwater.

Uses

Groundwater refers to water located beneath the ground in rock formations known as aquifers. Six major aquifer areas exist in the Tennessee Valley region. One of the most important is in the Valley and Ridge Province, which is characterized by its Karst geology. Approximately half the region has limited groundwater availability because of natural geohydrological conditions. Decreasing water table levels indicate that too much water is being pumped from aquifers in the central and western portions of the region.

More than 64 percent of the region’s residents rely totally, or in part, on groundwater for potable drinking water. For every public surface water supply system, three public groundwater systems exist; but, in general, the groundwater systems serve fewer people. Over 1.7 million residents (22 percent) in the region maintain individual household groundwater systems, usually a well. All the areas in the Tennessee Valley region can generally supply enough water for at least domestic needs. Groundwater is also used by nearly 3,700 community water systems, businesses, industries, hospitals, churches, campgrounds, and schools.

Supply and Quality

Precipitation is the source of both surface water and groundwater. In an average year, precipitation across the Tennessee Valley region ranges from 40 to 85 inches, with an average of 52 inches. Water entering the groundwater system is stored in the pore spaces in unconsolidated sediments, or in fractures and solution openings in the bedrock. All groundwater in storage moves toward areas where it is discharged, such as springs, streams, and wells. Consequently, the base flow of streams is related to the amount of groundwater available. Stream baseflow is that portion of the stream flow that is sustained by groundwater, rather than rain-

fall runoff. During the dry season, when rainfall is lowest, stream flow is sustained primarily by groundwater discharging into the stream. Groundwater in relatively shallow carbonate aquifers is discharged rapidly during dry periods, causing a decline in water table levels in unconfined aquifers and thus reduced stream flow. Groundwater discharge in a normal year approximately equals the annual baseflow of streams (over half the annual rainfall runoff into streams).

For the most part, groundwater quality is sufficient to support existing water supply uses, though some minimal treatment, such as filtration and chlorination, may be required. However, no agency maintains a network of observation wells to detect groundwater contamination from routine human activities. There have been some instances of groundwater contamination in the region from improper waste disposal, coal mining activities, oil and gas exploration, agricultural activities, septic tanks, industries, coal-fired plant ash ponds, and general urbanization activities. Contamination has required closure of well and spring supplies in some areas. Toxic compounds have been found in the groundwater at some locations. The degree and extent of contamination vary from case to case.

Groundwater is naturally mineralized and exhibits variable characteristics. In some local areas, it can possibly affect health. Fluoride, for example, can exceed Interim Primary Drinking Water Standards in parts of the Highland Rim physiographic province, and hydrogen sulfide can give a "rotten egg" odor to water in other areas.

Some parameters can vary by a factor of 10 to 100 in concentration among the physiographic provinces (e.g., the sulfate concentrations in groundwater of the Blue Ridge province generally are less than 20 milligrams per liter, but in the coastal plain province, concentrations can exceed 1,400 milligrams per liter). See Section 5 in this document (Volume 2, Technical Document 1, Comprehensive Affected Environment) for a description and illustration of the physical geographic (physiographic) provinces in the TVA region.

The quality can change dramatically at a single location depending on the depth of the well, the aquifer used, and how the well is constructed. If several aquifers exist in an area, the water quality depends upon the depth of the well and which aquifer is tapped. Shallow aquifers generally have better quality than deeper aquifers because they are low in dissolved solids, soft, and only slightly acidic. Extremely deep water is generally so high in dissolved solids (brine) that it is considered unsuitable for most uses. Water that comes in contact with sandstone or shale containing pyrite can have high iron or sulfur content. Acidic water (such as rainfall) reacts with limestone and dolomite rocks to release bicarbonates, calcium, and magnesium, which tend to make the water hard and alkaline.

Bacteriological contamination of groundwater can occur in carbonate rock areas where contaminated surface drainage enters the ground through sinkholes or disappearing streams. Springs located in carbonate rock areas are particularly susceptible to contamination during storm periods, but wells can also be affected. Natural groundwater quality is generally believed good.

AQUATIC LIFE

The construction of the TVA dam and reservoir system fundamentally changed the character of the Tennessee River and its tributaries. While dams promote navigation, flood control, power benefits, and reservoir-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal, and annual patterns that are characteristic of a river (TVA 1990). Characteristics include water, sediments, nutrients, and organic material that affect the health, number, and diversity of aquatic life. Aquatic life can also be affected by runoff and erosion due to construction of power plants and runoff and acid drainage from mines to extract fuel to use in power plants.

In broad terms, aquatic life in the Tennessee River basin can be considered to exist in the three habitat types previously described, i.e., flowing streams, tributary reservoirs and tailwaters, and mainstream reservoirs. The following descriptions of these three types of environments are to a large extent general and apply to all river basins and reaches included in this study.

Flowing Streams

Small first- and second-order streams in the Tennessee Valley typically provide unstable habitat conditions. These support only those relatively few species able to survive and reproduce under such conditions. The small streams that rise in the Appalachian Mountains and the Cumberland plateau commonly have steep gradients, large rock substrates (stream beds), and cold temperatures. The aquatic community contains relatively few fish and insect species, and other types of aquatic life are rare. Rainbow, brown, and native brook trout (*Salvelinus fontinalis*) occur in these streams. These small streams rising in the Blue Ridge province of the southern Appalachian Mountains contain little carbonate alkalinity. Therefore, they have little capacity to resist pH change from acidic precipitation or other acidic inputs. Data exists to indicate decreased alkalinity through time in many of these streams. However, the actual effect of these acidification processes on the ecological quality of surface waters in the Southeast is virtually unknown. Other types of lower gradient small stream habitats seldom support aquatic life of direct use to people.

A virtual explosion in the diversity of aquatic life accompanies the perennial flow and diversity of habitats in larger creeks and small rivers. These streams flow within well-established chan-

nels with a flood plain that becomes part of the watercourse during high flows. A variety of fish, insects, crustaceans, mollusks, and other aquatic groups colonize each habitat. Over time, complex communities have evolved, including resident species and those which migrate from one habitat to another during the year or over the course of their development. Stream habitats support large sunfish (*Lepomis* spp.) and bass populations sought by sports fishermen all year, as well as other species, such as white bass (*Morone chrysops*), sauger (*Stizostedion canadense*), and suckers (*Catostomus* spp.) that are harvested during seasonal spawning migrations.

A few of the larger tributary rivers in the Tennessee Valley remain unimpounded (undammed), including the Emory, Sequatchie, North Fork Holston, and Buffalo Rivers. Also, extensive stream reaches exist above reservoirs on the Clinch, Powell, and French Broad Rivers, and there are long stretches of flowing streams below headwater reservoirs on both the Duck and Elk Rivers. These large free-flowing rivers, like their smaller tributaries, support extremely diverse aquatic communities.

Tributary Reservoirs and Tailwaters

Reservoirs on tributary rivers of the Tennessee River are typically deep storage reservoirs that retain waters for long periods of time. Little flow and regular periods of thermal stratification result in oxygen depletion in the deeper water. These aquatic habitats are simplified relative to undammed streams, and fewer species are found. However, some species relatively rare in streams (e.g., largemouth bass [*Micropterus salmoides*], gizzard shad [*Dorosoma cepedianum*]) develop large populations in these reservoirs. Other non-native fish species, such as striped bass (*Morone saxatilis*), have been introduced into some reservoirs to fill unexploited niches, producing popular sport fisheries.

Even though TVA attempts to enhance fish spawning by providing stable pool levels for a two-week period during the peak of the spring spawning season, certain aspects of reservoir operations are detrimental to fish populations in tributary reservoirs. The most productive region of a reservoir is the shoreline because of submerged vegetation for cover and organic material and aquatic invertebrates (benthos) for food. Operations that alter this reservoir margin have a variety of negative effects. Water level drawdowns for hydroelectric power production destroy cover and reduce the food supply for young-of-year fish. Drastic changes in levels due to flood control can discourage spawning, strand fish eggs on the shoreline, and leave fish in isolated pools.

Lack of minimum flows in the first few miles below tributary dams may severely limit the habitat needed by native fish. It may restrict their movement, migration, reproduction, and available food supply. On days when turbine use is intermittent, daily temperature variations of 5 to 9 degrees C (41 to 48 degrees F) are common in tributary tailwaters and can stress some fish species. Dissolved oxygen levels of less than 5 or 6 milligrams per liter affect fish growth, and levels of less than 3 or 4 milligrams per liter lead to decreased survival and poor reproduction. TVA has recently implemented a plan to improve dam tailwater conditions by maintaining minimum continuous flows and aerating releases below 16 dams to increase dissolved oxygen. TVA will also delay unrestricted summer drawdown until the first of August on 10 tributary reservoirs to improve recreation and associated economic development.

For the most part, TVA tributary reservoir releases support healthy stocked cold-water fisheries, primarily rainbow and brown trout (*Salmo trutta*). The ability of tailwaters below dams to support these fisheries is one of the positive effects of TVA reservoir system construction. The Chatuge Reservoir tailwater supports a self-sustaining wild trout population. A few tailwaters, such as those below Douglas and Cherokee reservoirs, support cool- and warm-water fisheries.

Benthic invertebrates (benthos), are a vital part of the food chain of aquatic ecosystems. Benthos refers to the wide variety of animals that live on or in the first few inches of the mud, sand, gravel, or other material that makes up the bottom of streams and lakes. Benthic life includes worms, snails, and crayfish, which spend all of their lives in or on the substrate, and aquatic insects, mussels and clams, which live there during all or part of their life cycle. They transform nutrients and organic material into biomass and provide a food base for fish and other vertebrate predators.

Most benthic organisms have specific habitat requirements in terms of physical, chemical, and biological factors. Alterations of these factors cause changes in both the composition and productivity of the benthic community. Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters. Benthic organisms generally are extremely limited in the deep portions of tributary reservoirs because of the low water flow and low dissolved oxygen. Shoreline habitat is limited because of water level fluctuations. In the tailwater areas below tributary dams, only those species survive that can tolerate low dissolved oxygen, high turbulence, and cold temperatures. Further downstream, the number of benthic species increases as natural reaeration occurs, dissolved oxygen rises, and temperatures climb.

Because most tributary reservoirs are deep and have long hydraulic retention times, they tend to follow the pattern described above. They have thermal stratification persisting during the warm months and one period of complete mixing that lasts throughout the colder months. During stratification, light and nutrients in the mixed layer combine to produce phyto-

plankton, microscopic plant life, which in turn supports a growing zooplankton microscopic animal life community. The productivity of this layer is usually limited by nutrient inflows from the watershed and varies from reservoir to reservoir.

During the period of complete mixing, nutrients and organic materials that have accumulated in the deeper water and sediments are recycled to the surface, where they promote the growth of phytoplankton. Because most of the inflowing nutrients and organics are retained in the reservoir, less are released downstream, so the tailwaters tend to be less productive than the river before it was dammed.

Mainstream Reservoirs

The nine mainstream reservoirs on the Tennessee River differ from tributary reservoirs primarily in that they are more shallow, have greater flows, and thus have much lower hydraulic retention times. They generally do not become as strongly stratified as tributary reservoirs. Although dissolved oxygen in the deeper regions of the reservoir is often reduced, it is seldom depleted. Winter drawdowns on mainstream reservoirs are much less severe than on tributary reservoirs, so bottom habitats generally remain wet all year. This benefits benthic organisms and promotes the growth of aquatic plants in the extensive shallow overbank areas of some reservoirs. These plants benefit fisheries by providing cover and nursery habitat, but create extensive mosquito breeding areas and have led to conflicts among fishermen, boaters, and shoreline landowners whose access to the water is limited by thick vegetation.

The lack of stratification in mainstream reservoirs creates a habitat where plankton are constantly cycled into and out of the zone with sufficient sunlight for growth. This creates some of the same inhibitions on growth that limit plankton production in large undammed rivers. Ordinarily, however, these factors are sufficiently muted to permit sufficient plankton growth to support healthy aquatic communities. Phytoplankton growth in Tennessee River mainstream reservoirs is more likely to be limited by light than by nutrient availability.

Since oxygen depletion near the bottom is rare, benthic communities occur in the mainstream reservoirs. However, species diversity is low in comparison to the rivers before reservoirs were formed. Benthic communities in mainstream reservoirs tend to be dominated by midge larvae, aquatic worms, mayflies, mussels, and sometimes caddisflies and snails.

The effect of dams on benthic species diversity is most readily apparent in mussels. Because of their long lives, sedentary nature, and tendency to occur clumped in areas of suitable habitat, mussels are highly vulnerable to disruptions of habitat or changes in environmental factors. Prior to the formation of reservoirs, the Tennessee River and its tributaries supported a large and diverse mussel fauna. Damming the rivers reduced the amount of suitable habitat (shallow, flowing water over stable gravel or cobble bottom). Today, there are only about 175 miles of suitable mussel habitat in the Tennessee River. This represents 27 percent of what once existed. Nearly all of this is located in Guntersville, Wheeler, Pickwick, and Kentucky reservoirs, where commercial musseling is still carried on. Pollution, sedimentation, and commercial overharvesting have adversely affected mussel stocks that survived the destruction of habitat due to dams. Recent investigations indicate that mussel stocks in the main river and most tributaries are continuing to decline. Mussel species dominate the list of threatened and endangered species in the Tennessee Valley.

The Asiatic clam *(Corbicula fluminea)* was introduced into the Tennessee river from the West Coast during the 1950s. It is now a major component of the benthic community throughout the Tennessee system and has been implicated as a fouling agent in water intake structures.

A more recent and potentially more troublesome invader is the zebra mussel *(Dreissena polymorpha)*, which recently reached the Tennessee River via barge traffic from the Great Lakes area, where it was introduced from Eurasia in the mid-1980s. Zebra mussels are now present in low numbers throughout the length of the river and are likely to increase in numbers during the next few years. Because of their tendency to attach in large numbers to firm substrates, zebra mussels have enormous potential for biofouling (clogging) power plant water intakes and other systems that use raw water. It is estimated that zebra mussels will cost water users in excess of $5 billion in the Great Lakes area alone by the year 2000. Zebra mussels will be a major factor in future decisions regarding the type and location of any new water-using facilities in the TVA region.

Tennessee River mainstream reservoirs generally support healthy fish communities, ranging from about 50 to 90 species per reservoir. There are good to excellent sport fisheries, primarily for black basses (*Micropterus* spp.), crappie (*Pomoxis* spp.), sauger (*Stizostedion canadense*), white (*Morone obrysops*) and striped basses (*Morone saxatilis*), sunfish (*Lepomis* spp.), and catfish (*Ictalurus* spp.). The primary commercial species are channel (*Ictalurus punctatus*) and blue catfish (*Ictalurus furcatus*) and buffalo (*Ictiobus* spp.). Fish consumption advisories have been issued for some reservoirs, notably Wheeler for DDT contamination and Nickajack, Watts Bar, and Fort Loudoun for PCB contamination.

Cumberland River

The Cumberland River is formed by the junction of the Poor and Clover Forks in Harlan County, Kentucky, about 693 miles above its confluence with the Ohio River near Smithland, Kentucky *(Figure T1-63)*. The river flows westerly, then southwesterly into Tennessee. At Nashville it turns northwesterly back into Kentucky, emptying into the Ohio River about 58.5 miles upstream of the junction of the Ohio and Mississippi rivers. The drainage area of the Cumberland is 17,598 square miles. A system of locks and dams makes the Cumberland commercially navigable (maintained 9 foot channel) from the Ohio to mile 381.0 at Celina, Tennessee. TVA operates two fossil plants on the Cumberland, Gallatin on Old Hickory Lake and Cumberland on Barkley Lake. The hydroelectric plant at Great Falls Dam on the Caney Fork is also part of the TVA system.

The Nashville District United States Army Corps of Engineers operates nine multi-purpose reservoirs which incorporate hydroelectric production facilities on the Cumberland River and tributaries. Approximately half the power production from eight of these projects is marketed through the Southeastern Power Administration to TVA. The Corps of Engineers does not anticipate any significant changes in these power resources. The Corps of Engineers has, however, completed a hydropower optimization feasibility study at Lake Cumberland which focused on uprating the existing six units at Wolf Creek Powerhouse for peaking operation. On the middle Cumberland River reservoir regulation integrates the need for adequate cooling water at TVA's Gallatin and Cumberland City Fossil Plants on Old Hickory Lake and Lake Barkely, respectively. In addition, the Corps of Engineers has performed a preliminary analysis of pumpback at Laurel Lake on the Upper Cumberland River.

SURFACE WATER

The Cumberland River and its tributaries generally exhibit moderate to high concentrations of calcium and magnesium and a slightly alkaline pH because much of the basin is comprised of limestone and dolomitic bedrock. Total dissolved solids concentrations, a measure of all salts in solution, range from 1.0 to 100 milligrams per liter (mg/L) in the upper Cumberland, upstream of Nashville. These low values contrast with the generally higher concentrations of dissolved solids in the lower Cumberland watershed, in particular the mainstream river downstream of Nashville (U.S. Army Corps of Engineers 1975). There total dissolved solids concentrations range from 100 to 300 milligrams per liter. These increased concentrations are due in part to a change in rock formation in the Nashville area. The area east of Nashville is underlain by Ordovician Age limestones and shales, which is more resistant and less soluble than the Mississippian Age limestones, found in the area west of Nashville. The first is more resistant and less soluble than the latter.

Generally, the mainstream Cumberland River exhibits lower suspended solids concentrations than its tributaries. Suspended solids in the mainstream and in the upper Cumberland watershed tributaries usually range in concentrations from 0 to 300 milligrams per liter. The lower Cumberland watershed tributaries, west of Nashville, are characterized by higher suspended solids concentrations ranging from 300 to 2,000 milligrams per liter. The higher values in the lower Cumberland watershed tributaries are caused in part by differences in soils and rock formation. The Mississippian materials of the lower watershed are generally more erosion prone than the Ordovician materials of the upper watershed. Topography and land usage also influence the erodibility of the lower Cumberland tributary valleys.

Erosion due to runoff in the lower Cumberland watershed is the primary source of the suspended solids described above. Shoreline and stream-bank erosion are also thought to be major contributors of silts and clays. The generally lower suspended solids levels in the mainstream river result from dredging for the navigation channel of the river. This has created areas of reduced velocity and formed deposits of sediment. Sediment deposition also occurs in the upper Cumberland flood control reservoirs, upstream of the study area. Wolf Creek Dam, Dale Hollow Dam, Center Hill Dam, and J. Percy Priest Dam trap large amounts of suspended solids and sediments, and discharge waters with relatively low suspended solids levels into areas downstream.

GROUNDWATER

The formations that comprise the Mississippian carbonate aquifer in the Highland Rim and the Ordovician carbonate aquifer in the Central Basin of the Cumberland River basin are primarily limestone and dolomite, with small amounts of shale. Water in these carbonate aquifers occurs in solution-enlarged openings and resides in confined-to-partly-confined space near the land surface. It can also be confined at depth in aquifers. These aquifers are important sources of drinking water for rural users and some public supplies.

The Mississippian carbonate and Ordovician carbonate aquifers are connected to land surface by caves and sinkholes in many areas and are susceptible to contamination. In general, the water hardness exceeds 200 milligrams per liter as calcium carbonate. In the Highland Rim, iron and sulfate concentrations in water from the Mississippian carbonate aquifer may exceed 0.30 and 500 milligrams per liter, respectively. The odor of sulfide is detectable in water from some wells.

AQUATIC LIFE

The Cumberland River is in most important ways similar to the Tennessee River in both its natural characteristics and the ways in which it has been developed and altered. Aquatic habitats and aquatic life characteristics are also similar, and the previous general discussion of flowing streams and the effects of reservoirs on aquatic communities in the Tennessee River basin is also applicable to the Cumberland River system. In the mainstream Cumberland River area, studies of aquatic life have been generally geared to sport fisheries, stocking programs, and species of commercial importance. Fish studies are more complete than evaluations of aquatic habitats or invertebrate species. Compositional and community studies on the Cumberland River are qualitative at best.

Early studies of the wild river indicated a much varied habitat depending on the area through which the river passed. Mountainous areas in the upper basin were characterized by waterfalls, riffles, and limestone banks. The river was generally shallow except during high flow seasons. As the Cumberland passed through the flatter terrain of the mid and lower watershed region, waterfalls became less impressive in size, but riffle and ravine character continued. Wetlands and broad floodplains generally characterized the Cumberland from Nashville downstream to the mouth.

The formation of reservoirs caused numerous changes in the aquatic life of the Cumberland River. These changes, however, are not well documented in the scientific literature. Community, distribution, and inventory studies after the formation of reservoirs are lacking for the remaining free-flowing portions of the river. Site-specific aquatic biological surveys have been done by TVA at Cumberland and Gallatin fossil-fuel plants and at the site of the canceled Hartsville Nuclear Plant.

The tributary reservoirs of the Cumberland River basin are similar to the tributary reservoirs described for the Tennessee River. Laurel River Lake, Lake Cumberland (Wolf Creek Dam), Dale Hollow Lake, and Center Hill Lake are deep, steep-sided reservoirs with substantial winter drawdowns. J. Percy Priest Lake is somewhat shallower with more sloping shorelines.

Laurel River Lake supports a good trout and walleye (*Stizostedion vitreum*) fishery. Lake Cumberland has a good fishery for black bass (*Micropterus* spp.), striped bass (*Morone saxatilis*), and walleye (*Stizostedion vitreum*). Center Hill lake also supports a good black bass (*Micropterus* spp.) and striped bass (*Morone saxatilis*) fishery. Dale Hollow is world-famous for its smallmouth bass (*Micropterus dolomiou*) fishery. It also maintains a good lake trout (*Salvelinus namaycush*) fishery. J. Percy Priest Lake continues to provide a good fishery for black bass (*Micropterus* spp.), striped bass (*Morone saxatilis*), crappie (*Pomoxis* spp.), and bluegill (*Lepomis macrochirus*) despite very heavy fishing pressure.

The cold tailwaters of Laurel River Lake, Lake Cumberland, Dale Hollow Lake, and Center Hill Lake provide good to excellent rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) fisheries. Striped bass (*Morone saxatilis*) are stocked below J. Percy Priest Dam, providing one of the best-noted and most-fished resources in the region, especially when discharge rates are high.

The Cumberland River mainstream reservoirs are similar to their counterparts on the Tennessee River. Cordell Hull Lake is relatively deep and subject to cold-water inflows that contribute to a spotty sport fishery. The upstream portion of the lake maintains an excellent but not well-known and consequently underutilized trout (*Salvelinus namaycush*) and walleye (*Stizostedion vitreum*) fishery, as well as a good striped bass (*Morone saxatilis*) fishery. The downstream portion of the lake is intermediate in terms of temperature, and thus not ideal for either warm-water or cold-water fish species, although a fair largemouth bass (*Micropterus salmoides*) fishery exists in the embayment areas. Old Hickory and Cheatham Lakes have good fisheries for black bass (*Micropterus* spp.), crappie (*Pomoxis* spp.), and bluegill (*Lepomis macrochirus*). Lake Barkley is similar to Kentucky Lake on the Tennessee River, and the two are connected by a short canal near the two dams. Both lakes are nationally famous for their black bass (*Micropterus* spp.) and crappie (*Pomoxis* spp.) fisheries. Barkley also supports good populations of white bass (*Morone chrysops*), bluegill (*Lepomis macrochirus*), and blue (*Ictalurus furcatus*) and channel (*Ictalurus punctatus*) catfish.

Ohio River

The lower Ohio River receives drainage from an extensive 204,000 square-mile watershed that reaches into 13 states, encompassing much of the east central United States. The upper Ohio Valley is highly industrialized, and the sources of pollution from industrial and municipal sources are many and varied. Non-point source pollution, primarily from agricultural runoff and mining, also contributes to the sediment and pollution load. A series of locks and dams allows commercial navigation along the entire 981-mile length of the river from the Mississippi River to Pittsburgh, Pennsylvania. About 136 million metric tons of freight are transported on the Ohio annually. TVA's Shawnee Fossil Plant is located on the Ohio River just downstream from Paducah, Kentucky.

SURFACE WATER

The Ohio River supplies more than one-half of all surface water withdrawn in the state. It forms the northern boundary of Kentucky for a distance of 664 stream miles. The river system drains an area of 33,300 square miles in Kentucky (about 82 percent of the state). Identifying sources of contamination in such a large basin is difficult. The Ohio River Valley Water Sanitation Commission is responsible for evaluating water quality in the mainstream.

GROUNDWATER

The alluvial aquifer, an aquifer which exists in material deposited by flowing water, along the Ohio River is by far the most intensively used aquifer in Kentucky. Many towns and industries located along the river depend upon large surface supplies from the river and on groundwater supplies from shallow wells in the alluvium. Properly constructed wells near the river can induce infiltration of stream flow, which ensures dependable supplies. The quality of water in the alluvium generally is suitable for most uses but may require treatment for excessive hardness and iron for some uses. Hardness commonly exceeds 300 milligrams per liter as calcium carbonate, and iron commonly exceeds 1 milligram per liter. Contamination of the aquifer by wastes from industrial sites and from landfills and septic tank systems in urban areas poses the most serious water quality-related problem. High groundwater levels are a potential problem in the Louisville area, where water levels are just a few feet below structures in some places.

AQUATIC LIFE

The lower Ohio River is a large river habitat, often turbid or cloudy, with swift currents. Bottom substrates or stream beds are often rocky near shore, with cobble, gravel, and sand in the channel. The benthic community includes a substantial mussel population in certain areas, which is threatened by zebra mussels. Zebra mussels are now found in large numbers throughout the lower Ohio River. A very high percentage of native mussels from Smithland Dam to the Mississippi River have been found to have zebra mussels attached to their shells. Large numbers of attached zebra mussels interfere with the feeding and movement of native mussels. In other areas, they have resulted in the virtual elimination of native mussel populations.

New dams on the lower Ohio (i.e., Newburgh, Uniontown, and Smithland) have created reservoirs on that section of the river. These reservoirs have in turn created additional flooded brush and timber habitat, as well as small embayments in the lower portions of tributary streams. The fishery for black bass (*Micropterus* spp), crappie (*Pomoxis* spp.), and bluegill (*Lepomis macrochirus*) has been greatly enhanced by this additional habitat. The tailwaters of these dams provide outstanding fisheries for striped bass (*Morone saxatilis*) and sauger (*Stizostedion canadense*).

Fish consumption advisories have been placed on paddlefish (*Polyodon spathula*), paddlefish eggs (harvested for caviar), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and white bass (*Morone obrysops*) along the entire length of the Ohio River bordering Kentucky because of chlordane, a pesticide, and PCB contamination. Little Raven Creek, a tributary below Paducah, has a consumption advisory for all fish species due to PCB contamination. Also, the West Kentucky Wildlife Management Area Lakes, which are oxbow and overflow lakes that drain into the Ohio River below Paducah, have a consumption advisory for largemouth bass (*Micropterus salmoides*) because of mercury contamination.

Green River

The Green River Basin is located in south central Kentucky and north central Tennessee. The drainage area is 9,273 square miles, of which 377 are in Tennessee. The Green River rises in Lincoln and Casey Counties in Kentucky and flows generally westward for 330 miles to its confluence with the Ohio River just upstream from Henderson, Kentucky. A system of seven locks and dams enables navigation on the downstream portion of the Green River.

The upper basin is characterized by rugged, hilly terrain. The central part of the basin drains the Karst region, an area that is interlaced with large cave systems. The Karst region includes Mammoth Cave National Park. In the Karst region, surface streams are almost non-existent. Most of the water drainage is subterranean, eventually draining to the Green River via large springs. The lower basin consists primarily of alluvial plains. TVA's Paradise Fossil Plant is located on the Green River about 100 miles from the mouth.

SURFACE WATER

The Green River basin contains about one-fourth of Kentucky's land area and is the largest drainage basin in the state. Reservoirs have been constructed by the U.S. Army Corps of Engineers on the Rough, Nolin, and Barren Rivers, as well as on the mainstream of the Green River in the upper basin. The topography in this section of the Interior Low Plateaus is characterized by gently rolling terrain underlain by limestone in the upper basin and hills and broad flood plains underlain by sandstone, shale, and coal in the lower basin. Land uses in the upper basin include agriculture, urban areas, and mining or drilling. Major sources of stream contamination in the upper basin are agriculture

(sediment, nutrients, and pesticides); mining or drilling (chloride); on-site and municipal wastewater-treatment systems (decomposable organic matter, nutrients, and bacteria); and urban stormwater runoff (toxic metals, nutrients, and sediment).

Concentrations of chloride in the upper basin of the Green River are higher than those recorded at other locations in the basin and have been associated with brines from oil production. However, dissolved solids concentrations in the upper basin were not high relative to those in other Kentucky streams. Concentrations of sulfate, another major component of dissolved solids were low in samples collected during 1987-89. The relatively high median concentrations of nitrite (0.87 milligrams per liter) and suspended sediment (27 milligrams per liter) were among the highest for Kentucky's monitoring locations. The high values possibly were due to agricultural and urban runoff and municipal wastewater discharges.

GROUNDWATER

The Pennsylvanian aquifer system in the Green River basin is in the coal mining regions of eastern and west central Kentucky. Wells tapping these aquifers are used for domestic and livestock supplies.

Concentrations of dissolved solids in water from the shallow groundwater circulation zone of the Pennsylvanian aquifer system in eastern Kentucky generally do not exceed the drinking water standard. The water is moderately hard, with only about 25 percent of the hardness values being larger than 120 milligrams per liter. The water generally contains iron in excess of the secondary drinking water standard. Concentrations of chloride generally are smaller than 110 milligrams per liter, and 90 percent of the nitrate concentrations are smaller than 1.2 milligrams per liter.

Water from the Pennsylvanian aquifer system in west central Kentucky generally contains dissolved solids concentrations larger than 500 milligrams per liter. Water from these aquifers is hard to very hard—the median hardness is 120 milligrams per liter. Concentrations of iron generally are larger than 300 micrograms per liter, and chloride concentrations normally are smaller than 60 milligrams per liter. Concentrations of nitrate are larger in the western Kentucky Pennsylvanian aquifers than in the eastern Kentucky Pennsylvanian aquifers. In the western Kentucky aquifers, 25 percent of the nitrate concentrations are larger than 1.2 milligrams per liter, compared to 10 percent for the eastern Kentucky Pennsylvanian aquifers.

The coal mining regions of eastern and western Kentucky are being mined and extensively explored for oil and gas reserves. Water samples from deep oil-test wells commonly are salty.

AQUATIC LIFE

The four reservoirs in the Green River basin are headwater reservoirs. They generally possess the same characteristics in terms of depth, stratification, water level fluctuations, and impacts on aquatic communities as the tributary reservoirs described in the Tennessee River basin. In addition to these reservoirs, there are also six navigation locks and dams on the Green River and one on the Barren River. These are virtually run-of-the-river dams and appear to stabilize the river substrate or stream beds and protect aquatic life.

Green River contains a varied habitat which supports 146 fish species representing 22 taxonomic families. Additionally, Green River contains a diverse benthic community including a number of mussel species. Some of the upper basin tributary streams and reservoir tailwaters support good sport fisheries for rainbow (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Additionally, a good muskellunge (*Esax masquinongy*) fishery exists in the central and upper basins in both reservoirs and major streams. The reservoirs and the larger streams in the lower basin provide good warm-water fisheries for largemouth bass (*Micropterus salmoides*), white crappie (*Pomoxis* spp.), blue (*Ictalurus furcatus*) and channel catfish (*Ictalurus punctatus*), and bluegill (*Lepomis macrochirus*).

The major source of pollution in the Green River Basin is mining in the western coal-fields region of the lower basin. The river is very turbid or cloudy due to runoff from these coal fields and extensive barge traffic. Other sources of pollution in the basin include municipal wastewater-treatment plants and agricultural runoff. Two streams in the basin currently have fish consumption advisories in place for PCB contamination: Drakes Creek from the city of Franklin to the Barren River, and Mud River from the city of Russellville to the Green River.

Mississippi River

The lower Mississippi River in the reach that borders west Tennessee is one of the largest rivers in the world. Its drainage basin includes nearly all of the United States between the Rocky Mountains and the Appalachian Mountains. The drainage basin is 1,247,000 square miles and includes the nation's most productive industrial and agricultural regions. Ships can travel the river for more than 1,800 miles from Minneapolis, Minnesota, to the Gulf of Mexico. TVA operates the Allen Fossil Plant on the Mississippi River at Memphis, Tennessee.

SURFACE WATER

The Mississippi River has an average daily discharge of 312,000 million gallons per day at Memphis, Tennessee, and 377,000 million gallons per day at Vicksburg, Mississippi. In general, the quality of water in the Mississippi is suitable for most uses. The median concentrations of alkalinity (106 milligrams per liter), sulfate (55 milligrams per liter), dissolved solids (239 milligrams per liter), and nitrite plus nitrate (1.2 milligrams per liter) were much less than the federal criteria for untreated drinking water supplies. About half of the sulfate in the Mississippi River is due to runoff over weathered rock, and the other half is due to biochemical processes and human activities.

GROUNDWATER

The most extensive and productive aquifer in Tennessee is the Tertiary sand, along the Mississippi River, which supplies about 190 million gallons of water per day to the city of Memphis. Calcium bicarbonate-type water from this confined aquifer has small concentrations of dissolved solids (90 percent of analyses are less than 163 milligrams per liter), and is generally soft (median hardness is 39 milligrams per liter). The only major water quality problem is a large iron concentration, which requires that the water be treated before use. The median iron concentration is 600 micrograms per liter.

There is concern, however, that leakage of contaminated water from the overlying alluvial aquifer may degrade water quality in the Tertiary sand. In addition, several hazardous waste sites are located in recharge areas of this important aquifer.

The chemical characteristics of water in the shallow (less than 200 feet below land surface) Mississippi River alluvial aquifer are fairly uniform throughout the aquifer. A chemical quality change occurs gradually, with depth as the result of ion exchange and other natural geochemical processes. Dissolved solids concentrations and pH values of water at depths of about 100 feet or less in recharge areas may be much smaller than 100 milligrams per liter and 7 standard units, respectively.

AQUATIC LIFE

The lower Mississippi River is turbid and swift, with shifting sand and silt substrates or stream beds that are not conducive to colonization by benthic organisms. Commercial fishing occurs on the Mississippi, primarily for catfish (*Ictalurus* spp.) and buffalo (*Ictiobus* spp.). Zebra mussels now occur throughout the Mississippi River. A significant sport fishery for largemouth bass (*Micropterus salmoides*), crappie (*Pomoxis* spp.), and bluegill (*Lepomis macrochirus*) exists in the numerous cutoffs, oxbows and backwater sloughs found in this section of the river. A fish consumption advisory for chlordane contamination is in effect for all fish species in the Mississippi River adjacent to Shelby County, Tennessee (Memphis), and McKellar Lake, Wolf River, Loosahatchie River and Nonconnah Creek, which are tributaries to the Mississippi River in Shelby County.

Water Quality Indices and Rationale for Weightings

TVA's existing energy resources and many of the energy resource options considered for Energy Vision 2020 can affect water quality. The primary impact categories evaluated for Energy Vision 2020 include: human health by ingestion, water supply and waste assimilation, and fish and aquatic life and biodiversity. A full explanation of the process used to develop measures for environmental evaluation criteria can be found in Volume 2, Technical Document 4, Evaluation Criteria.

Water Quality Indices

Water quality indices were developed to help characterize how TVA power system operations might contribute to each of the impact areas selected. The indices provide measures to evaluate environmental impacts of alternative future energy supply strategies. Measures in the indices are weighted by the relative contribution of TVA power system operations to water quality impacts and issues.

Eight measures of power system operation that affect water quality are used to evaluate the three impact areas. There are two direct measures: water consumption and water use. Six surrogate measures were used: coal burned; heat releases to surface water; power production by coal-fired, nuclear, and hydroelectric plants; and the number of new power plants constructed. A surrogate measure is a substitute measure that varies in the same way as the pollutant it represents. The uses of these eight measures in the index and their weighting factors are given in the table in *Figure T1-66*.

HUMAN HEALTH–INGESTION

The discharge of toxic metals in waste streams from coal-fired power plant sites presents the greatest potential risk to health from ingestion (eating or drinking) and is estimated at 50 percent of TVA's effects. These discharges are made directly to water bodies that supply drinking water for humans and livestock and serve as habitats for aquatic organisms. As a result, toxic metals can become concentrated in fish tissue.

FIGURE T1-66. **Weighting Factors for Water Quality Evaluation Measures Used in Three Impact Area Indices**

Environmental Measure	Health Ingestion	Water Supply and Waste Assimilation	Fish and Aquatic Life and Biodiversity
Heat Releases to Surface Water		0.10	0.05
Water Consumption		0.10	
Water Use			0.03
Coal Burned			0.20
Nuclear Power Production	0.05		0.02
Coal Power Production	0.60		0.05
Hydroelectric Peaking Power Production	0.35	0.80	0.60
New Power Plants Constructed			0.05

For effects on human health, the hazards of atmospheric deposition are considered low and are estimated at 10 percent of total human health-ingestion effects. Mercury in flue gases is the contaminant of main concern. Its concentration in the gas is small, and atmospheric dispersion decreases the concentration further. A secondary consideration is acid rain effects on water bodies resulting in the mobilization of metals in lakes and streams. This is not an important issue in the TVA region, however, because the geology of most of the region, with the exception of some Appalachian Mountain areas, provides ample buffering capacity to resist changes in pH. The surrogate measure for coal-fired power plant effects is millions of kilowatt-hours of coal-fired production. The weighting for the combined effects discussed above is 60 percent or a factor of 0.60.

Hydroelectric power plant discharge of metals released from sediments is second in importance for effects on human health due to ingestion of toxic metals and is estimated at 35 percent of total human-health effects. It is assigned a weighting factor of 0.35. It is second to coal-fired plant releases because it is likely to contain a smaller variety of metals and would only be important at tributary dams during summer months. Biomagnification may be a more important pathway for ingestion in this situation because the entire flow of the river may be contaminated, as opposed to a contaminant plume that organisms could avoid. The surrogate measure for hydroelectric plant effects is millions of kilowatt-hours of peaking hydroelectric production.

Because of the relatively small quantities of metals and the minute quantities of radionuclides present in nuclear plant discharges, the effect on human health by ingestion is estimated at only 5 percent (weighting factor of 0.05) of the total TVA effects. The surrogate measure for nuclear plant effects is millions of kilowatt-hours of nuclear plant production.

WATER SUPPLY AND WASTE ASSIMILATION

The primary effects on water supply and waste assimilation result from operation of hydroelectric plants. Operations alter the flow regime of the river downstream, both reducing flows and dissolved oxygen concentration at certain times. This effect is estimated at 80 percent (weighting factor of 0.80) of total TVA effects on water supply and waste assimilation and is measured by millions of kilowatt-hours of peaking hydroelectric power production. Coal-fired and nuclear power plants consume water and release heat to surface water. Water consumption adversely affects both water supply and waste assimilation, whereas heat releases only affect waste assimilation. These effects are very minor compared to the effects of altering the flow of the river and are each estimated at 10 percent (weighting factor of 0.10) of the total TVA effects. Water consumption (millions of gallons) is a direct measure, and the heat release rate (billions of Btu) is the surrogate measure for thermal effects.

FISH AND AQUATIC LIFE AND BIODIVERSITY

TVA's action in damming the Tennessee River and its tributaries to generate power, control floods, and allow navigation primarily affects aquatic life in surface waters by changing water quality and aquatic habitats. These effects are most pronounced in tributary tailwaters where altered flow patterns from hydroelectric plant releases result in dramatic reductions in numbers and kinds of aquatic life. Because these releases commonly are drawn from near the bottom of the reservoir, they cause tailwaters to be colder, lower in dissolved oxygen, and higher in toxic materials derived from sediments than undammed portions of the stream. This combination of factors is estimated to account for about 60 percent (weighting factor of 0.60) of power generation-related effects on aquatic life. The best surrogate measure would be one proportional to the amount of hydroelectric plant operation on the rivers most vulnerable to these effects. This led to the choice of millions of kilowatt-hours of peaking hydroelectric plant production.

The next most important category of effects on aquatic life is associated with the fuel cycle, specifically habitat destruction from the mining of coal and the effects of runoff from mines. These effects are widespread and difficult to quantify, but are estimated to account for about 20 percent (weighting factor of 0.20) of all TVA power system aquatic life impacts. The best surrogate measure for such effects is tons of coal burned in the pro-

duction of electric power. This should be directly proportional to mining activities.

Coal-fired generated power is estimated to account for about 5 percent of aquatic ecosystem effects. Liquid discharge from coal-fired plants, including those from ash storage and disposal, and effects of materials reaching surface waters through fallout and rainout of air pollutants are the primary factors involved. The best surrogate measure of these effects is millions of kilowatt-hours of coal-fired generated power.

The effects of releases of heated water on aquatic life were once expected to be important, but experience has shown that not generally to be the case. Releases of heated water are judged to contribute 5 percent of the overall aquatic effects by TVA, and to be best measured in gross terms by the total amount of heat released to the river from TVA coal-fired and nuclear power plants.

A related effect is drawing plankton and fish through equipment or injuring or killing them by causing them to collide with intake screens when cooling water is being drawn from the river or lake. This has been shown to cause only minor local effects (about 3 percent of the total TVA effects) on fish and aquatic life and biodiversity and is best measured by the total amount of water used by TVA power plants.

Localized effects of power-related construction activities, such as new or modified plants or transmission facilities, are considered to be minor, perhaps 5 percent, measured by the number of new plants built. Non-thermal discharges of radionuclides and miscellaneous chemicals from nuclear power plants are also relatively minor, with a 2 percent estimated weighting factor, measured by millions of kilowatt-hours of nuclear power generated.

SECTION 5: LAND RESOURCES

Introduction to Land Resources and Problems

The TVA region encompasses some 58 million acres. Of this area, non-federal rural land occupies about 50 million acres. Some of the most diverse and beautiful natural resources in the United States are in this seven-state region.

With few exceptions, virtually the entire Tennessee Valley and its adjacent region have been affected by human influences through agriculture, timber harvesting, or other land uses. Over half the Tennessee Valley region is forest lands and about 35 percent is in agricultural land uses. The remaining area is composed of open water, urban areas, and other miscellaneous land uses.

This section contains information about geology and groundwater, agricultural land, forest resources, biological resources, Class I areas, cultural resources, recreational resources, and other land uses.

Geology and Groundwater

The potential of power plants to affect the quality of groundwater is discussed in Section 3 of this document (Volume 2, Technical Document 1, Comprehensive Affected Environment). Groundwater occurs in aquifers of porous soils, sediments, and in fractures and openings of rock formations. Groundwater movement in the region ranges from very slow to very rapid and is completely dependent on site-specific hydrogeology. The distribution of groundwater in the TVA region is influenced by variability in geology, hydrology, and topography among six different physiographic regions.

PROVINCES OF PHYSICAL GEOGRAPHY

The map in *Figure T1-67* shows the TVA region's areas of physical geography. Physical geography determines the location and types of aquifers containing groundwater and the susceptibility of groundwater to various forms of pollutants. Erosion and pollutant runoff into streams are related to physical geography and soil type when power plants or other facilities are built. These aspects will be considered in environmental reviews when a site is chosen for a power plant.

The easternmost part of the region is in the Blue Ridge physiographic province, an area composed of the remnants of an ancient mountain chain. This region has a greater variation in terrain than any other region in the Tennessee Valley. Terrain ranges from nearly level along floodplains to rugged mountains that reach elevations of more than 6,000 feet. The rocks of the Blue Ridge have been subjected to much folding and faulting and are mostly shales, sandstones, conglomerates, and slate (sedimentary and metamorphic rocks of Precambrian age). A few areas, such as Cades Cove, in the Great Smoky Mountains National Park, are underlaid by carbonate rocks that contain large amounts of groundwater in solution openings. In most places, the dense, massive bedrocks contain little groundwater except where they have faulted and fractured.

Located east of the Cumberland Plateau and west of the Blue Ridge province, the Valley and Ridge province has complex folds and faults with alternating valleys and ridges trending northeast to southwest. Ridges have elevations of up to 3,000 feet and are generally capped by dolomites and resistant sandstones on the west sides, while valleys have developed in more soluble limestones and dolomites. The dominant soils in this province are residual clays and silts derived from in-situ weathering. Groundwater occurs mostly in the solution-widened fractures, joints, and bedding planes. Karst features such as sinkholes and springs are numerous in the Valley and Ridge. ("Karst" refers to a type of topography that is formed in carbonate rocks by dissolution and that is characterized by sink holes, caves, springs, and underground drainage.)

The Cumberland Plateau rises about 1,000 to 1,500 feet higher than the adjoining Valley and Ridge Province and Highland Rim. It extends about 175 miles, ranging northeast to southwest across central Tennessee. The bedrock is a sequence of near horizontal Pennsylvanian sandstones, shales, conglomerates, and coals, underlaid by Mississippian and older shale and carbonates. The area underlaid by the resistant Pennsylvanian sandstones has produced a "table-top" landscape. Groundwater usually occurs in areas of shallow, sandy soils and in deeper cracks in the bedrock. At depth, the Mississippian carbonates possess mature Karst features. Sinkholes, large caves, sinking streams, and springs typify the landscape, resulting in a complex aquifer system. Rapid groundwater movement is typical.

The Highland Rim section of the Interior Low Plateaus province presents a gently rolling plateau that occupies much of central Tennessee and parts of Kentucky and northern Alabama. The bedrock of the Highland Rim is flat-lying Mississippian carbonates. These formations constitute the most extensive aquifer in the Tennessee region. The Mississippian formations weather to form a deep flinty overlay typically exhibiting a rubble zone at the interface of the soil and bedrock. In places this overlay may rest directly on Chattanooga shale, which

serves as an aquitard. In many places the carbonate bedrock transports groundwater rapidly. However, in the broad dissected highlands, streams barely cut into the overlay and therefore have little effect on the discharge of water.

The Central Basin (Nashville Basin) of the Interior Low Plateaus province is an oval area in middle Tennessee lying about 200 feet below the surrounding Highland Rim. The bedrock is carbonate rocks that are generally flat-lying but are locally folded. Soil cover is usually thin, and surface streams cut into bedrock. Groundwater usually occurs in areas of carbonate rock that have been dissolved by water and in cracks in bedrock. The lack of unconsolidated overlay, along with open joints in rock, allows rapid runoff and infiltration of precipitation. Water is briefly stored above stream level and rapidly discharged to streams and springs through solution openings. As a result, small streams respond quickly to precipitation and have poorly sustained base flows.

The Coastal Plain province extends along the western edge of the region, and the Tennessee River flows along the eastern boundary against the edge of the Highland Rim. The major aquifers of the Coastal plain section lie in unconsolidated formations. They are of alluvial origin and consist of a heterogeneous assemblage of gravels, sands, silts, and clays. Occurrence of groundwater in the alluvial aquifers depends, in part, on the thickness of the formation and hydraulic characteristics of media composing the aquifer.

SOILS

A complex and diverse mosaic of soils reflects the great contrasts in geology and topography in the TVA region. Typically, the valley and river bottom soils are quite fertile and are used primarily for agriculture. In contrast, the forested ridges and mountains often have soils which have been highly leached and are therefore less fertile.

Impacts/Acidic Deposition and Deposition of Nitrogen

Current levels of acidic deposition are not thought to have significant impacts on the soils of the TVA region, with the exception of those in the higher elevations in the eastern portion of the region (Irving, 1991). TVA's contribution to acidic deposition is discussed earlier in Section 2 of this document (Volume 2, Technical Document 1, Comprehensive Affected Environment). Higher inputs of acidic deposition could accelerate depletion of base nutrients beyond the soil's natural ability to replenish them in soils with low buffering capacities and nutrient levels. Nutrient deficiencies could eventually occur and adversely impact forest productivity. As soil acidifies, toxic metals, such as aluminum, become more mobile and can damage plant roots. Fish and other aquatic life may be affected when aluminum is leached from the soil into surface waters. Other metals such as lead, cadmium, and zinc are also considered toxic and may be mobilized as soil acidification continues. Soil acidification and its associated impacts are of particular concern in the Great Smoky Mountains National Park, located in the eastern portion of the Energy Vision 2020 study area, and in Class I wilderness areas.

In some instances, acidic deposition can be beneficial to soils and plants through its fertilizing effects. Sulfur and nitrogen, essential plant nutrients, are often found in limited concentrations or unavailable forms in the soil. Studies have shown that atmospheric inputs of these elements can meet specific crop needs. Nitrogen, an essential element required by all plants will generally have a positive impact in most Tennessee Valley forests; however, it can become detrimental when present in excessive amounts, especially in high elevation forests. Excess nitrogen in high elevation forests can trigger adverse physiological changes within certain plants and can contribute to soil acidification. TVA's contribution of nitrogen oxides is discussed earlier in Section 2, Air Resources of this document (Volume 2, Technical Document 1, Comprehensive Affected Environment).

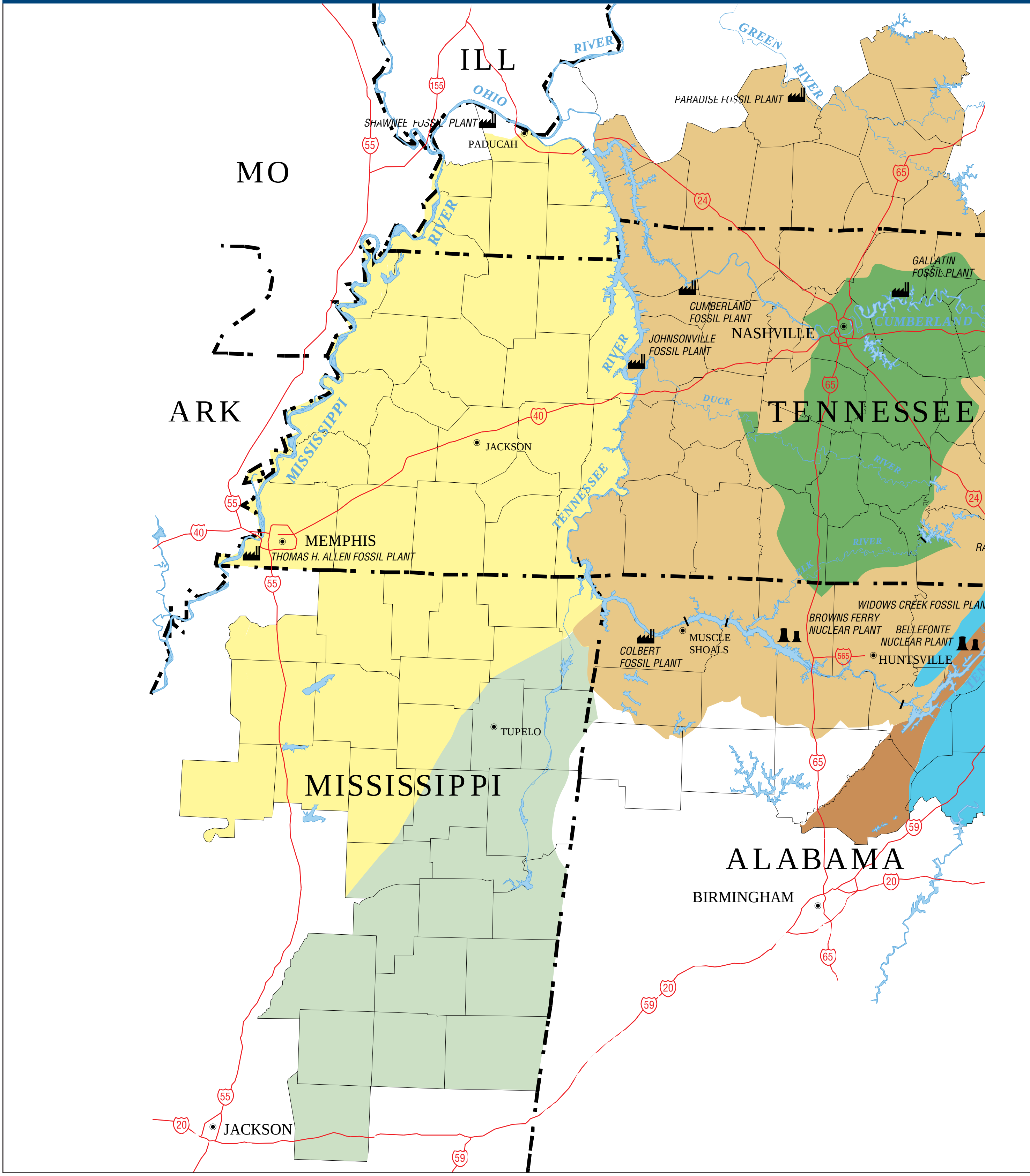
Soil Erosion

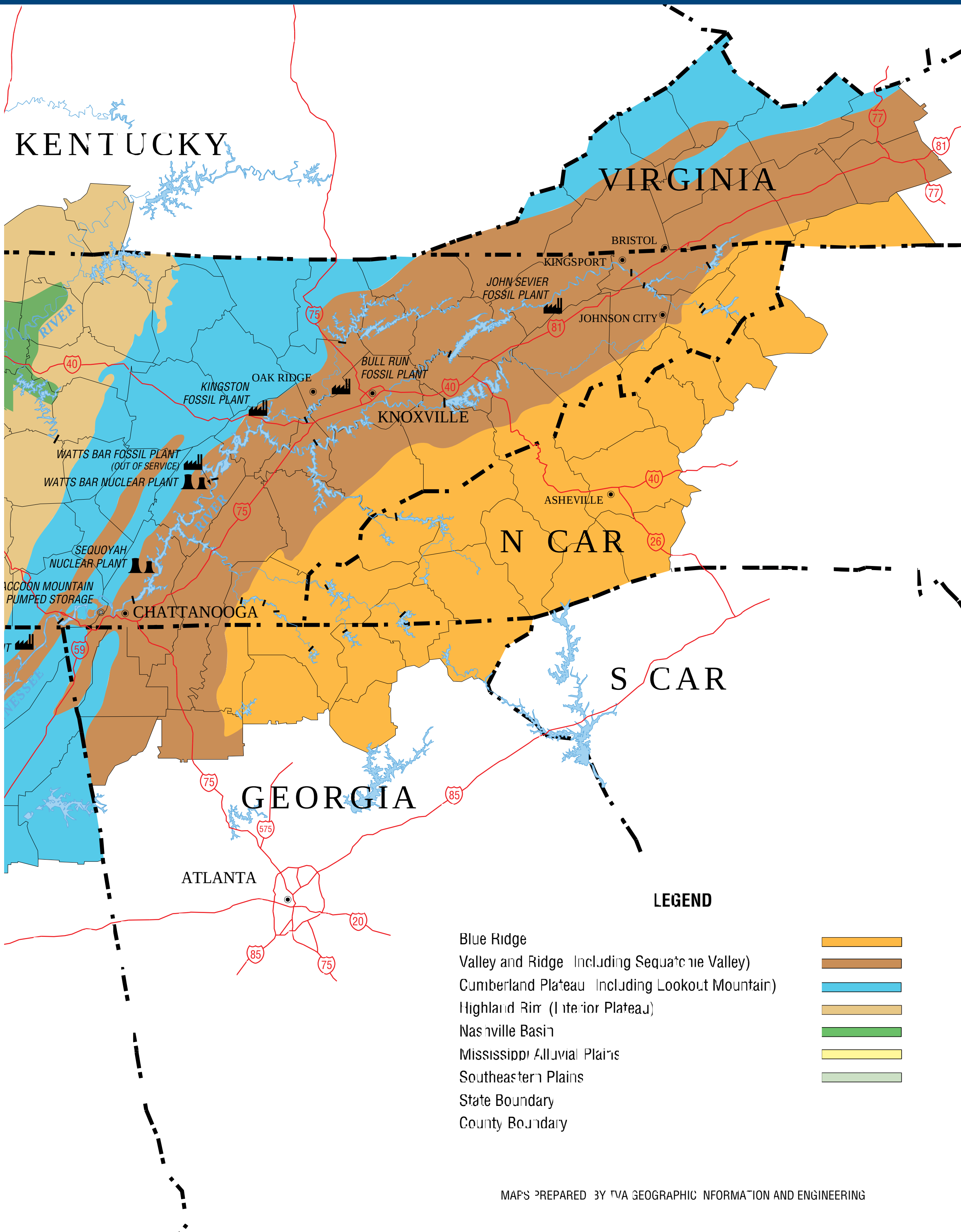
As in all areas inhabited by man, resource problems do exist. Erosion from all land uses in the region due to water or runoff is estimated to be 187 million tons annually (NRI 1982). Eighty-four percent of the erosion is considered to exceed tolerance levels for sustaining present land uses established by the Natural Resource Conservation Service.

Regionally, cropland has the largest percentage of land with excessive erosion. Cropland acreage represents approximately one-fourth of the region, and 51 percent of this acreage is estimated to be eroding at rates exceeding tolerance. This excessive erosion can be linked to the extreme vulnerability of the region's soils to the loss of productivity, which in turn affects farm income.

Some of the coal used to fuel TVA's power plants comes from surface mining. TVA's coal usage is discussed in Volume 2, Technical Document 2, Environmental Consequences. Soil erosion resulting from surface mining remains a concern for some parts of the region. Although production techniques have improved greatly, surface mining still promotes soil degradation and erosion to some extent.

FIGURE T1-67. **The Surface Geography Shown as Physiographic Provinces for the Energy Vision 2020 Study Area**




KENTUCKY
VIRGINIA
GEORGIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
SEQUOYAH NUCLEAR PLANT
PUMPED STORAGE
CHATTANOOGA
ATLANTA
LEGEND
Blue Ridge
State Boundary
County Boundary

Agricultural Lands

INTRODUCTION

Crops in the TVA region can be either positively or negatively affected by emissions from TVA power plants. Section 2, Air Resources in this document (Volume 2, Technical Document 1, Comprehensive Affected Environment) contains a discussion of potential effects.

Small farms that grow and market a wide diversity of agricultural products characterize agriculture in the Tennessee Valley. This region encompasses a wide range of soil types and properties. They range from the delta soils of the western region, producing abundant row crops, to the mountainous topography of the east, dotted with small farms producing a variety of traditional crops and high-income products such as Christmas

FIGURE T1-68. **U.S. Crop Production Rankings of States in the TVA Region**

	TVA REGION STATES						
Crops	**Alabama**	**Georgia**	**Kentucky**	**Mississippi**	**North Carolina**	**Tennessee**	**Virginia**
GRAINS							
Rice (All)				5			
Corn (Sweet)		9					
Rye		2			4		
VEGETABLES							
Tomatoes (F)		6				8	5
Tomatoes (P)							
Cucumbers (F)		4			9		7
Cucumbers (P)					3		
Lima Beans (F)		2					
Snap Beans (F)		4			8	5	9
Snap Beans (P)						9	
Onions (F)							
Watermelons (F)		5			9		
Cantaloupes (F)		5					
Bell Peppers (All)			8		7		10
Cabbage (F)		4			9		8
Spinach (F)							6
Sweet Potatoes	6	7		5	1		10
Spring Potatoes	6				3		
Summer Potatoes							5
FRUITS AND NUTS							
Strawberries (All)					9		
Blueberries		6			4		
Peaches (Freestone)		3			8		9
Grapes (All)		10					
Apples (All)					7		6
Pecans	4	1		7	10		
Peanuts	3	1			4		7
OTHER							
Hay (non-Alfalfa)			3			4	
Tobacco (All)		6	2		1	3	5
Cotton (All)	9	7		3	10	8	

Note: (F) = Fresh, (P) = Processed, (All) = Fresh and Processed.

Source: USDA National Agricultural Statistics Service (NASS), 1993.

trees, tobacco, vegetables, and other specialty crops. Farm sales in the Tennessee Valley have shifted from a predominantly row-crop agriculture to one that is more balanced. Forest products have increased in importance.

A minimal portion of prime farmland could conceivably be affected by building new power plants. Any future site-specific environmental reviews for power plant siting would assess any impact to prime farmland. The major impact is conversion to industrial/residential uses associated with urban growth. Power plants can affect urban growth by supporting new industry location to the region.

AGRICULTURAL LANDS AND CROP PRODUCTION

The Tennessee Valley region is a predominantly rural area with 40 percent of the land area in crop production or pasture and hay, and 55 percent in forest cover. Major crops produced in the region are tobacco, corn, cotton, soybeans, and wheat. (See the table in *Figure T1-68.*) With the exception of wheat, average yields of these major crops in the region have been consistently below the national average. While average yields are generally increasing for major crops, the rate of increase does not appear to be as great within the region as it is nationwide. The region is also a major production area for poultry broilers as well as non-poultry livestock. (Arkansas ranks number one, Georgia ranks number two, and Alabama ranks number three, with major growing areas in Kentucky and Tennessee.)

PRIME FARMLAND

Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses. It combines favorable soil quality, a good growing season, and adequate moisture. It produces the highest crop yields with the least amount of fuel, fertilizers, and labor. About 14 million acres of prime farmland occupy the Tennessee Valley region, with 55 percent crop land, 23 percent pasture, 20 percent forest, and 2 percent nonagricultural. This is about one-fourth of the region's non-federally owned land. The proportion of prime farmland is highest in the western portion of the region and lowest in the eastern portion. Under careful management, it can be farmed continuously without harming the environment or the resource base. According to the 1992 National Resource Inventory, there are 19,793,200 acres in the TVA 201-county region of prime farmland (48% cropland, 22% pasture land, 23% forest land, and 6% non agricultural use).

Agricultural Lands and Energy Crops

Energy crops include short rotation and woody crops that potentially could provide fuel for power plants. If enough energy crops were grown, other crops could be displaced. In 1993, Oak Ridge National Laboratory published a study, "The Potential Supply and Cost of Biomass from Energy Crops in the TVA Region," that concluded agricultural land in the TVA region could potentially support 18,000 megawatts of capacity fired by wood or 30,000 megawatts of capacity fired by switchgrass. This is more than the total additional capacity needed by TVA during the planning period for Energy Vision 2020.

Forest Resources

Forests in the TVA region can be affected by emissions from power plants. Section 2 in this document (Volume 2, Technical Document 1, Comprehensive Affected Environment) contains discussion of potential effects. The information used to produce the data in this section was obtained from U.S.D.A. Forest Service Experiment Station statewide forest inventories (Alabama, 1990; Georgia, 1989; Kentucky, 1988; Mississippi 1987; North Carolina, 1990; Tennessee, 1989; and Virginia, 1992). These inventories use a sampling scheme combining a forest-nonforest classification of points on aerial photographs with measurements on forested locations at the intersection of a sampling grid. At these locations, per-acre estimates are obtained from measured trees. Each forested sample point represents from 3,000 to 7,000 acres of forest.

FOREST LANDS

The 201 counties of the Tennessee Valley region contain 58.3 million acres. Fifty-three percent of the area is forested *(Figure T1-69)*. Reserved forest land, consisting of parks, wilderness areas, and other forested lands specifically withdrawn from commercial timber cutting by legislation or administrative designation, totals 944,976 acres. The remainder of the forested area, 30 million acres, or 97 percent of the forest, is classified as timberland. The following sections examine this timberland.

Non-industrial private landowners own 76.8 percent of the timberland; forest industries control 9.3 percent. Public holdings total 4.3 million acres or about 14 percent. National forests located mainly in the southern Appalachian region on the eastern edge of the TVA study area account for about 62 percent of public timberlands.

FOREST TYPES

The forest type classifications are derived from the frequency with which a species or combination of species occurs on the timberland of an area. The primary forest type in the 201-county area is the oak-hickory forest type (64 percent), followed by the loblolly-shortleaf type and the oak-pine type (14 percent each). Other forest types including oak-gum-cypress, elm-ash-cottonwood, maple-beech-birch, and white pine-hemlock (less than 9 percent).

FOREST INVENTORY

The total standing inventory of live trees 5 inches in diameter or larger is 1,447 million green tons, including growing stock and rough and rotten trees. "Growing stock" refers to wood from live trees of traditional commercial quality. "Rough and rotten trees" are of less than usual commercial quality. These two classifications may be further divided by species group into hardwood and softwood. The hardwood growing stock in the affected area is 1,033 million green tons or 91 percent; rough and rotten trees total 99 million tons or 9 percent. Softwood growing stock totals 310 million green tons (98 percent), and softwood rough and rotten totals 5 million tons (2 percent).

Among growing stock species, yellow-poplar *(Liriodendron tulipifera)* is the most common individual species (9.8 percent of total volume) followed by white oak *(Quereus alba)* (9.3 percent) and loblolly pine *(Pinus taeda)* (8.1 percent). Among hardwood groups, the oaks *(Quercus spp.)* total 37 percent of the inventory and hickory *(Carya spp.)* 7.9 percent.

GROWTH AND HARVESTS

Ideally, in order for forests to be sustainable, the volume harvested should not exceed forest growth. It is important to examine the relationship of growth and harvests (also referred to as removals) within the 201-county Tennessee Valley region.

FIGURE T1-69. **TVA Region Forest Statistics**

	Volume (Cubic Feet)	
Growing Stock	41,826,310	
Growing Stock Hardwoods	32,161,815	
Growing Stock Softwoods	9,664,495	
Rough & Rotten Stock	3,224,914	
Rough & Rotten Hardwoods	3,071,501	
Rough & Rotten Softwoods	153,413	
All Trees	45,051,224	
Hardwoods	35,233,316	
Softwoods	9,817,908	
Growth		
Total	1,429,355	
Hardwoods	1,016,785	
Softwoods	412,570	
Removals		**Ratio**
Total	870,641	1.64
Hardwoods	500,332	2.03
Softwoods	370,309	1.11
		Rate
Net Change	558,714	1.24%
Hardwoods	516,453	1.61%
Softwoods	42,261	0.44%

	Area: Acres	Area: Percent of Total
Land Use		
Nonforest Land	26,375,886	45.22%
Timberland	31,005,678	53.16%
Other Forest	944,976	1.62%
Total	58,326,540	100.00%
Ownership		
National Forest	2,673,559	8.62%
Other Public	1,652,496	5.33%
Forest Industry	2,874,900	9.27%
Farmer	7,723,525	24.91%
Misc. Private	16,081,198	51.87%
Total	31,005,678	100.00%
Forest Type		
White Pine-Hemlock	282,626	0.91%
Spruce-Fir	13,130	0.04%
Longleaf-Slash	11,359	0.04%
Loblolly-Shortleaf	4,260,862	13.74%
Oak-Pine	4,221,778	13.62%
Oak-Gum-Cypress	1,712,320	5.52%
Oak-Hickory	19,933,723	64.29%
Elm-Ash-Cottonwood	141,722	0.46%
Maple-Beech-Birch	428,158	1.38%
Total	31,005,678	100.00%

Data for growing stock trees were obtained from the U.S. Forest Service inventories and does not include the effects of any harvests started after the last periodic inventory. Data for harvests indicate the average annual removal of timber from timberland since the time of the last survey (usually 7 to 9 years).

For the total growing stock resource in the 201-county area, net annual growth totals 51.3 million tons and estimated annual harvests total 31.3 million tons. Thus, annual net change in the area is 20 million tons. The net change rate (net change volume/growing stock inventory) is 1.3 percent per year.

Another measure for comparing growth and harvests is the growth/drain ratio. It is derived by dividing the volume of growth by the volume of harvests. For example, if the growth/drain ratio is 1.0, growth and harvests are in balance. In the 201-county area, the growth/drain ratio of all growing stock is 1.6.

Examining these statistics by species group can provide more insight on the changes taking place. In the TVA region, softwood growing stock growth is 14.8 million tons and harvests are 13.3 million tons, for a net change of 1.5 million tons. The growth/drain ratio is 1.1. In comparison, the annual growth for hardwoods is 36.5 million tons, and annual harvest totals 17.9 million tons, resulting in a net change of 18.6 million tons. The net change rate is 1.6 percent, and the growth/drain ratio is 2.0.

Class I Air Quality Areas

The Clean Air Act gives special protection to national parks and national wilderness areas. These areas are designated "Class I Areas" and air quality is regulated within their boundaries. According to EPA regulations, air pollution effects constitute an unacceptable adverse impact in Class I Areas if they meet any of the following criteria:

- Diminish the national significance of the area
- Impair the quality of the visitor experience
- Impair the structure and function of the ecosystem.

Federal land managers are required to assess air quality in Class I Areas and determine possible impacts of air pollutants on resources.

There are seven Class I Areas in the Tennessee Valley region, as shown in the map in Figure T1-18 (U.S. EPA 1993). These Class I Areas include Sipsy, Alabama; Cohutta, Georgia; Mammoth Cave, Kentucky; Joyce Kilmer/Slickrock, North Carolina; Linville Gorge, North Carolina; Shining Rock, North Carolina; and the Great Smoky Mountains, Tennessee/North Carolina. An additional class 1 area, the Mingo National Wilderness Area is just outside the TVA region in Missouri.

Cultural Resources

Potential impacts to cultural resources can be caused by construction of power plants, air pollutants, and by coal and uranium mining and provision of biomass fuels for power plants. Although air quality can negatively impact cultural resources within the TVA region, these potential impacts are for the most part insignificant and can generally be managed or mitigated.

A more direct potential impact to cultural resources is the procurement of fossil and biomass fuels. Strip mining for coal (fossil fuel) can impact both archaeological sites and historic structure resources. Timber harvesting (biomass fuel) can also impact archaeological sites and standing structures. Increased use of biomass fuels may also lead to changes in land use patterns through the establishment of more corporate-owned tree plantations, which can lead to the abandonment or destruction of historically or architecturally important farm complexes.

Future site-specific environmental reviews for power plant siting would assess any impacts to cultural resources and archaeological sites.

The Tennessee Valley region is renowned for its numerous archaeological sites. The National Historic Preservation Act requires all federal agencies to identify, protect, and manage significant cultural resources on their land or those affected by their undertakings whether on federal or nonfederal property. Cultural resource management is concerned with maintaining the integrity of significant archaeological remains, man-made structures or features, and sites of historical importance.

Recreational Resources

Recreational resources can be affected by power plant emissions leading to visibility impairment, by water releases for hydroelectric power production, and by other activities that could result from the selection of future resources in Energy Vision 2020. The Tennessee Valley region affords diverse scenic and outdoor recreation resources. The lakes, rivers, and mountains of the region provide a wide variety of outdoor recreation activities including fishing, skiing, swimming, hiking, hunting, wildlife observation, sightseeing, and camping and are dependent upon clean water and healthy, diverse flora and fauna. Public lands including national parks and monuments, national forests, TVA lands, and state parks and forests provide significant recreation opportunities. These public lands, as well as private lands, also provide an aesthetic "backdrop" for recreation and tourism activities in the region. Significant river-based recreation resources are provided as shown in *Figure T1-70*. The TVA reservoirs named in *Figure T1-63* are also significant river-related recreation

resources. A complete listing of natural areas can be found in the 18 Categories of Natural Areas Appendix at the end of this document.

In the 1980s, the South accounted for more than half of the nation's population growth and is expected to be one of the dominant growth regions into the twenty-first century. As a growing portion of the United States population leaves the active labor force, growth of retirement centers and associated travel in the South and Southwest may increase even more rapidly than in the past. Travel and tourism present significant and growing contributions to the economic activity in the Tennessee Valley region. In 1991, travel and tourism accounted for 126,000 jobs, about 5.5 percent of non-farm employment.

FIGURE T1-70. **Designated River Recreation Resources in the TVA Region**

Wild and Scenic Rivers	National Recreation Rivers
Obed-Emory Rivers (Tennessee)	Big South Fork River (Tennessee/Kentucky)
Horsepasture River (North Carolina)	Chattahoochee (Georgia)
New River & South Fork New River (North Carolina)	
Chattooga River (South Carolina/Georgia)	
Sipsey River (Alabama)	
Black River (Mississippi)	

Other Land Use Conditions

ELECTRIC AND MAGNETIC FIELDS

Implementation of Energy Vision 2020 strategies for the future may result in the construction of new transmission lines and in the installation of energy-efficient electrical appliances. Either of these activities could result in the production of electric and magnetic fields (EMF). EMF arises from both nature and human activity. For example, the earth and individual human beings produce direct current magnetic fields. Lightning is an extremely powerful electric charge. Human-produced EMF can be caused by direct current, such as the voltage from batteries, or alternating current, such as the voltage from most electric power lines in the United States. Every device that generates, transmits, or uses electricity produces electric and magnetic fields. This list includes electric appliances, motor vehicles, and electric wiring. There is no place on earth where an individual is not exposed to EMF. In modern societies, individuals are exposed to varying levels of EMF throughout their daily activities.

EMF from electric devices and power lines is generally much weaker than that produced by the human body itself and is usually too small to be noticed (Carnegie Mellon University 1989). Because this induced EMF is weak, scientists thought for many years that it had no adverse health effects. However, a 1979 epidemiological study suggested a potential link between magnetic fields associated with electric distribution lines and childhood leukemia (Bonneville Power Administration 1989). After 15 years of research, the results have been mixed. A few additional studies have suggested similar links to various forms of cancer, particularly studies of EMF exposures in occupational settings. Other studies have found no such links and no studies have yet found a cause-and-effect relationship. If EMF does pose a risk, most researchers believe the risk is low, and most scientists familiar with the issue agree that more research into the effect of EMF on health is needed. It is likely to be many years before more definitive conclusions can be reached.

High-voltage power lines have been the subject of much of the research into the potential health effects of EMF. Transmission lines are the means by which TVA-generated power reaches distribution points. When a new supply-side resource is added to the TVA system, it must be connected to the TVA transmission system. A supply-side resource built at a new plant site would require new transmission lines and possibly result in additional population exposures to EMF. In addition, other resource options, such as those involving dispersed power generation, may result in increased population exposures since they are usually built in more populated areas.

No federal regulations govern EMF exposure levels. A few states have established guidelines or standards for electric field levels. Two states, New York and Florida, have magnetic field standards. Some municipalities have established electric or magnetic field standards. None of the states in which TVA operates have set or proposed EMF standards.

TVA adopted interim guidelines in 1993 that address EMF exposures. Under these guidelines, TVA will take into account EMF exposure when planning new transmission lines. Whenever practical, TVA will route new lines to avoid homes, schools, and other densely populated areas. In addition, TVA will design new transmission lines and upgrades of existing lines to reduce EMF levels.

COAL PROCUREMENT

The amount of coal purchased by TVA and whether it comes from underground or surface operations can have differing environmental effects. Site-specific environmental impact reviews will address TVA fuel requirements in some detail.

Most of TVA's fossil plants are located near two major coal-producing regions. These regions are the southern Appalachian region, which includes eastern Kentucky, Virginia, West Virginia, Tennessee, northern Georgia, and northern Alabama; and the eastern interior region, including western Kentucky, southern Illinois, and southern Indiana. TVA purchases about 35 to 40 million tons of coal annually to fuel its 11 operating fossil plants.

TVA's eastern coal procurements are about 7.1 percent of the eastern United States production (east of the Mississippi River) and about 0.36 percent of the western United States production. The maps in *Figures T1-71* and *T1-72* show the location and intensity of TVA coal procurement in the eastern and western United States by county for fiscal year 1994. The table in *Figure T1-73* gives TVA the amount and percent of coal procurement by state.

The acquisition of low-sulfur western coal serves as one component of the compliance strategy for sulfur dioxide emission reductions required under the Clean Air Act amendments of 1990. In fiscal year 1994, 1.59 million tons, or 4.2 percent of coal procurements, were from western states. For the 1995 to 2000 period, the estimate for annual procurement of western coal is 4.2 million tons. In fiscal year 1994, 6.5 million tons of coal were procured from surface mines, 17 from underground mines, and the source of 14.3 tons was either surface or underground mines.

Land-related environmental impacts of mining are primarily the direct and indirect impacts of changes in land use. Past impacts have included acid drainage from exposed sulfur-bearing rock, erosion from disturbed mining areas and coal transport roads, loss of wildlife habitat, deforestation, stream siltation, unstable land situations, and fugitive dust; however, the Surface Mining Control and Reclamation Act (SMCRA) now addresses these issues in permitting enforcement. Other land-related mining impacts can include loss of prime farm land, encroachment on threatened or endangered species, and loss of cultural and archaeological resources.

FIGURE T1-73. **TVA Coal Procurement by State**

State	FISCAL YEAR 1994 Thousands of Tons	Percent
Colorado	1,196	3.2
Illinois	3,907	10.3
Kentucky	27,091	71.7
Ohio	213	0.6
Pennsylvania	567	1.5
Tennessee	1,008	2.7
Utah	365	1.0
Virginia	1,282	3.4
West Virginia	2,118	5.6
Wyoming	29	0.1
Total	**37,776**	**100.0**

Mines in the southern Appalachians are often developed on lands which are not well suited to agriculture. Ideally, commercial timber is harvested and marketed prior to excavation for mining. Aesthetics is another potential environmental concern. Mining operations usually clash with the surrounding landscape, and in the case of high elevation ridge-side or ridge-top surface mining, the operation may be visible for many miles, either as a distinct feature or as a disruption of the skyline. Mine reclamation requires restoration to original contour, and appropriate re-vegetation can mitigate long-term visual aesthetics impacts, as well as impacts resulting from changes in land-use.

Mining in the eastern interior region is more likely to involve either agricultural or forested lands. Long-range visual aesthetic impacts are less likely to be significant because of topography.

COAL COMBUSTION SOLID WASTES

The amount of coal used as fuel is related to the solid waste produced. The combustion of pulverized coal in power plant boilers produces solid wastes as fly ash and bottom ash (or boiler slag in some boiler designs). The primary constituents of ash and slag are silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3). Flue gas desulfurization by wet limestone scrubbers for environmental control produces a gypsum sludge ($CaSO_42H_2O$) solid waste. Coal washing residue creates another waste. Any of these wastes may be marketed as byproducts depending on their quality and market conditions.

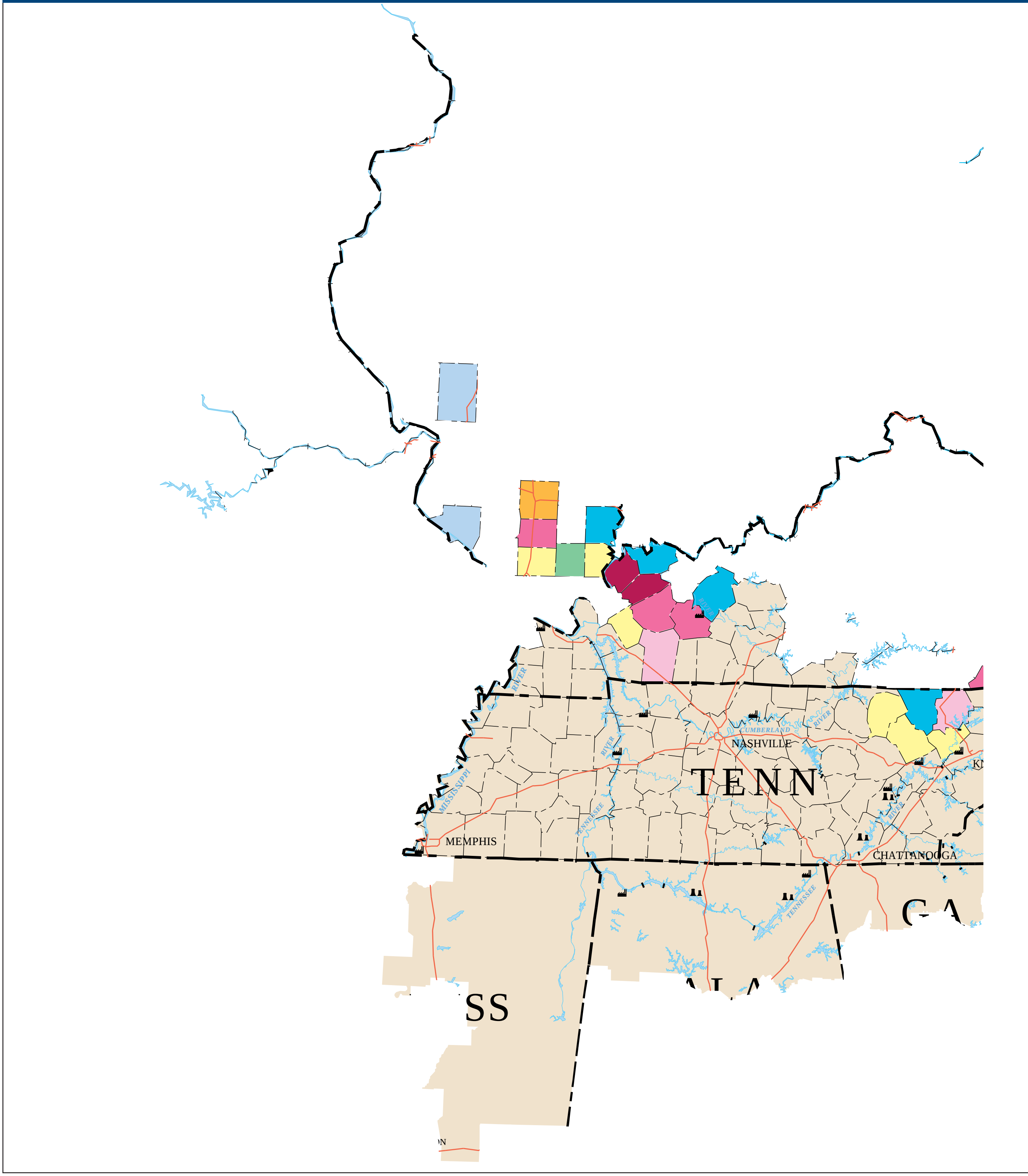
TVA coal-fired plant production of these byproducts during fiscal year 1994 is listed in *Figure T1-74*. TVA's total coal combustion byproduct utilization from 1989 to 1994 is summarized in *Figure T1-75*. Selected coal combustion byproduct usage is shown in *Figure T1-76*. The total production of byproducts was nearly 6 million tons with almost half being fly ash. Bottom ash/slag, flue gas desulfurization, and gypsum sludge accounted for 20 percent each.

The remainder of the byproducts is either disposed of or stored on the plant site in ash ponds or dry-stacked landfills. The liquid waste discharges from ash ponds are permitted according to the National Pollution Discharge Elimination System. At some plants, possible groundwater contamination is monitored by sampling groundwater in the nearby area.

URANIUM PROCUREMENT

The natural uranium for TVA's nuclear plants comes from uranium producing areas all over the world. The world's major ura-

FIGURE T1-71. **TVA Procured Coal from Seven Eastern States in Fiscal Year 1994**



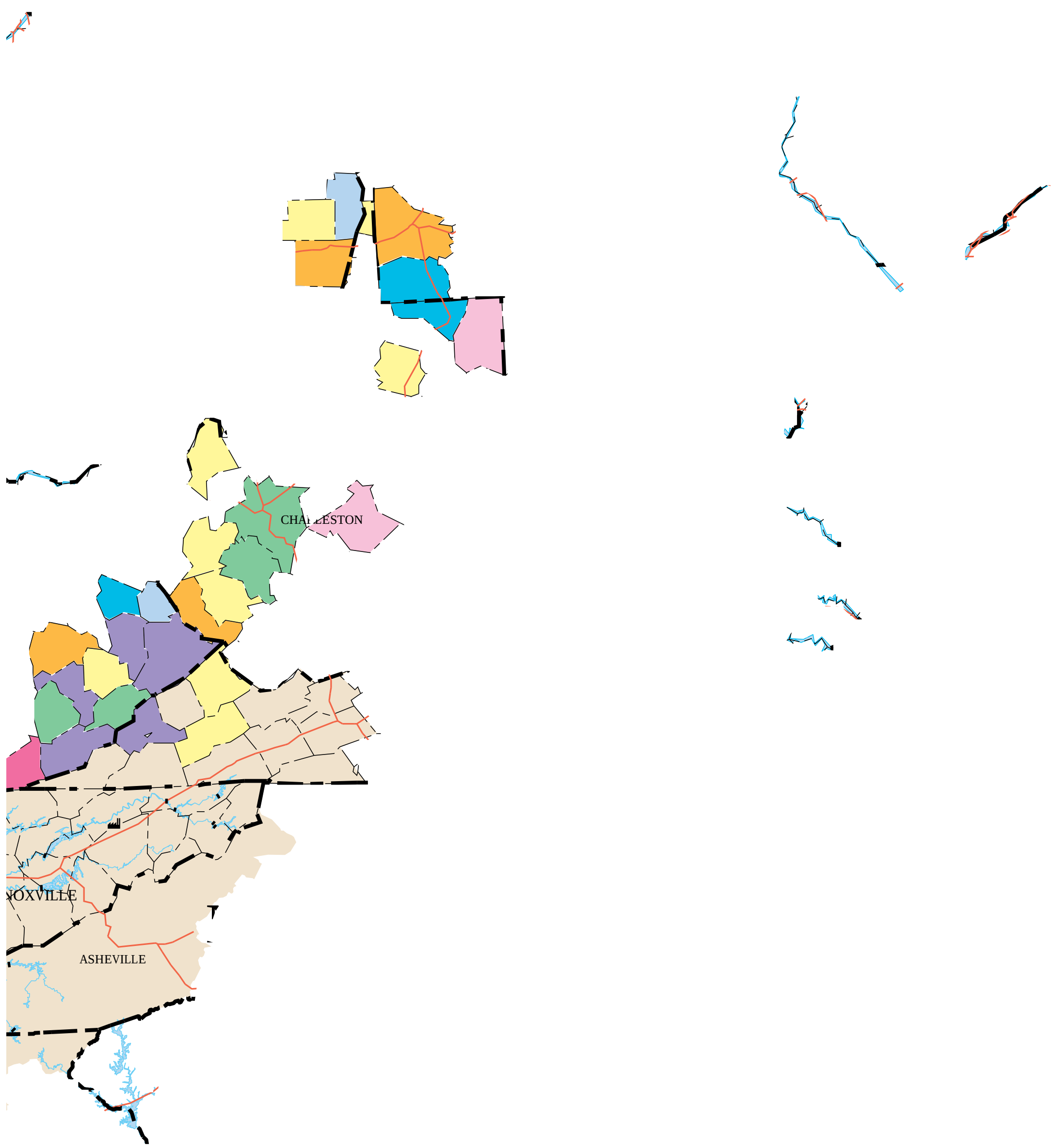

ASHEVILLE

FIGURE T1-72. **TVA Procured Coal from Three Western States in Fiscal Year 1994**

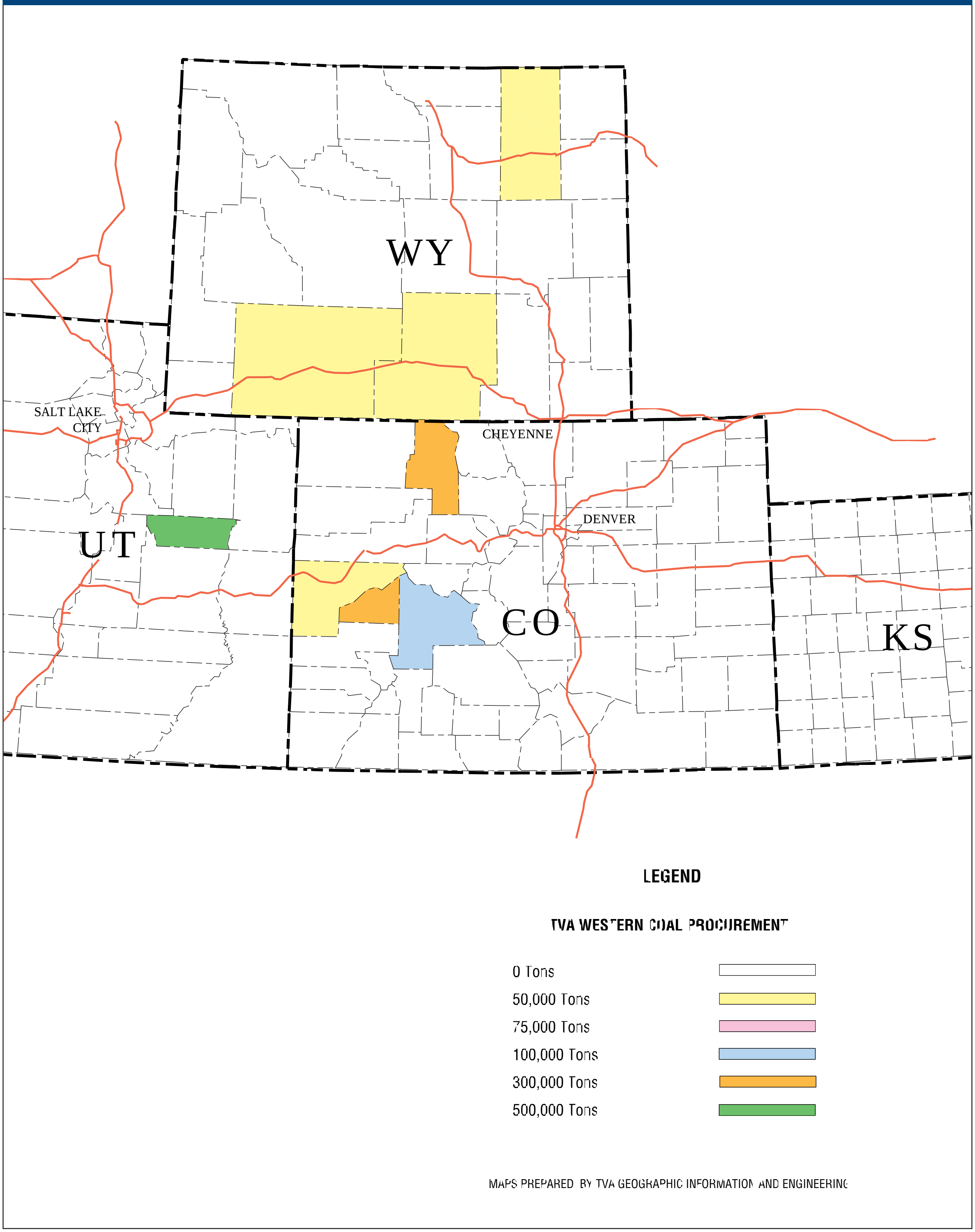


FIGURE T1-74. **TVA Coal Combustion Byproduct Production, Fiscal Year 1994**

Plant	COAL Coal Burn (Tons)	Coal Ash (%)	BYPRODUCT Fly Ash (Tons)	Bottom Ash/Slag (Tons)	Gypsum (Flue Gas Desulfurization Sludge) (Tons)	Coal Wash (Tons)
Allen	2,023,847	8.31	42,045	126,136		
Bull Run	2,119,542	8.79	158,362	27,946		
Colbert (1-4)	1,826,608	11.59	169,363	42,341		
Colbert (5)	1,158,004	9.92	91,899	22,975		
Cumberland	5,766,501	10.26	473,314	118,329	964,577	
Gallatin	2,522,861	7.99	161,261	40,315		
John Sevier	2,047,223	11.53	188,836	47,209		
Johnsonville	3,555,731	10.01	284,743	71,186		
Kingston	3,925,284	8.94	280,736	70,184		
Paradise (1-2)	3,482,965	8.74	76,103	228,308	559,631	539,860
Paradise (3)	2,020,667	8.57	43,293	129,878		313,203
Shawnee (1-9)	3,302,792	10.13	267,658	66,915		
Shawnee (10)	380,970	7.28	137,239	43,857		
Widows Creek (1-6)	1,629,437	10.29	134,135	33,534		
Widows Creek (7)	1,162,420	11.01	102,386	25,596	221,886	
Widows Creek (8)	1,474,021	10.87	128,181	32,045	400,346	
TOTALS	**38,398,872**		**2,739,555**	**1,126,754**	**2,146,440**	**853,063**

FIGURE T1-75. **TVA Coal Combustion Byproduct Utilization, Fiscal Years 1989 to 1994**

Fiscal Year	Utilization (Tons)
1989	487,309
1990	625,761
1991	770,921
1992	1,038,244
1993	701,822
1994	1,176,568

FIGURE T1-76. **Selected Coal Combustion Byproduct Uses**

Byproduct Use	BYPRODUCT Fly Ash	Bottom Ash	Boiler Slag	Flue Gas Desulfurization Sludge
Cement/Concrete Products	X	X	X	X
Asphalt Products		X	X	
Roofing Granules			X	
Roadbed, Road Surfacing, Embankments	X		X	
Grit for Snow/Ice Control		X	X	
Blasting Grit			X	
Landfill and Structural Fill	X	X		
Gypsum Wall Board				X

nium producing countries are Canada, Australia, South Africa, Niger, Russia, Namibia, Uzbekistan, Tajikistan, Kazakhstan, and the United States. Current annual world production is approximately 80 million pounds of U3O8. TVA's five nuclear units use a total of about 2.5 million pounds of U3O8 per year. TVA currently has sufficient inventory to last until 1999.

Much of the world's uranium is produced in dry, arid thinly populated areas like the southwestern United States and the Australian outback. Mining methods range from open-pit mining to deep-pit mining to low impact leaching operations. Environmental management is an integral part of overall mining operations. Extensive monitoring programs are implemented. One of the main objectives of environmental plans is to return as much of the mining site to its former state as possible once mining operations are completed. Decommissioning plans are made, funded, and implemented.

After mining, the natural uranium is transported to either of the two conversion plants located in Illinois or Ontario, Canada, for further refinement and processing. Subsequently, the natural uranium is typically shipped to one of the federal government's uranium enrichment plants located at Paducah, Kentucky or Portsmouth, Ohio. TVA receives its nuclear fuel in the form of fabricated nuclear fuel assemblies in which the uranium has been encapsulated in metal tubes.

TVA and a number of other United States utilities are expected to soon be using commercial grade slightly enriched

uranium derived from nuclear warheads in the true sense of swords to plowshares. Under this program, the highly enriched uranium obtained from both United States and Russian nuclear warheads will be diluted to low levels, which allows its use in commercial nuclear plants. A substantial reduction in the quantity of nuclear warheads in the world is a major benefit to the environment and mankind.

NUCLEAR WASTE

Introduction

The nuclear fuel used for power plants produces radioactive solid wastes requiring storage and disposal. These wastes are placed in two categories: low-level radioactive waste and high-level radioactive waste. These indicate the type of radioactive material, the intensity of its radiation, and the time required for decay of the radiation intensity to natural levels.

High-Level Nuclear Waste

Background

Ninety-nine percent of high-level waste from commercial nuclear plants is used fuel that has released most of its energy. The fuel that runs nuclear power plants is made up of small uranium pellets. These are placed inside long metal fuel rods. These fuel rods are grouped together into fuel assemblies, which are placed inside a reactor. In the fission process, uranium atoms begin to split in a chain reaction, one after another. The fission process yields energy in the form of heat for power plant operation.

Certain changes take place in the fuel during the fission process. Most of the fission products—the nuclei left over after the atom has split—are radioactive. Over time, these trapped fission products reduce the efficiency of the chain reaction. Approximately every 18 months, the oldest fuel assemblies that have already released their energy are removed and replaced with fresh fuel. Operation of TVA's 5 nuclear units will produce about 115 metric tons of used fuel each year.

After it is removed from the reactor, used fuel is stored at nuclear plant sites either in pools (steel-lined, concrete vaults filled with water) or in dry casks (above-ground concrete or steel containers). The radioactive waste remains locked inside the uranium pellets which are still encased in the fuel rods. Used fuel has been stored safely at nuclear plant sites since the late 1950s, when the first nuclear energy plants began making electricity.

Within six months of fuel removal and storage at the plant site, 98 percent of the fuel's radiation has dissipated. Forty to 50 years after the spent fuel is removed from the reactor, its radioactivity has decreased to 1 percent of its initial radioactivity. A very small percentage of nuclear wastes remain radioactive for thousands of years.

Radioactive waste has been a prominent topic in the controversy over nuclear energy. Often the attention focuses on the disposal of spent fuel from nuclear reactors. Radiation has been studied for nearly a century, and scientists can detect even the smallest amount. Scientists and engineers believe they know how to safely isolate radioactive material underground so it will not pose a danger to current or future generations. A permanent repository with multiple barriers, both natural and man-made, is to be designed and built by the Department of Energy to ensure radioactivity does not escape and waste is isolated from the environment. Waste will be sealed in metal canisters and placed a half-mile or more underground in a stable geological environment.

The feasibility of underground waste repositories has been demonstrated in studies and test projects. Geologic repositories deep underground have been endorsed by independent scientific organizations around the world, including the National Academy of Sciences, the National Research Council, and the Congressional Office of Technology Assessment. Almost all other countries with a nuclear energy program, including Germany, France, and Japan, have determined that deep geologic disposal is the safest system of permanent nuclear waste management.

The Nuclear Waste Policy Act (NWPA) of 1982 established a program to build the nation's first underground high-level waste repository early in the next century. The act and its amendments charge the Department of Energy (DOE) with the following tasks:

- Locating, building, and operating a deep-mined geologic permanent repository for high-level waste
- Evaluating the need for a monitored retrievable storage facility—a short-term, continuously monitored facility for the interim storage of spent fuel
- Developing a transportation system that safely links United States nuclear power plants, the monitored retrievable storage, and the permanent repository.

In 1987, amendments to the Nuclear Waste Policy Act of 1982 designated the remote area of Yucca Mountain, Nevada, northwest of Las Vegas, for study as a possible permanent repository site. The Department of Energy has begun site characterization, the comprehensive scientific investigation of Yucca Mountain's suitability. The permanent repository facility must meet strict licensing requirements of the U.S. Nuclear Regulatory Commission. Additional oversight will be provided by the U.S. Environmental Protection Agency, the State of Nevada, and the Technical Review Board appointed by the President.

Concern about the transportation of high-level waste is another issue related to disposal. The federal government has established controls and regulations to ensure that radiation exposure from accidents does not occur under either normal or abnormal conditions. To date, there have been more than one million ship-

ments of radioactive materials, mostly for medical purposes, with a lower than average vehicle accident rate. No one has ever been injured due to radiation exposure from the 6,000 spent fuel assemblies transported to date in the United States.

Spent fuel is shipped in specially constructed casks, each of which must be licensed by the Nuclear Regulatory Commission (NRC). The casks must be able to withstand several severe shocks without leaking—a 30-foot drop onto a flat, unyielding horizontal surface with the cask oriented to cause maximum damage; a 40-inch drop onto the pointed end of a steel bar, also with the cask oriented for maximum damage; exposure to a 1,475 degrees F fire for 30 minutes with no artificial post-fire cooling; and immersion in water to a depth of three feet for at least eight hours immediately following the fire test. The Nuclear Regulatory Commission tests required to license shipping casks are more stringent than conditions the casks would be subjected to in actual accidents.

Below is a listing of other federal agencies involved in the management of high-level radioactive waste:

- The Environmental Protection Agency issues generally applicable environmental radiation standards effective outside the boundaries of sites that possess radioactive materials.
- The Nuclear Regulatory Commission develops and enforces regulations to protect the public health and safety from all domestic commercial nuclear activities. Rules on mined geologic repositories have been formulated that will specifically implement the general environmental standards set forth by the Environmental Protection Agency.
- The Department of Transportation governs the shipment of all privately owned radioactive materials, including nuclear waste, by all modes of transport. It also administers the labeling, classification, and marking of all radioactive waste packages.
- The Department of Interior through the U.S. Geological Survey cooperates with the Department of Energy on technical activities in the earth sciences, including geologic investigations in support of waste disposal.

Status of TVA Spent Fuel Storage

TVA plans to continue to store spent nuclear fuel on-site at plant locations where it is generated until the Department of Energy accepts physical custody by shipment off-site to a monitored retrievable storage facility or to a permanent underground repository for ultimate disposal by burial. TVA is currently storing some 760 and 417 metric tons of used fuel on site at Browns Ferry and Sequoyah Nuclear Plants, respectively. Current spent fuel storage capacity is sufficient at Sequoyah Nuclear Plant until 2004 and at Browns Ferry Nuclear Plant until 2007. Based on one-unit operation at Watts Bar Nuclear Plant, spent fuel storage capacity will be sufficient until 2018. TVA has sufficient outside site area at each of its nuclear facilities to store any high-level waste associated with decommissioning activities and life-of-plant quantities of used fuel. As the pools approach the current storage limits, TVA will initiate studies to increase on-site storage capacity.

Low-Level Nuclear Waste

Low-level radioactive waste consists of items that have come into contact with radioactive materials. Activities that use radioactive materials, and therefore produce low-level waste, include biomedical and pharmaceutical research, industrial processes, diagnosis and medical treatment, and nuclear-generated energy. In a nuclear energy plant, the low-level radioactive waste comes primarily from small particles in the internal reactor-cooling water that are captured in filters, deposited in valves and pumps, or collected on surfaces inside the plant. Many items such as filters, cloth and paper wipes, plastic shoe covers, tools and materials, water purification media (resins), and other residues collect varying quantities of radioactivity.

The radioactive particles in low-level radioactive waste emit the same types of radiation that occur in nature. About 90 percent of low-level radioactive waste fades away through radioactive decay into natural levels of radioactivity within 10 years. About 99.9 percent of it diminishes to natural levels in less than 300 years.

Low-level radioactive waste is measured by volume generated or volume disposed of, usually in cubic meters. Generators of low-level radioactive waste have worked to reduce the volume sent to disposal sites. TVA regularly compares its low-level radioactive waste volumes to the best and median volume generators in the nuclear industry. Low-level radioactive waste production at TVA nuclear plants is currently about 70 percent of the industry average. Reduction of waste volume is accomplished through a combination of on-site volume minimization and off-site volume reduction processes. Waste volume is reduced through compaction, incineration, and decontamination.

Low-level waste that is shipped to disposal sites travels by ground transportation in special boxes, drums, or steel containers designed to meet Nuclear Regulatory Commission and Department of Transportation standards for impact resistance. The type of container required depends on the amounts and types of radioactive elements in the waste. There has never been a serious transportation incident involving the disposal of radioactive material.

The purpose of low-level radioactive waste disposal is to isolate the waste from both people and the environment. Designs for building disposal facilities include shallow land bur-

ial, a below-ground vault, an above-ground vault, modular concrete canister disposal, and earth-mounded concrete bunkers. Although the disposal approach may vary, depending on the location, all disposal facilities use a series of natural and engineered barriers to prevent the radioactive material from reaching the environment. All of them meet strict federal and state requirements for isolating the waste until the radioactivity has faded to natural background levels.

In 1980, Congress passed the Low-Level Radioactive Waste Policy Act. That law requires every state to develop an adequate disposal site for its own waste or to form "compacts" with other states to provide regional disposal. The states participating in the Southeast Compact Commission have selected North Carolina as the host state to select, license, and construct a new disposal site. The current schedule calls for this facility to be complete in 1998. Until July 1995, the low-level waste generators located in the eight Southeastern states were required to dispose of their waste at the Barnwell, South Carolina disposal facility. In July, South Carolina withdrew from the Southeast Compact Commission in order to open the Barnwell facility to all states except North Carolina. Barnwell is expected to remain open to these users for another 7 to 10 years. TVA plans to continue to use the Barnwell facility for low-level radioactive waste disposal until the North Carolina facility is opened. Should either or both of the disposal facilities close unexpectedly, low-level radioactive waste will be stored in on-site facilities at the TVA nuclear plants. These facilities are sized to handle any anticipated storage needs for the foreseeable life of the plants.

Below is a listing of agencies involved in the regulation of low-level radioactive waste:

- The **U.S. Nuclear Regulatory Commission** licenses many of the facilities that produce low-level waste, including nuclear energy plants, and regulates low-level radioactive waste disposal.
- The **U.S. Environmental Protection Agency** develops general standards to protect the public from radiation.
- The **U.S. Department of Transportation** regulates the interstate shipment of privately owned radioactive materials.
- The **U.S. Department of Energy** coordinates national planning with the states for managing low-level radioactive waste.
- The **U.S. Geological Survey** offers technical assistance with studies of hydrology and geology of proposed sites.
- **State governments** are responsible for disposal of the low-level radioactive waste generated in their states or for joining a regional compact. State governments are responsible for selecting and licensing a site according to federal standards and monitoring its operation. Most states have licensing authority from the Nuclear Regulatory Commission for low-level waste disposal within their state.
- **The Nuclear Regulatory Commission** regulations cover the off-site disposal of low-level radioactive waste; the Nuclear Regulatory Commission and the U.S. Department of Transportation cover the transportation of waste; and the Nuclear Regulatory Commission regulations cover on-site storage.

Biological Resources

INTRODUCTION

Biological resources such as wetlands, wildlife, vegetation, sensitive ecosystems, endangered species, and unique natural areas can potentially be affected by dams, power plant emissions, and sites for power plants. The Tennessee Valley region contains a wide diversity of flora, fauna, and biological habitats. Biological resources of the Valley are summarized in this section.

TERRESTRIAL ECOLOGY

Wetlands

Wetlands are defined as lands that are covered by shallow water or with the water table near the surface. They support vegetation typically found in wet habitats, have soils wet enough to produce anaerobic conditions, and/or have a substrate saturated or covered with water at some time during the growing season (Cowardin et al. 1979). Although wetlands occur throughout the TVA region, they are most extensive in the south and west. There are two main types of wetlands—palustrine, or marshy, and lacustrine, formed by lakes (U.S. Fish and Wildlife Service National Wetland Inventory data). The most common palustrine types are forested wetlands (also the most extensive type in the TVA region), scrub-shrub wetlands, and emergent wetlands. The most common lacustrine wetland type is aquatic bed wetlands.

Over half of the wetland acreage that originally occurred in the seven states forming the TVA region has been lost (Dahl 1990). The major causes of wetlands loss are agricultural conversion, inundation by reservoirs, and conversion to urban or other non-agricultural land uses. The rate of wetland loss has slowed in recent years, and further destruction of wetlands is discouraged by Executive Order 11990, the North American Wetlands Conservation Act, and other regulations. Any future site-specific environmental reviews for power plant siting will consider wetlands in assessing potential impacts.

Wildlife

The TVA region contains portions of six physiographic regions (see the map in *Figure T1-67*) and a great variety of plant and

animal communities. About 70 species of mammals, 300 species of birds (including 175 that nest within the region), 65 species of reptiles, and 77 species of amphibians regularly occur in the region. Several salamander species are only found in the TVA region. Few other terrestrial vertebrate species are restricted to the TVA region.

Except for many birds, game species, and species listed as endangered or threatened (see species list at the end of this document in the Threatened and Endangered Species Appendix), little population trend information is available for terrestrial animals. Systematic censuses conducted since the mid-1960s show that populations of about 18 percent of the bird species nesting in the region are declining, while about 10 percent are increasing (Nicholson in press). About 30 percent of the bird species are encountered too infrequently by this survey to show population trends. The majority of the birds with declining population trends are species that nest in North America and winter in Latin America. Many of these species require large tracts of forest and are adversely affected by forest fragmentation resulting from land use changes such as road and power line construction and suburban and agricultural development. Several bird species that require early successional habitats, both permanent residents and long-distance migrants, also show a decline.

Twenty-two species of mammals and 34 species of birds are legally hunted or trapped in the TVA region. The population trends of these species in the region generally parallel their trends elsewhere, with northern bobwhite *(Colinus virginianus)* and most duck species declining, and white-tailed deer *(Odocoileus virginianus)*, wild turkeys *(Meleagris gallopavo)*, geese, and wood ducks *(Aix sponsa)* increasing.

Vegetation

The six physiographic regions within TVA's 201-county area contain approximately 4,300 species of herbs, shrubs, and trees in numerous habitats and plant communities. It also contains several non-forested plant communities, such as cedar glades, balds, remnant prairies, gravel bars, and cliff faces. These areas are extremely small compared to the extensive forests that characterize this region.

Based on an analysis of late successional forests, Braun (1950) recognized five major forest regions in the TVA region. *(See Figure T1-77.)* Three of these regions are further divided into sections, generally along physical geology boundaries. The major tree species in these regions are listed in *Figure T1-78*.

Local vegetation types vary greatly within Braun's divisions because of variation in elevation, relief, soil fertility, moisture, and the degree of human disturbance. The tree species composition of early to mid-successional forests (forests in the early to middle stages of their cycle) is fairly uniform across the TVA region on sites with similar environmental conditions. Red cedar *(Juniperus virginiana)* and mixed cedar types are common on reverting old fields and on sites with shallow, basic soils. Yellow pines (especially loblolly *[Pinus taeda]*, Virginia *[P. virginiana])* and shortleaf *(P. echinata)* are widespread and occur both in tree plantations and naturally in early successional stands. Oak-hickory forests, often mixed with yellow pines, are widespread on drier, upland sites. Bottomland hardwoods containing such species as oaks, sweetgum *(Liquidambar styraciflua)*, maples *(Acer spp.)*, and other wet-site hardwoods are typical of rich alluvial lowlands. Sugar maple *(Acer saccharum)* and American beech *(Fagus grandifolia)* frequently occur on rich, north slopes and, along with species such as hemlock *(Tsuga canadensis)*, northern red oak *(Quercus rubra)*, and basswood *(Tilia heterophylla)*, are common at higher elevations in the eastern portion of the region.

STRESSORS TO THE FORESTS OF THE TENNESSEE VALLEY

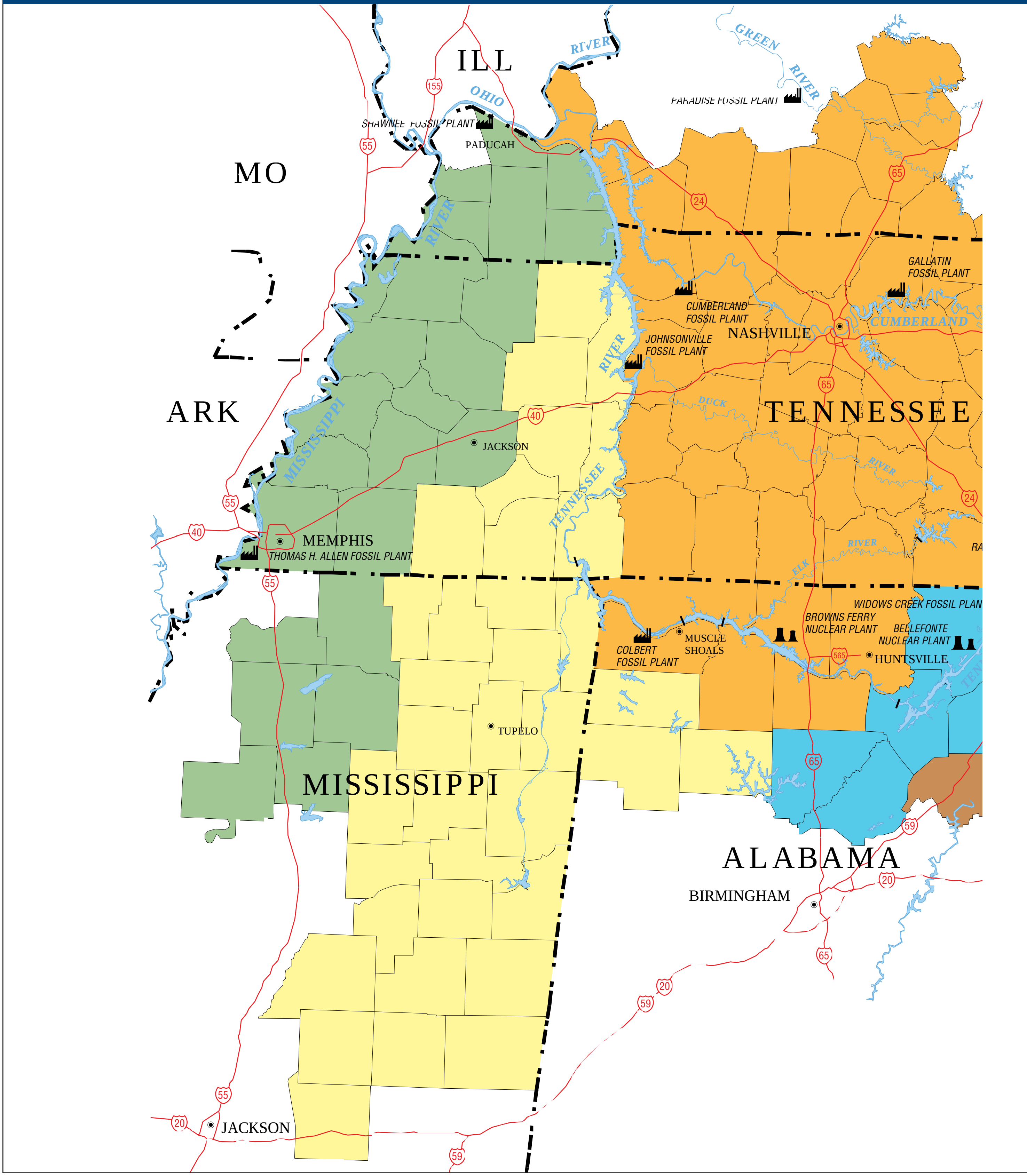
Power plant emissions are one of several stressors to forests in the Tennessee Valley. Power plant emissions and their potential effects have been discussed previously. Since the cumulative effects of various stressors can negatively affect forests, all key stressors are discussed in this section.

The forests of the Tennessee Valley are in a constant state of change. Presence or repression of fire, environmental conditions, people, and introduced pests have helped shape the current landscape. Forest stressors include past land use practices that resulted in erosion and site degradation, extreme climatic conditions (freezing injury, ice damage, drought, flooding), air pollutants, and exotic as well as native forest insects and diseases.

Currently, several stressors raise concern for the health of forests in this region. Tropospheric ozone is produced by complex photochemical reactions involving sunlight and the emission of volatile organic compounds and nitrogen oxides from automobiles, power plants, factories, and other sources of high temperature combustion. Ozone in the troposphere, the portion of the atmosphere 7 to 10 miles from the earth's surface, can occur at levels that cause visible injury to numerous plants and have potentially deleterious interactions with other forces in forest settings (Johnson and Lindberg 1992). Acidic deposition is also considered to be a forest health stressor, especially to red spruce *(Picea rubens)*, the most sensitive regional tree species.

A number of diseases and pests introduced to the Tennessee Valley have recently or will soon impact the forest (Ferguson and Bowman 1994; Great Smoky Mountains National Park 1993; Langdon and Johnson 1992). The gypsy moth *(Lymantria dispar)*, is of major concern. It is projected to reach the northeast

FIGURE T1-77. **The Five Major Forest Regions of the Energy Vision 2020 Study Area**



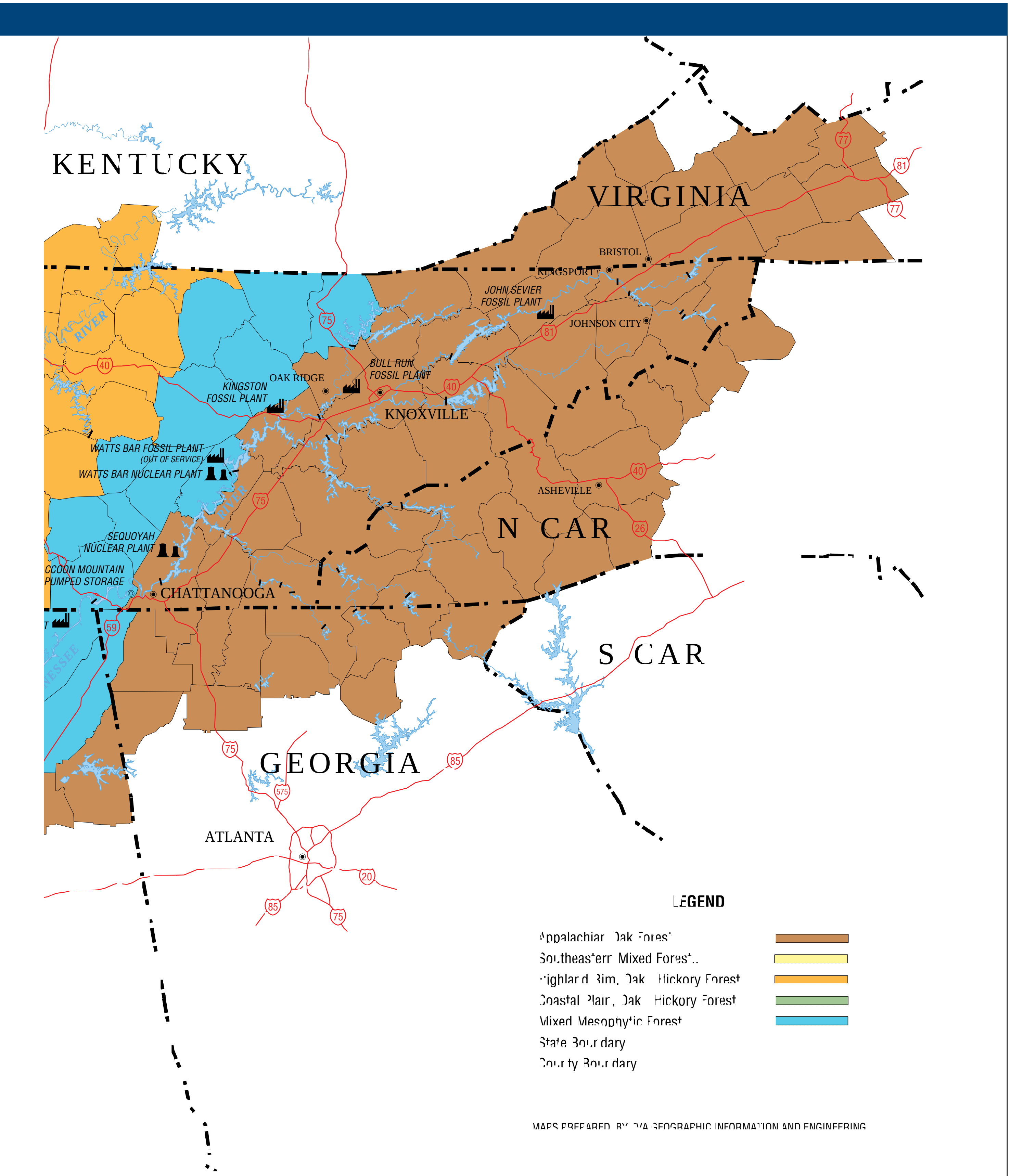

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
RIVER
OAK RIDGE
BULL RUN FOSSIL PLANT
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
CCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
75
40
81
77
59
26
85
575
20
LEGEND
Appalachian Oak Forest
Southeastern Mixed Forest
Highland Rim, Oak Hickory Forest
Coastal Plain, Oak Hickory Forest
Mixed Mesophytic Forest
State Boundary
County Boundary
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-78. **Trees in the Major Forest Regions and Sections of the Tennessee Valley**

The Mixed Mesophytic Forest Region—Cumberland Mountains Section

Tuliptree	*Liriodendron tulipifera*
Basswood	*Tilia heterophylla*
Sugar maple	*Acer saccharum*
Beech	*Fagus grandifolia*
Northern Red oak	*Quercus rubra*
Yellow buckeye	*Aesculus octandra*
White ash	*Fraxinus americana*
Cucumber magnolia	*Magnolia acuminata*
Red maple	*Acer rubrum*
Black gum	*Nyssa sylvatica*

Cumberland and Allegheny Plateaus Section

Beech	*Fagus grandifolia*
Tuliptree	*Liriodendron tulipifera*
Basswood	*Tilia heterophylla*
Sugar maple	*Acer saccharum*
Northern Red oak	*Quercus rubra*
White ash	*Fraxinus americana*
White oak	*Quercus alba*
Cucumber magnolia	*Magnolia acuminata*
Shagbark hickory	*Carya ovata*
Mockernut hickory	*Carya tomentosa*
Black gum	*Nyssa sylvatica*
Red maple	*Acer rubrum*

The Western Mesophytic Forest Region—Nashville Basin Section

Tuliptree	*Liriodendron tulipifera*
Sugar maple	*Acer saccharum*
White oak	*Quercus alba*
Northern Red oak	*Quercus rubra*
Hackberry	*Celtis laevigata*
American elm	*Ulmus americana*
Red cedar	*Juniperus virginana*
Winged elm	*Ulmus alata*
Shagbark hickory	*Carya ovata*
Black gum	*Nyssa sylvatica*
Chinkapin oak	*Quercus muehlenbergii*
Post oak	*Quercus stellata*
Redbud	*Cercis canadensis*
Beech	*Fagus grandifolia*
Wild cherry	*Prunus serotina*
White ash	*Fraxinus americana*
Bitternut hickory	*Carya cordiformis*
Fraser magnolia	*Magnolia fraseri*
Red maple	*Acer rubrum*
Chestnut oak	*Quercus prinus*
Black oak	*Quercus velutina*
Scarlet oak	*Quercus coccinea*

The Oak-Chestnut Forest Region—Southern Appalachians Section, Cove Hardwoods and Oak-Chestnut Communities

Basswood	*Tilia heterophylla*
Sugar maple	*Acer saccharum*
Northern red oak	*Quercus rubra*
Yellow buckeye	*Aesculus octandra*
Silverbell	*Halesia caroliniana*
Canadian hemlock	*Tsuga canadensis*
Yellow birch	*Betula lutea*
Sweet birch	*Betula lenta*

The Oak-Pine Forest Region—Gulf Slope Section

Chestnut oak	*Quercus prinus*
Pignut hickory	*Carya glabra*
Loblolly pine	*Pinus taeda*
Shortleaf pine	*Pinus echinata*
Southern red oak	*Quercus falcata*
Post oak	*Quercus stellata*
Black oak	*Quercus velutina*
Blackjack oak	*Quercus marilandica*
Mockernut hickory	*Carya tomentosa*

Southeastern Evergreen Forest Region—Mississippi Alluvial Plain Section

Silver maple	*Acer saccharinum*
American elm	*Ulmus americana*
Pin oak	*Quercus palustris*
Cottonwood	*Populus deltoides*
White oak	*Quercus alba*
Sweetgum	*Liquidambar styraciflua*
Cherrybark oak	*Quercus pagodaefolia*
Sycamore	*Platanus occidentalis*
Black oak	*Quercus velutina*
Red mulberry	*Morus rubra*
Sassafras	*Sassafras albidum*
Walnut	*Juglans nigra*
Honeylocust	*Gleditsia triacanthos*

corner of Tennessee in 15 to 20 years. Oak trees are the most susceptible. Stands with a higher component of oaks are also more susceptible to dieback and decline. Oak decline, a slow-acting disease complex, is caused by a combination of age, stress factors, and normally non-aggressive insects and fungi. A natural process, oak decline, is hastened and compounded by past land use, loss of species such as the American chestnut *(Castanea dentata*), replacement with species less adapted to the site, and other conditions.

Dogwood anthracnose is a disease caused by the fungus *Discula destructiva*. It was detected in the southern Appalachians in the late 1980s and has spread throughout much of the Valley. Flowering dogwood *(Cornus florida)* is the target species. At some sites all dogwood trees have been killed, while some trees at lower elevations on drier sites have sustained little damage. Other hardwood diseases include Dutch elm disease, caused by the *Ceratocytis ulmi* fungus, which attacks American *(Ulmus americana)*, slippery *(U. rubra)*, and winged elms *(U. alata)*. High levels of mortality among elm trees follow disease outbreaks. Butternut canker, caused by the fungus *Seriococcus clavigineti-juglandacearum* has a lethal effect on butternut *(Juglans cinerea)*. This fungus went unnoticed in the southeastern United States until less than a decade ago. Butternut populations are plummeting, and in 1990 butternut was added to the federal list of candidates for protection by the Endangered Species Act. Beech bark disease was detected in the Great Smoky Mountains several years ago. The disease is caused by a combination of the beech bark scale insect *(Cryptococcus fagisuga)* and the *Nectria* fungus. High levels of American beech mortality are expected if the disease spreads.

Three insects are serious pests to Valley coniferous forests (Ferguson and Bowman 1994). The balsam woolly adelgid *(Adelges piceae)* was detected in the southern Appalachians in the late 1950s. It is a non-native mortal pest of mature Fraser fir *(Abies fraseri)* native to the southern mountains. Virtually all natural stands of fir have been infested, and few mature firs remain. The hemlock woolly adelgid *(Adelges tsugae)*, accidentally imported from Asia, has already infested many Eastern hemlocks in Virginia. Widespread mortality is expected. This adelgid is expected to move throughout the Appalachians and may eliminate most of the hemlock, both the Eastern type and the native Carolina hemlock *(T. caroliniana)*. Most species of conifers are susceptible to attack during intense outbreaks by the native southern pine beetle *(Dendroctonus frontalis)*. In the Tennessee Valley all shortleaf, loblolly, and Virginia, Table-Mountain pines *(P. pungens*) pitch pines *(P. rigida)*, and eastern white pines *(P. strobus)* are attacked. Overstocked or homogeneous stands are the most susceptible to high mortality during periodic beetle outbreaks.

Harmful non-indigenous invasive plant species also pose a threat. Both privet *(Ligustrum*.spp.*)* and Japanese honeysuckle *(Lonicera japonica)* are shade-tolerant and form a dense layer of low vegetation, altering forest regeneration patterns. Another pervasive shade-tolerant plant is bittersweet *(Celastrus scandens)*, but it is not yet known to hamper stand regeneration. The grass microstegium *(Microstegium vimineum)* carpets moist forest understories, changing the composition of the herbaceous layer. Some shade-intolerant species introduced, such as autumn olive *(Elaeagnus umbellata)*, multiflora rose, *(Rosa multiflora)*, and kudzu *(Pueraria lobata)* can cause local problems. A potential problem species that is spreading south is mile-a-minute weed *(Polygonum perfoliatum)*, an aggressive annual spread by animals that eat its fleshy fruits.

Usually these pests, pathogens, or agents of damage are viewed individually. However, they often work together and impact the forest through a multiple stressor system complex.

SENSITIVE OR THREATENED ECOSYSTEMS

The TVA region includes several terrestrial communities that are either restricted to the TVA region, are best represented here, or include a large proportion of their total area in the region. These include the Southern Appalachian spruce-fir, cedar glade, and limestone cave systems. Several endangered and native plant and/or animal species, as well as species not found outside the TVA region, occur in each of these communities. Therefore, knowledge of these threatened ecosystems is important for the future implementation of energy resources including the site-specific environmental reviews to be performed.

Southern Appalachian Spruce-Fir Forest

The Southern Appalachian spruce-fir forest is an ecosystem rich in animals and native and rare plants. However, these forests have experienced serious disturbances in the last century. Commercial logging and associated fires of the early 1900s reduced the forests to a fraction of their former expanse (Korstian 1937). Currently these forests are being severely impacted by the balsam woolly adelgid, an imported insect first detected in the southern Appalachians in the late 1950s (Spears 1958). Mature Fraser fir, a southern mountain endemic, is highly susceptible to the adelgid, with death occurring in two to seven years after infestation. Furthermore, some evidence suggests a red spruce growth decline in the past 20 years, as well as canopy crown deterioration since the mid-1980s (Peart et al. 1992; McLaughlin et al. 1987).

The red spruce-Fraser fir ecosystem occupies approximately 103 square miles in the southern Appalachian mountains of southwestern Virginia, eastern Tennessee, and western North Carolina and is generally confined to mountain peaks above 5,000-

foot elevation. The larger stands are shown in the map in *Figure T1-50*. Spruce-fir forests occur as a series of island-like stands at high elevation. The largest contiguous area of red spruce-Fraser fir forest (48,721 acres) is located in the Great Smoky Mountains National Park (Dull et al. 1988). The remaining 26 percent of the ecosystem is located in the Black Mountains (7,221 acres), Balsam Mountains (4,648 acres), Roan Mountain including Unaka Mountain (1,699 acres), Mt. Rogers Area including Whitetop Mountain (1,582 acres), Plott Balsams (952 acres), Grandfather Mountain (928 acres), and Long Hope Mountain (498 acres) (Dull et al. 1988; Groton 1985).

Cedar Glades

Cedar glades are areas of exposed limestone bedrock, gravel, and/or shallow soil over limestone bedrock, sparsely vegetated with low-growing herbaceous plants and red cedars (Quarterman 1989). Their greatest concentration occurs within the Interior Low Plateaus physiographic province in central Kentucky, central Tennessee, and northern Alabama. A few glades also occur within the Ridge and Valley province of Virginia, Tennessee, Georgia, and Alabama. Twenty-two species or subspecies of plants are only found on these southeastern glades. The total area of cedar glades, most of which are within the TVA region (Baskin and Baskin 1986), is only a few thousand acres. Many have been destroyed or heavily disturbed by urban and suburban development, highway construction, and reservoir impoundment.

Caves

Over 5,000 caves and related Karst features such as sinkholes have been identified in the TVA region (TVA undated). They are widespread in the eastern two-thirds of the region. Many species of invertebrates, as well as one fish, and one salamander, are restricted to caves in the TVA region. Several of these species occur in only one or two caves. Several of these species, as well as several bats inhabiting caves, are listed as endangered or under consideration for endangered listing. Important stresses to cave ecosystems include groundwater pollution, changes in cave climate and hydrology resulting from modifications to cave entrances, and disturbances to cave formations and fauna by human visitation.

THREATENED AND ENDANGERED SPECIES

Knowledge of threatened and endangered species in the TVA region is important for the future deployment of energy resources including the site-specific environmental reviews to be performed. Thirty-eight species of plants and 100 species of animals in the TVA region are either listed as endangered or threatened species or formally proposed for such listing by the U.S. Fish and Wildlife Service (USFWS). These species, their distribution by river basin, and their habitats are listed in the Threatened and Endangered Species Appendix. An additional 380 species in the TVA region have been identified by the U.S. Fish and Wildlife Service as candidates for listing (USFWS 1993, 1994a, 1994b). The distribution of many candidate species is poorly known and not included here.

The 83 aquatic animals are endangered by loss of habitat due to the building of reservoirs; alterations of flow, temperature, and water chemistry regimes in river stretches downstream of dams; stream channel modifications such as channeling; and habitat degradation from point and non-point pollution. Most plants and terrestrial animals are endangered by loss of habitat due to land use changes such as agricultural clearing, highway construction, and suburban development.

The 83 aquatic species presented in the Threatened and Endangered Species Appendix occur in 4 broad habitat types, 3 of which have been described in some detail in Section 3, Water Resources in this document (Volume 2, Technical Document 1, Comprehensive Affected Environment). Under-ground aquifer habitats, not mentioned in Water Resources, are inhabited by three listed species. Each of these species (Alabama cavefish, *Speoplatyrhinus poulsoni;* Alabama cave shrimp, *Pulaemonias alabamae;* and Kentucky cave shrimp, *Pulaemonias ganteri*) occurs in one or a few caves located in an extremely limited geographic area.

The vast majority of the listed aquatic species presented in the Threatened and Endangered Species Appendix (65 of the 80 remaining species) typically occur in smaller rivers and creeks that have not been substantially affected by impoundment or other large-scale modifications. Twenty-five of these species occur in various Gulf drainages, while the remaining 40 species occur in interior basin streams, primarily the Tennessee and Cumberland river systems. Most of these small-stream listed species survive where habitat conditions and aquatic communities retain much of their original characteristics. Several of these species occur together as members of diverse communities in important and often protected stream reaches such as the upper Clinch, Powell, and Duck rivers in the Tennessee system; the middle portion of the Green River; and the Cahaba River, Mobile system.

Tributary reservoirs and their tailwaters make up the second aquatic habitat discussed in Water Resources, but they contain no listed species. Since these habitats are substantially different from the original character of the streams they do not meet the needs of listed species.

Large river habitats, even though substantially affected by dams, still support surviving populations of 15 listed species included in the Threatened and Endangered Species Appendix. Four of these species occur in the Mobile River system, while the other 11 exist in the mainstreams of the Tennessee,

Cumberland, Ohio, Green, and/or the Mississippi rivers. Most of these species survive in sections of large rivers where important original habitat conditions persist. Often these sections occur just downstream from the dams. Several of these species typically occur together as parts of diverse communities in locations such as the Tennessee River downstream from Pickwick Landing Dam and the Cumberland River downstream from Cordell Hull Dam.

UNIQUE AND SIGNIFICANT NATURAL AREAS

Siting of power plants and emissions for pollutants from power plants can potentially affect unique and significant natural areas. Site-specific environmental reviews would address any impacts to these areas as future resources are implemented. Natural areas in the TVA region include national, state, and privately owned lands that are managed for significant ecological resources, including forest, wildlife, water, rare plants and animals, or research. Most areas are managed to maintain their wild character and scenic beauty, to serve as a vital habitat for migrating birds and large mammals or endangered species, to provide important outdoor recreation resources in natural landscapes, or to serve as a nature educational tool. Many areas are managed to allow natural processes to predominate.

Natural areas contain an array of significant natural resources, from large wilderness areas, national wildlife refuges, and national parks, to intensively managed forests and recreational parks. Aquatic natural areas include state and national scenic rivers, mussel sanctuaries, and critical habitats for rare fishes. Natural areas vary in size from a few acres to several thousand acres. Many cross state boundaries or are managed cooperatively by several agencies. Categories of natural areas can be found at the end of this document in the Seventeen Categories of Natural Areas Appendix.

Threatened and Endangered Species Appendix

Distribution of Endangered and Threatened Species in the TVA Region by River Basins

Name	Common Name	Status [1]	Tennessee	Cumberland	Green	New	Lower Ohio
MAMMALS							
Canis rufus	Red wolf	LE	X				
Glaucomys sabrinus coloratus	Northern flying squirrel	LE	X			X	
Myotis grisescens	Gray bat	LE	X	X	X		
Myotis sodalis	Indiana myotis	LE	X	X	X	X	X
Plecotus townsendii virginianus	Townsend's big-eared bat	LE				X	
BIRDS							
Falco peregrinus	Peregrine falcon	LE	X	X			
Haliaeetus leucocephalus	Bald eagle	LE/PT	X	X			X
Picoides borealis	Red-cockaded woodpecker	LE	X	X	X		
Sterna antillarum athalassos	Interior least tern	LE					X
Vermivora bachmanii	Bachman's warbler	LE			X		
REPTILES							
Alligator mississippiensis	American alligator	LT				X	
Graptemys oculifera	Ringed map turtle	LT					
Nerodia eryth rogaster neglecta	Copperbelly water snake	PT					X
Sternotherus depressus	Flattened musk turtle	LT					
FISHES							
Acipenser oxyrhynchus desotoi	Gulf sturgeon	LT					
Cyprinella caerulea	Blue shiner	LT					
Cyprinella monacha	Spotfin chub	LT	X				
Erimystax cahni	Slender chub	LT	X				
Etheostoma boschungi	Slackwater darter	LT	X				
Etheostoma chienense	Relict darter	LE					
Etheostoma etowahae	Etowah darter	LE					
Etheostoma n sp.	Bluemask darter (=jewel)	LE		X			
Etheostoma percnurum	Duskytail darter	LE	X	X			
Etheostoma (Ulocentra) sp.	Cherokee darter	LT					
Etheostoma wapiti	Boulder darter	LE	X				
Notropis albizonatus	Palezone shiner	LE	X	X			
Noturus baileyi	Smoky madtom	LE	X				
Noturus flavipinnis	Yellowfin madtom	LT	X				
Noturus stanauli	Pygmy madtom	LE	X				
Percina antesella	Amber darter	LE					
Percina aurolineata	Goldline darter	LT					
Percina jenkinsi	Conasauga logperch	LE					
Percina tanasi	Snail darter	LT	X				
Phoxinus cumberlandensis	Blackside dace	LT		X			
Scaphirhynchus albus	Pallid sturgeon	LE					
Speoplatyrhinus poulsoni	Alabama cavefish	LE	X				

[1] Status codes: LE - Listed Endangered; LT - Listed Threatened; PE - Proposed Endangered; PT - Proposed Threatened
[2] Ex = Extirpated

Mississippi Main Stem	Mississippi Tributaries	Pearl	Pascagoula	Mobile	Savannah	Santee	Habitat
							Forests, fields
						X	Spruce-fir/hardwood ecotone
	X			X			Caves, rivers, lakes
X	X			X			Caves, riparian areas
							Caves, nearby forests
	X			X		X	Cliffs, large rivers, reservoirs
X	X						Lakes, large rivers, wooded shorelines
	X	X	X	X			Mature/old growth pine forests
X							Large rivers, sandbars
				X			Swamp forests
		X					Lakes, swamps
		X					Large rivers
X							Forested wetlands, streams
				X			Small rivers
				X			Large rivers
				X			Small rivers, large creeks
							Small rivers, large creeks
							Small rivers
							Small creeks, springs
	X						Small creeks
				X			Small rivers
							Small rivers, large creeks
							Small rivers, large creeks
				X			Small creeks
							Small rivers, large creeks
							Small rivers, large creeks
							Large creeks
							Small rivers, large creeks
							Small rivers
				X			Small rivers
				X			Small rivers
				X			Small rivers
							Large rivers, small rivers
							Small creeks
X							Large rivers
							Cave streams

Threatened and Endangered Species Appendix

Distribution of Endangered and Threatened Species in the TVA Region by River Basins (continued)

Name	Common Name	Status [1]	Tennessee	Cumberland	Green	New	Lower Ohio
CLAMS							
Alasmidonta atropurpurea	Cumberland elktoe	PE		X			
Alasmidonta raveneliana	Appalachian elktoe	LE	X				
Conradilla caelata	Birdwing pearlymussel	LE	X				
Cyprogenia stegaria	Fanshell	LE	X		X		
Dromus dromas	Dromedary pearlymussel	LE	X	X			
Epioblasma brevidens	Cumberland combshell	PE	X	X			
Epioblasma capsaeformis	Oyster mussel	PE	X				
Epioblasma florentina florentina	Yellow-blossom pearlymussel	LE	Ex [2]				
Epioblasma metastriata	Upland combshell	LE					
Epioblasma obliquata obliquata	Catspaw	LE		X	X		
Epioblasma othcaloogensis	Southern acornshell	LE					
Epioblasma penita	Southern combshell	LE					
Epioblasma torulosa gubernaculum	Green blossom pearlymussel	LE	X				
Epioblasma torulosa rangiana	Northern riffleshell	LE			X		
Epioblasma torulosa torulosa	Tuberculed blossom pearlymussel	LE	Ex [2]	Ex [2]			Ex [2]
Epioblasma turgidula	Turgid blossom pearlymussel	LE	X				
Epioblasma walkeri	Tan riffleshell	LE	X	X			
Fusconaia cor	Shiny pigtoe pearlymussel	LE	X				
Fusconaia cuneolus	Fine-rayed pigtoe	LE	X				
Hemistena lata	Cracking pearlymussel	LE	X	X	X		
Lampsilis abrupta	Pink mucket	LE	X	X	X		X
Lampsilis altilis	Fine-lined pocketbook	LT					
Lampsilis perovalis	Orange-nacre mucket	LT					
Lampsilis virescens	Alabama lampmussel	LE	X				
Medionidus acutissimus	Alabama moccasinshell	LT					
Medionidus parvulus	Coosa moccasinshell	LE					
Obovaria retusa	Ring pink	LE	X	X	X		
Pegias fabula	Little-wing pearlymussel	LE	X	X			
Plethobasus cicatricosus	White wartyback	LE	X				
Plethobasus cooperianus	Orange-foot pimpleback	LE	X	X	X		X
Pleurobema clava	Clubshell	LE	X		X		
Pleurobema curtum	Black clubshell	LE					
Pleurobema decisum	Southern clubshell	LE					
Pleurobema furvum	Dark pigtoe	LE					
Pleurobema georgianum	Southern pigtoe	LE					
Pleurobema gibberum	Cumberland pigtoe	LE		X			
Pleurobema marshalli	Flat pigtoe	LE					
Pleurobema perovatum	Ovate clubshell	LE					
Pleurobema plenum	Rough pigtoe	LE	X	X	X		

[1] Status codes: LE - Listed Endangered; LT - Listed Threatened; PE - Proposed Endangered; PT - Proposed Threatened
[2] Ex = Extirpated

Mississippi Main Stem	Mississippi Tributaries	Pearl	Pascagoula	Mobile	Savannah	Santee	Habitat
							Small rivers, creeks
							Small rivers, creeks
							Small rivers
							Rivers
							Rivers
							Small rivers
							Small rivers
							Large rivers
				X			Small rivers
							Large rivers
				X			Small rivers, creeks
				X			Small rivers, creeks
							Small rivers
							Small rivers, creeks
							Large rivers
	X						Creeks
							Small rivers, creeks
							Small rivers, creeks
							Small rivers, creeks
							Rivers, large creeks
							Rivers
				X			Small rivers, creeks
				X			Small rivers, creeks
							Creeks
				X			Small rivers, creeks
				X			Small rivers, creeks
							Rivers
							Creeks
							Large rivers
							Large rivers
							Rivers, large creeks
				X			Small rivers, creeks
				X			Small rivers, creeks
				X			Small rivers, creeks
				X			Small rivers, creeks
							Small rivers, creeks
				X			Small rivers, creeks
				X			Small rivers, creeks
							Rivers

Threatened and Endangered Species Appendix

Distribution of Endangered and Threatened Species in the TVA Region by River Basins (continued)

Name	Common Name	Status [1]	Tennessee	Cumberland	Green	New	Lower Ohio
CLAMS continued							
Pleurobema taitianum	Heavy pigtoe	LE					
Potamilus capax	Fat pocketbook	LE					X
Potamilus inflatus	Inflated heelsplitter	LT					
Ptychobranchus greenii	Triangular kidneyshell	LE					
Quadrula cylindrica strigillata	Rough rabbitsfoot	PE	X				
Quadrula fragosa	Winged mapleleaf	LE	Ex [2]				
Quadrula intermedia	Cumberland monkeyface	LE	X				
Quadrula sparsa	Appalachian monkeyface	LE	X				
Quadrula stapes	Stirrupshell	LE					
Toxolasma cylindrellus	Pale lilliput	LE	X				
Villosa perpurpurea	Purple bean	PE	X				
Villosa trabalis	Cumberland bean	LE	X	X			
SNAILS							
Anguispira picta	Painted snake coiled forest snail	LT	X				
Athearnia anthonyi	Anthony's river snail	LE	X				
Marstonia ogmorhaphe	Royal marstonia	LE	X				
Mesodon clarki nantahala	Noonday globe	LT	X				
Tulotoma magnifica	Tulatoma	LE					
ARTHROPODS							
Microhexura montivaga	Spruce-fir moss spider	PE	X				
Palaemonias alabamae	Alabama cave shrimp	LE	X				
Palaemonias ganteri	Kentucky cave shrimp	LE			X		
Lirceus usdagalun	Lee County cave isopod	LE	X				
Orconectes shoupi	Nashville crayfish	LE		X			
FLOWERING PLANTS							
Apios priceana	Price potato-bean	LT	X	X			X
Arabis perstellata var. ampla	Rockcress	PE		X			
Arenaria cumberlandensis	Cumberland sandwort	LE		X			
Astragalus bibullatus	Ground-plum	LE		X			
Betula uber	Virginia roundleaf birch	LT	X				
Clematis morefieldii	Morefield's leather flower	LE	X				
Clematis socialis	Alabama leather flower	LE					
Conradina verticillata	Cumberland rosemary	LT	X	X			
Dalea foliosa	Prairie clover	LE	X	X			
Echinacea laevigata	Purple-coneflower	LE				X	
Echinacea tennesseensis	Tennessee coneflower	LE		X			
Euphorbia purpurea	Glade spurge	LT	X				
Geum radiatum	Spreading avens	LE	X				

[1] Status codes: LE - Listed Endangered; LT - Listed Threatened; PE - Proposed Endangered; PT - Proposed Threatened
[2] Ex = Extirpated

Mississippi Main Stem	Mississippi Tributaries	Pearl	Pascagoula	Mobile	Savannah	Santee	Habitat
				X			Small rivers, creeks
							Rivers, creeks
				X			Small rivers
				X			Small rivers, creeks
							Small rivers
							Small rivers
							Small rivers
				X			Small rivers
				X			Small rivers
							Creeks
							Small rivers, creeks
							Small rivers, creeks
							Forested bluffs
							Spring runs
							Cliffs
				X			Rivers
						X	Spruce-fir forests
							Caves
							Caves
							Caves
							Large creeks
				X			Hardwood forests, forest edges
							Calcareous slopes
							Sandstone overhangs
							Cedar glades
							Creek terraces
							Hardwood forests
				X			Forest edges, open woodlands
							Riverine gravel bars
							Cedar glades
							Cedar glades, open woods, limestone bluffs
							Cedar glades
							Rich or swampy woods
							High elevation acidic rock outcrops

Threatened and Endangered Species Appendix

Distribution of Endangered and Threatened Species in the TVA Region by River Basins (continued)

Name	Common Name	Status [1]	Tennessee	Cumberland	Green	New	Lower Ohio
FLOWERING PLANTS continued							
Hedyotis purpurea var. montana	Mountain bluet	LE	X				
Helianthus eggertii	Eggert sunflower	PT	X	X	X		
Helonias bullata	Swamp pink	LT	X				
Isotria medeoloides	Small whorled pogonia	LT	X				
Lesquerella lyrata	Lyre-leaf bladderpod	LT	X				
Lesquerella perforata	Spring Creek bladderpod	PE		X			
Liatris helleri	Blazing star	LT				X	
Marshallia mohrii	Barbara buttons	LT	X				
Pityopsis ruthii	Ruth golden aster	LE	X				
Ptilimnium nodosum	Harperella	LE	X				
Sagittaria fasciculata	Arrowhead	LE	X				
Sagittaria secundifolia	Arrowhead	LT	X				
Sarracenia oreophila	Green pitcher plant	LE	X				
Sarracenia rubra ssp. jonesii	Mountain sweet pitcher plant	LE	X				
Schwalbea americana	Chaffseed	LE					
Scutellaria montana	Mountain skullcap	LE	X				
Sisyrinchium dichotomum	Reflexed blue-eyed grass	LE					
Solidago spithamaea	Blue ridge goldenrod	LT	X				
Spiraea virginiana	Virginia spiraea	LT		X			
Trillium persistens	Persistent trillium	LE					
Xyris tennesseensis	Yellow-eyed-grass	LE	X				
FERNS AND FERN ALLIES							
Phyllitis scolopendrium var. americanum	American harts-tongue fern	LT	X				
Thelypteris pilosa var. alabamensis	Alabama streak-sorus fern	LT					
LICHENS							
Gymnoderma lineare	Rock gnome lichen	PE	X				

[1] Status codes: LE - Listed Endangered; LT - Listed Threatened; PE - Proposed Endangered; PT - Proposed Threatened
[2] Ex = Extirpated

Mississippi Main Stem	Tributaries	Pearl	Pascagoula	Mobile	Savannah	Santee	Habitat
						X	High elevation acidic rock outcrops
				X			Hardwood forests
						X	Bogs, meadows, edges of meandering streams
							Hardwood forests
							Cedar glades
							Flood plains, agricultural fields
						X	Acidic soils of high elevation outcrops
				X			Marshes, wet meadows
							Boulders in rivers
				X			Gravel bars, rocks in rivers
							Non-forested seepage areas
							Gravel bars, rocks in rivers
				X			Bogs, wet meadows, moist woodlands
							Mountain bogs and streamsides
				X			Open, sandy, acidic pine woods
				X			Hardwood, mixed forests
						X	Rich basic soils of clearings, woodland edges
						X	Acidic, sandy balds
							Riverine gravel bars
					X		Rich ravines
				X			Forested seeps
							Cave, sinkhole mouths
				X			Crevices of Pottsville sandstone
							High elevation cliffs

Seventeen Categories of Natural Areas Appendix

National Wildlife Refuges

Name	State
Wheeler National Wildlife Refuge	AL
Lake Isom National Wildlife Refuge	TN
Reelfoot Lake National Wildlife Refuge	TN
Tennessee National Wildlife Refuge	TN
Hatchie National Wildlife Refuge	TN
Chickasaw National Wildlife Refuge	TN
Noxubee National Wildlife Refuge	MS
Cross Creeks National Wildlife Refuge	TN
Blowing Wind Cave National Gray Bat Sanctuary	AL

Wilderness Areas

Name	State
Kimberling Creek Wilderness Area	VA
Gee Creek Wilderness Area	TN
Beartown Wilderness Area	VA
Ellicott Rock Extension Wilderness Area	GA
Cohutta Wilderness Area	GA
Bald River Gorge Wilderness Area	TN
Joyce Kilmer-Slickrock Wilderness Area	NC
Ellicott Rock Wilderness Area	GA
Southern Nantahala Wilderness Area	NC
Citico Creek Wilderness Area	TN
Lewis Fork Wilderness Area	VA
Shining Rock Wilderness Area	NC
Big Frog Wilderness Area	TN
Little Dry Run Wilderness Area	VA
Little Wilson Creek Wilderness Area	VA
Sipsey Wilderness Area	AL
Linville Gorge Wilderness Area	NC

Fish Hatcheries

Name	State
Buffalo Springs State Fish Hatchery	TN
Dale Hollow National Fish Hatchery	TN
Summerville State Fish Hatchery	AL
Flintville State Fish Hatchery	TN
Cohutta National Fish Hatchery	GA
Summerville State Fish Hatchery	GA
Lake Burton State Fish Hatchery	GA
Eagle Bend State Fish Hatchery	TN
Chattahoochee National Fish Hatchery	GA
Erwin National Fish Hatchery	TN

State Scenic Rivers

Name	State
Tuckahoe Creek State Scenic River	TN
Harpeth State Scenic River	TN
Conasauga State Scenic River	TN
Chattooga National Wild And Scenic River	GA
Roaring River State Scenic River	TN
Hiwassee State Scenic River	TN
French Broad State Scenic River	TN
Spring Creek State Scenic River	TN
Hatchie State Scenic River	TN
Collins State Scenic River	TN
Blackburn Fork State Scenic River	TN
Buffalo State Scenic River	TN

Outstanding Resource Waters

Name	State
Metropolis Lake	KY
Mammoth Cave Underground River System	KY
Murphys Pond	KY
Ohio River (Livingston County)	KY
Tennessee River	KY
Barren River	KY
Ohio River (McCracken County)	KY
Green River (Butler County)	KY
Green River (Edmonson County)	KY

State Forests

Name	State
Pickett State Forest	TN
Bledsoe State Forest	TN
Scott State Forest	TN
Lewis State Forest	TN
Prentice Cooper State Forest	TN
Standing Stone State Forest	TN
Stewart State Forest	TN
Chickasaw State Forest	TN
Natchez Trace State Forest	TN
Cedars Of Lebanon State Forest	TN
Lone Mountain State Forest	TN
Franklin-Marion State Forest	TN
Chuck Swan State Forest	TN
Lebanon Forests State Forest	TN
Pennyrile State Forest	KY

Pocket Wilderness Areas

Name	State
North Chickamauga Creek Pocket Wilderness Area	TN
Virgin Falls Pocket Wilderness	TN
Laurel-Snow Pocket Wilderness	TN
Stinging Fork Falls Pocket Wilderness	TN

Mussel Sanctuaries

Name	State
Cumberland River No. 3 State Mussel Sanctuary	TN
Kentucky Reservoir No. 2 State Mussel Sanctuary	TN
Cumberland River No. 1 State Mussel Sanctuary	TN
Tennessee River Mussel Sanctuary	KY
Powell River State Mussel Sanctuary	TN
Guntersville Reservoir State Mussel Sanctuary	TN
Kentucky Reservoir No. 1 State Mussel Sanctuary	TN
Cumberland River No. 2 State Mussel Sanctuary	TN
Clinch River State Mussel Sanctuary	TN
Cumberland River Mussel Sanctuary	KY
Duck River State Mussel Sanctuary	TN
Nickajack Reservoir State Mussel Sanctuary	TN
Chickamauga Reservoir State Mussel Sanctuary	TN

Federal Committee on Ecological Reserves Research Natural Areas

Name	State
Berry Island FCER Research Natural Area	TN
Plott Cove FCER Research Natural Area	GA
Old Robinson Road FCER Research Natural Area	MS
Hematite FCER Research Natural Area	KY
Bluff City FCER Research Natural Area	AL
Walker Cover FCER Research Natural Area	NC
Black Mountain FCER Research Natural Area	NC
Dividing Ridge FCER Research Natural Area	KY
Bee Branch FCER Research Natural Area	AL
Pond Hollow FCER Research Natural Area	KY
Britton Ford FCER Research Natural Area	TN
Morgan Hill FCER Research Natural Area	MS
Goose Pond Upland Swamp FCER Research Natural Area	TN
Sinking Pond Upland Swamp FCER Research Natural Area	TN

National Natural Landmarks

Name	State
Chestnut Oak Disjunct National Natural Landmark	MS
Cedar Glade Natural Area National Natural Landmark	TN
Dismals National Natural Landmark	AL
Mt. Mitchell State Park National Natural Landmark	NC
Cathedral Caverns National Natural Landmark	AL
Beaverdam Creek Swamp National Natural Landmark	AL
Harrell Prairie Hill National Natural Landmark	MS
Reelfoot Lake National Natural Landmark	TN
Morgan Hill Research Natural Area	MS

National Natural Landmarks (continued)

Name	State
Bienville Pines Scenic Area National Natural Landmark	MS
May Prairie National Natural Landmark	TN
Big Bone Cave National Natural Landmark	TN
Taylor Hollow National Natural Landmark	TN
Piney Falls National Natural Landmark	TN
McAnultys Woods National Natural Landmark	TN
Cumberland Caverns National Natural Landmark	TN
Sinking Pond National Natural Landmark	TN
Newsome Sinks Karst Area National Natural Landmark	AL
Long Hope Creek Spruce Bog National Natural Landmark	NC
Savage Gulf National Natural Landmark	TN
Lost Sea National Natural Landmark	TN
Shelta Cave National Natural Landmark	AL
Grassy Cove Karst Area National Natural Landmark	TN
Conley Hole National Natural Landmark	TN
Goose Pond National Natural Landmark (Coffee County)	TN
Thumping Dick Cove National Natural Landmark	TN

Critical Habitat Areas

Name	State
Slender Chub Designated Critical Habitat	TN
Kentucky Cave Shrimp Designated Critical Habitat	KY
Conasauga Darter Designated Critical Habitat	GA
Indiana Bat Designated Critical Habitat	KY
Alabama Cavefish Designated Critical Habitat	AL
Spotfin Chub Designated Critical Habitat	TN
Smoky Madtom Designated Critical Habitat	TN
Slackwater Darter Designated Critical Habitat	AL
Yellowfin Madtom Designated Critical Habitat	TN
Amber Darter Designated Critical Habitat	GA

Nature Preserves

Name	State
Chaney Lake State Nature Preserve	KY
Sandy Mitchell Hollow TNC [1] Preserve	TN
Metropolis Lake State Nature Preserve	KY
Mill Creek Heronry TNC [1] Preserve	TN
Mantle Rock Nature Preserve	KY
Cressy Creek TNC Preserve	VA
Big Sheep Cliff Ridge TNC [1] Preserve	NC
Couchville Cedar Glade TNC [1] Preserve	TN
Flat Rock Glade State Nature Preserve	KY
Sunset Barrens Nature Preserve	KY
Raymond Athey Barrens State Nature Preserve	KY
Wash Morgan Hollow TNC [1] Preserve	TN
Taylor Hollow TNC [1] Preserve	TN

[1] The Nature Conservancy

Nature Preserves (continued)

Name	State
Little River Canyon National Preserve	AL
Pendleton Island TNC [1] Preserve	VA
Barnett Woods TNC Preserve	TN
Eller TNC Preserve	NC
Timber Ridge TNC Preserve	NC
Obion Creek Nature Preserve	KY
Jenkins Cranberry Bog TNC Preserve	TN
Logan County Glade State Nature Preserve	KY
Big Yellow Mountain TNC Preserve	NC
Aimee M. Rosenfield Memorial Preserve	KY
The Pinnacle TNC Preserve	VA
Woodburn Glade Nature Preserve	KY
Henry Wright TNC Preserve	NC
Hubbards Cave TNC Preserve	TN
Sneed Road Cedar Glade TNC Preserve	TN
Ochlawaha Bog TNC Preserve	NC
Mt. View Road Glade TNC Preserve	TN
Yarn Property TNC Preserve	GA
Terrapin Creek State Nature Preserve	KY
Roan Mountain TNC Preserve	NC
Powell River TNC Preserve	TN
Oak Ridge Barrens Preserve	TN

Wildlife Observation Areas

Name	State
Duck River Bottoms State Wildlife Observation Area	TN
Univ. Of Tenn. Arboretum State Wildlife Observation Area	TN
Eagle Bend Hatchery State Wildlife Observation Area	TN
Eastern State Wildlife Observation Area	TN
Chota Peninsula State Wildlife Observation Area	TN
Kingston Steam Plant State Wildlife Observation Area	TN
Big Hill Pond State Park State Wildlife Observation Area	TN
Cross Creeks National Wildlife Refuge Wildlife Observ. Area	TN
Blythe Ferry State Wildlife Observation Area	TN
Raccoon Mountain Pumped Storage State Wildlife Observ. Area	TN
Willow Grove/Lillydale State Wildlife Observation Area	TN
Nolichucky Reservoir State Wildlife Observation Area	TN
Savannah Bay/Chickamauga State Wildlife Observation Area	TN
Goose Pond State Wildlife Observation Area (Coffee County)	TN
Ijams Audubon Nature Center State Wildlife Observation Area	TN
Cove Lake State Park State Wildlife Observation Area	TN
Bledsoe Creek State Park State Wildlife Observation Area	TN
Signal Point State Wildlife Observation Area	TN
Old Hickory Trail State Wildlife Observation Area	TN
Herb Parsons Lake State Wildlife Observation Area	TN
Bays Mountain State Wildlife Observation Area	TN
Nickajack Cave State Wildlife Observation Area	TN
Monsanto Ponds Wildlife Observation Area	TN
Cyrpess Grove Nature Park Wildlife Observation Area	TN
Candies Creek/Chickamauga State Wildlife Observation Area	TN
Sugar Creek State Wildlife Observation Area	TN

Wildlife Observation Areas (continued)

Name	State
Lichterman Nature Center State Wildlife Observation Area	TN
Norris Songbird Trail State Wildlife Observation Area	TN
Erwin National Fish Hatchery State Wildlife Observation Area	TN
Elm Hill Sink Hole Wildlife Observation Area	TN
Dyson Ditch State Wildlife Observation Area	TN
Rankin Bottoms State Wildlife Observation Area	TN
Amnicola Marsh State Wildlife Observation Area	TN
Reelfoot Lake State Wildlife Observation Area	TN
Wilbur Lake State Wildlife Observation Area	TN
Alcoa Farm State Wildlife Observation Area	TN
Lake Graham State Wildlife Observation Area	TN
Mt. Roosevelt Overlook State Wildlife Observation Area	TN
Pace Point State Wildlife Observation Area	TN
Ft. Pillow Historic Area State Wildlife Observation Area	TN
Cheatham Reservoir Wildlife Management Area	TN
Percy Priest Wildlife Observation Area	TN
Radnor Lake State Wildlife Observation Area	TN
Cades Cove State Wildlife Observation Area	TN
Laurel Hill Lake State Wildlife Observation Area	TN

TVA Natural Areas

Name	State
Comby Ridge TVA Small Wild Area	TN
Riley Creek Islands TVA Habitat Protection Area	TN
Marble Bluff TVA Habitat Protection Area	TN
Possum Creek TVA Habitat Protection Area	TN
Whites Creek TVA Small Wild Area	TN
Chickamauga Shoreline TVA Habitat Protection Area	TN
Huff Branch TVA Habitat Protection Area	TN
Beech Island TVA Small Wild Area	TN
Chigger Point TVA Habitat Protection Area	TN
Big Ridge TVA Habitat Protection Area	TN
Fooshee Bend Islands TVA Habitat Protection Area	TN
Mink Creek TVA Habitat Protection Area	AL
Stowe Bluff TVA Habitat Protection Area	TN
Coffee Bluff TVA Habitat Protection Area	AL
Foster Falls TVA Small Wild Area	TN
Little Gizzard Creek TVA Small Wild Area	TN
Tribble Woods TVA Habitat Protection Area	TN
Metropolis Lake TVA Habitat Protection Area	KY
Hemlock Bluff TVA Small Wild Area	TN
Honey Bluff TVA Habitat Protection Area	AL
Clendenin Creek TVA Habitat Protection Area	TN
Lady Finger Bluff TVA Small Wild Area	TN
Sugar Grove TVA Habitat Protection Area	TN
Monks Corner TVA Small Wild Area	TN
Eagle Roost TVA Habitat Protection Area	TN
Blythe Ferry TVA Habitat Protection Area	TN
Grasshopper Creek TVA Habitat Protection Area	TN
Bayou Creek Ridge TVA Habitat Protection Area	KY
Cave Mountain TVA Small Wild Area	AL

TVA Natural Areas (continued)

Name	State
River Bluff TVA Small Wild Area	TN
Grassy Creek TVA Habitat Protection Area	TN
Stiners Woods TVA Habitat Protection Area	TN
Johnson Bend Islands TVA Habitat Protection Area	TN
Soddy Creek TVA Habitat Protection Area	TN
Fairview Slopes TVA Habitat Protection Area	TN
Armstrong Bend TVA Habitat Protection Area	TN
Butcher Bluff TVA Habitat Protection Area	TN
Norris Dam Cave TVA Habitat Protection Area	TN
Paint Rock Bluff TVA Small Wild Area	TN
Berry Island TVA Ecological Study Area	TN
Tellico Bluff TVA Ecological Study Area	TN
Three B TVA Habitat Protection Area	TN
Ware Branch Bend TVA Habitat Protection Area	TN
Honeycomb Creek TVA Small Wild Area	AL
Hematite Lake TVA Ecological Study Area	KY
Shellmound Road Bluff TVA Habitat Protection Area	TN
Nickajack Cave TVA Habitat Protection Area	TN
Little Cedar Mountain TVA Habitat Protection Area	TN
Thief Neck Island TVA Ecological Study Area	TN
Big Spring Creek TVA Small Wild Area	AL
Little Cedar Mountain TVA Small Wild Area	TN
Polecat Creek Slopes TVA Habitat Protection Area	TN
Marney Bluff TVA Habitat Protection Area	TN
Blue Springs Peninsula TVA Habitat Protection Area	TN
Murphy Hill TVA Habitat Protection Area	TN
Eaves Bluff TVA Habitat Protection Area	TN
Blowing Wind Cave TVA Habitat Protection Area	AL
Nickajack Cave TVA Small Wild Area	TN
Johnson Bottoms TVA Habitat Protection Area	TN
Panther Creek Swamp TVA Habitat Protection Area	KY
Alley Bluff TVA Habitat Protection Area	TN
Coon Gulf TVA Small Wild Area	AL
Dividing Ridge TVA Ecological Study Area	KY
Pond Hollow TVA Ecological Study Area	KY
Bear Creek TVA Habitat Protection Area	TN
Old First Quarters TVA Small Wild Area	AL
Rayburn Bridge TVA Habitat Protection Area	TN
Mccuiston Woods TVA Habitat Protection Area	KY
Long Island TVA Habitat Protection Area	TN
Cooper Falls TVA Habitat Protection Area	MS
Short Springs TVA Small Wild Area	TN
South Sauty Creek TVA Small Wild Area	AL
Big Ridge TVA Small Wild Area	TN
Fooshee Peninsula TVA Small Wild Area	TN

State Parks

Name	State
Marion Bridge TVA Habitat Protection Area	TN
Hungry Mother State Park	VA
Mousetail Landing State Rustic Park	TN
Tishomingo State Park	MS
Joe Wheeler State Park	AL
Pickwick Landing State Resort Park	TN
Reelfoot Lake State Resort Park	TN
Big Ridge State Rustic Park	TN
Meeman-Shelby Forest State Recreational Park	TN
Black Rock Mountain State Park	GA
Lake Lowndes State Park	MS
Lake Malone State Park	KY
Kenlake Resort State Park	KY
Fort Mountain State Park	GA
Tombigbee State Park	MS
Norris Dam State Resort Park	TN
Cedars Of Lebanon State Recreational Park	TN
Cumberland Mountain State Rustic Park	TN
Warriors Path State Recreation Park	TN
Rough River Dam Resort State Park	KY
Cossar State Park	MS
Shot Tower State Historical Park	VA
Blackburn State Park	GA
Monte Sano State Park	AL
Rickwood Caverns State Park	AL
Lake Barkley State Resort Park	KY
Bucks Pocket State Park	AL
Edgar Evins State Rustic Park	TN
Chickasaw State Rustic Park	TN
Long Hunter State Recreation Park	TN
Roan Mountain State Resort Park	TN
Rock Island State Rustic Park	TN
Panther Creek State Recreation Park	TN
T.O. Fuller State Recreation Park	TN
Grayson Highlands State Park	VA
Kentucky Dam Village State Resort Park	KY
Dale Hollow Lake State Park	KY
Mt. Mitchell State Park	NC
Cathedral Caverns State Park	AL
Lake Guntersville State Park	AL
Pennyrile Forest Resort State Park	KY
Breaks Interstate State Park	VA
Vogel State Park	GA
Roosevelt State Park	MS
Wall Doxey State Park	MS
Big Hill Pond State Park	TN
Henry Horton State Resort Park	TN
David Crockett State Recreation Park	TN
Trace State Park	MS
Indian Mountain State Camping Park	TN
Pickett State Rustic Park	TN
Bledsoe Creek State Camping Park	TN

State Parks (continued)

Name	State
Paris Landing State Resort Park	TN
Davy Crockett Birthplace State Historical Park	TN
Booker T. Washington State Recreation Park	TN
Cove Lake State Recreation Park	TN
Montgomery Bell State Resort Park	TN
Tims Ford State Rustic Park	TN
Standing Stone State Rustic Park	TN
Fall Creek Falls State Resort Park	TN
Natchez Trace State Resort Park	TN
Cloudland Canyon State Park	GA
J.P. Coleman State Park	MS
John W. Kyle State Park	MS
Bays Mountain Park State Natural Area	TN
Moccasin Creek State Park	GA
James H. Sloppy Floyd State Park	GA
Desoto State Park	AL
Columbus-Belmont Battlefield State Park	KY
Natural Tunnel State Park	VA
Ft. Mountain State Park	GA
George P. Cossar State Park	MS
Harrison Bay State Recreation Park	TN

State Natural Areas

Name	State
Flat Rock Mountain Registered State Natural Area	NC
Basin Spring Registered State Natural Area	TN
Shortleaf Pine State Natural Area	MS
Trotters Woods Registered State Natural Area	TN
White Oak State Natural Area	MS
Big Yellow Mountain Registered State Natural Area	NC
Grandfather Mountain Registered State Natural Area	NC
Walterhill Floodplain State Natural Area	TN
Stinging Fork State Natural Area	TN
Bayou Creek Registered State Natural Area	KY
Radnor Lake State Natural Area	TN
Factory Road Glade Registered State Natural Area	TN
Warren Wilson College Biol. Reserve Registered State Nat. Area	NC
Natural Bridge State Natural Area	TN
Colditz Cove State Natural Area	TN
Falling Waters Falls State Natural Area	TN
Honey Creek State Natural Area	TN
Carter Caves State Natural Area	TN
Sandy Bottom Registered State Natural Area	NC
Zahnd State Natural Area	GA
Goose Pond Registered State Natural Area (Coffee County)	TN
Balsam Gap Registered State Natural Area	NC
Lesser Alcoa Marsh Registered State Natural Area	TN
Big Clifty Prairie State Natural Area	KY
Bear Creek Rookery State Natural Area	KY
Sweetwater Branch Registered State Natural Area	TN
Ochlawaha Bog Registered State Natural Area	NC

State Natural Areas (continued)

Name	State
Gap Bog Registered State Natural Area	NC
Redbank Cove Registered State Natural Area	NC
Mt. Mitchell Park Registered State Natural Area	NC
Mt. Pisgah Registered State Natural Area	NC
Twin Arches State Natural Area	TN
Satulah Mountain Summit Registered State Natural Area	NC
Riverwoods State Natural Area	TN
James Avent Woodlot Registered State Natural Area	TN
Ames Plantation Registered State Natural Area	TN
Wildcat Hollow Registered State Natural Area	TN
Franklin Bog Registered State Natural Area	NC
Laurel-Snow State Natural Area	TN
Dunbar Cave State Natural Area	TN
Camp Branch Falls/Nantahala Gorge Registered State Natural Area	NC
Slagle Hollow Knobs/Steele Creek Park Registered State Nat. Area	TN
Barkley Prairie State Natural Area	KY
Browder Woods Registered State Natural Area	TN
Booger Swamp Registered State Natural Area	TN
Brady Mountain Registered State Natural Area	TN
Olive Preserve Registered State Natural Area	NC
Dripping Rock Bluff Registered State Natural Area	TN
Piney Falls State Natural Area	TN
Oak Ridge Barrens Registered State Natural Area	TN
Wright White Pine Stand Registered State Natural Area	TN
Metropolis Lake Registered State Natural Area	KY
Bear Creek Registered State Natural Area	TN
Grassy Pond Registered State Natural Area	TN
Steestachee Bald/Wesner Bald Registered State Natural Area	NC
Carmack Falls Registered State Natural Area	TN
Toxaway Creek/Rock Creek Registered State Natural Area	NC
Virgin Falls State Natural Area	TN
Short Mountain Registered State Natural Area	TN
Morrill Cave State Natural Area	TN
Fall Creek Falls State Natural Area	TN
Richland Balsam Registered State Natural Area	NC
Burgess Falls State Natural Area	TN
Hicks Gap State Natural Area	TN
North Fork Natural Area Registered State Natural Area	NC
Sinking Pond Registered State Natural Area	TN
Big Sheep Cliff Ridge Registered State Natural Area	NC
Sullenger Bend Registered State Natural Area	TN
Waterrock Knob Registered State Natural Area	NC
Memmingers Woods Registered State Natural Area	NC
Henry Wright Preserve Registered State Natural Area	NC
Great Smoky Mts. National Park/NC Registered State Nat. Area	NC
Bluebell Island Registered State Natural Area	TN
Julian Price Park Wetlands Registered State Natural Area	NC
Grandfather Mountain Corridor Registered State Natural Area	NC
Reelfoot Lake State Natural Area	TN
Scales Mountain Knobs Registered State Natural Area	TN
House Mountain State Natural Area	TN
Cedars Of Lebanon State Forest State Natural Area	TN

State Natural Areas (continued)

Name	State
Thompson Fossil Bed Registered State Natural Area	TN
Tanager Hill Registered State Natural Area	TN
The Craggies Registered State Natural Area	NC
Fork Ridge Balds/Mt. Hardy Registered State Natural Area	NC
Walker Branch Registered State Natural Area	TN
Frying Pan Gap Registered State Natural Area	NC
Back Slough/Laketon State Natural Area	KY
Tallahatchie State Natural Area	MS
Mosley Pond State Natural Area	KY
Malcolm Creek Rookery State Natural Area	KY
Rials Woods State Natural Area	KY
Forest Mill Pond Registered State Natural Area	TN
Hampton Creek Cove Class I State Natural Area	TN
Big Cypress Tree State Natural Area	TN
Joe Bryson Branch Registered State Natural Area	NC
Metal Ford Registered State Natural Area	TN
May Prairie State Natural Area	TN
Round Top Mountain State Natural Area	TN
Little Swan Creek Registered State Natural Area	TN
Pinky Falls Preserve Registered State Natural Area	NC
Horsepasture River Gorge/Windy Falls Registered State Nat. Area	NC
Hunter Bog Registered State Natural Area	TN
Little Buffalo River Bottoms Registered State Natural Area	TN
Short Mountain State Natural Area	TN
Pineola Bog Registered State Natural Area	NC
Warner Parks Registered State Natural Area	TN
Shelby Farms Forest State Natural Area	TN
Frozen Head State Natural Area	TN
Buck Creek Olivine Barrens Registered State Natural Area	NC
Stones River Mustard Field State Natural Area	TN
Sunk Lake State Natural Area	TN
Flat Laurel Registered State Natural Area	NC
Chestnut Bald/Silvermine Bald Registered State Natural Area	NC
Laurel Ridge Registered State Natural Area	NC
Flint River Bottoms Registered State Natural Area	TN
Wootens Bluff Registered State Natural Area	TN
Hawkins Cove State Natural Area	TN
Bone Cave State Natural Area	TN
Lacefield Falls Registered State Natural Area	TN
High Swan Natural Area Registered State Natural Area	NC
Grundy Forest State Natural Area	TN
Bays Mountain Park State Natural Area	TN
Piney Point State Natural Area	MS
McClures Bog Registered State Natural Area	NC
Dulany Bog Registered State Natural Area	NC
Savage Gulf State Natural Area	TN
Lake Barkley Rookery State Natural Area	KY
Big Ridge Registered State Natural Area	TN
Bottomland Hardwood State Natural Area	MS
Ozone Falls State Natural Area	TN
Greater Alcoa Marsh Registered State Natural Area	TN
Magendanz Falls Registered State Natural Area	TN

State Natural Areas (continued)

Name	State
Dennis Prairie State Natural Area	KY
Lick Creek State Natural Area	VA

Wildlife Management Areas

Name	State
Bean Switch Refuge State Wildlife Management Area	TN
Black Bayou Refuge State Wildlife Management Area	TN
Edgar Evins State Park Wildlife Management Area	TN
Ernest Rice Sr. State Wildlife Management Area	TN
Gallatin Steam Plant State Wildlife Management Area	TN
Haley-Jaqueth State Wildlife Management Area	TN
Horns Bluff Refuge State Wildlife Management Area	TN
Jackson Swamp State Wildlife Management Area	TN
Jarrell Switch State Wildlife Management Area	TN
Keyes-Harrison State Wildlife Management Area	TN
Maness Swamp Refuge State Wildlife Management Area	TN
Mustin Bottoms Refuge State Wildlife Management Area	TN
Obion River State Wildlife Management Area	TN
Pea Ridge State Wildlife Management Area	TN
White Lake Refuge State Wildlife Management Area	TN
Upper Sardis State Wildlife Management Area	MS
M.T.S.U. State Wildlife Management Area	TN
White Oak State Wildlife Management Area	TN
Bienville State Wildlife Management Area	MS
Caney Creek State Wildlife Management Area	MS
Catoosa State Wildlife Management Area	TN
Johns Mountain State Wildlife Management Area	GA
Oak Ridge State Wildlife Management Area	TN
Perryville State Wildlife Management Area	TN
Chickamauga State Wildlife Management Area	TN
Big Sandy State Wildlife Management Area	TN
Tradewater Wildlife Management Area	KY
Normandy State Wildlife Management Area	TN
Watts Bar State Wildlife Management Area	TN
Percy Priest State Wildlife Management Area	TN
Phipps Bend Refuge State Wildlife Management Area	TN
Freedom Hills State Wildlife Management Area	AL
Cove Creek Peninsula State Wildlife Management Area	TN
Cordell Hull Refuge State Wildlife Management Area	TN
Nolin Lake State Wildlife Management Area	KY
Tellico Lake State Wildlife Management Area	TN
Skyline State Wildlife Management Area	AL
Reelfoot Lake/Tenn. State Wildlife Management Area	TN
Chickasaw/Miss. State Wildlife Management Area	MS
Eastern State Wildlife Management Area	TN
Barkley Reservoir/Tenn. State Wildlife Management Area	TN
Barkley Lake Wildlife Management Area	KY
Aedc And Woods State Wildlife Management Area	TN
Tigrett State Wildlife Management Area	TN
Grenada Waterfowl Refuge State Wildlife Management Area	MS
Coopers Creek State Wildlife Management Area	GA

Wildlife Management Areas (continued)

Name	State
North Sauty Creek State Wildlife Management Area	AL
Hidden Valley State Wildlife Management Area	VA
Buffalo Springs State Wildlife Management Area	TN
Peal Land Wildlife Management Area	KY
Gallatin Steam Plant State Wildlife Management Area	TN
Pigeon Mountain State Wildlife Management Area	GA
Shelby Forest State Wildlife Management Area	TN
Cumberland Cove State Wildlife Management Area	TN
Cohutta State Wildlife Management Area	GA
Dale Hollow Lake Wildlife Management Area	KY
Land Between The Lakes/Tenn. State Wildlife Management Area	TN
Mallard-Fox Creek State Wildlife Management Area	AL
Fall Creek Falls State Wildlife Management Area	TN
Sevenmile Island State Wildlife Management Area	AL
Lick Creek State Wildlife Management Area	TN
Eagle Creek State Wildlife Management Area	TN
Cumberland Springs State Wildlife Management Area	TN
Cedar Hill Swamp State Wildlife Management Area	TN
Camden State Wildlife Management Area	TN
Alpine Mountain State Wildlife Management Area	TN
Cherokee (South) State Wildlife Management Area	TN
Chilhowee Mountain State Wildlife Management Area	TN
Hermitage State Wildlife Management Area	TN
Chuck Swan State Wildlife Management Area	TN
Anderson-Tully (Lower) State Wildlife Management Area	TN
Blythe Ferry State Wildlife Management Area	TN
Flintville Hatchery State Wildlife Management Area	TN
Rich Mountain State Wildlife Management Area	GA
Pennyrile Forest State Wildlife Management Area	KY
Swallow Creek State Wildlife Management Area	GA
Old Hickory State Wildlife Management Area	TN
Clinch Mountain State Wildlife Management Area	VA
Land Between The Lakes/Ky State Wildlife Management Area	KY
Swan Creek State Wildlife Management Area	AL
Ohio River Islands Wildlife Management Area	KY
Coleman River State Wildlife Management Area	GA
Raccoon Creek State Wildlife Management Area	AL
Henderson Island Refuge State Wildlife Management	TN
West Sandy State Wildlife Management Area	TN
Hiwassee Refuge State Wildlife Management Area	TN
Reelfoot Lake/Ky State Wildlife Management Area	KY
Volunteer Army Ammunition Plant State Wildlife Management Area	TN
Black Warrior State Wildlife Management Area	AL
Barren River Lake State Wildlife Management Area	KY
Prentice Cooper State Wildlife Management Area	TN
Lake Burton State Wildlife Management Area	GA
Jones Keeney Wildlife Management Area	KY
Yellow Creek State Wildlife Management Area	MS
West Kentucky State Wildlife Management Area	KY
Warwoman State Wildlife Management Area	GA
Ft. Campbell State Wildlife Management Area	KY

Wildlife Management Areas (continued)

Name	State
Choctaw State Wildlife Management Area	MS
Calhoun County State Wildlife Management Area	MS
Coosawattee State Wildlife Management Area	GA
Natchez Trace State Wildlife Management Area	TN
Kaler Bottoms Wildlife Management Area	KY
Chestatee State Wildlife Management Area	GA
Mud Creek State Wildlife Management Area	AL
Chattahoochee State Wildlife Management Area	GA
Okitibbee State Wildlife Management Area	MS
Blue Ridge State Wildlife Management Area	GA
Harmon Creek State Wildlife Management Area	TN
Winford Pond State Wildlife Management Area	KY
Chickasaw/Tenn. State Wildlife Management Area	TN
Old Hickory Lock 5 State Wildlife Management Area	TN
Pickett State Wildlife Management Area	TN
New Hope State Wildlife Management Area	TN
Cheatham State Wildlife Management Area	TN
Cordell Hull State Wildlife Management Area	TN
Standing Stone State Wildlife Management Area	TN
Gooch State Wildlife Management Area	TN
Lauderdale County State Wildlife Management Area	AL
Rankin Bottom State Wildlife Management Area	TN
Moss Island State Wildlife Management Area	TN
Doe Mountain State Wildlife Management Area	TN
Kingston Refuge State Wildlife Management Area	TN
Nathan Bedford Forrest State Wildlife Management Area	TN
Nolichucky State Wildlife Management Area	TN
Cheatham Reservoir Wildlife Management Area	TN
Rough River State Wildlife Management Area	KY
Talking Rock State Wildlife Management Area	GA
Little River State Wildlife Management Area	AL
John Bell Williams State Wildlife Management Area	MS
Crow Creek Refuge State Wildlife Management Area	AL
Kentucky Lake Wildlife Management Area	KY
Laurel Hill State Wildlife Management Area	TN
Sardis Waterfowl Refuge State Wildlife Management Area	MS
Cherokee (North) State Wildlife Management Area	TN
Crow Creek State Wildlife Management Area	AL
Lamarion State Wildlife Management Area	AL
Cheatham Reservoir State Wildlife Management Area	TN
Royal Blue State Wildlife Management Area	TN
Mt. Roosevelt State Wildlife Management Area	TN

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Glossary

The development of Energy Vision 2020, using TVA's interactive planning process, requires the careful, consistent use of certain key terms and phrases. Below are definitions of terms used often in Volume 2, Technical Document 1, Comprehensive Affected Environment. (Terms in definitions which are themselves defined in the Glossary are printed in *italics*.)

A

Acid Deposition—The wet or dry deposition of acid chemical compounds from the atmosphere.

Acid Rain—A complex chemical and atmospheric phenomenon that occurs when *emissions* of sulfur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on Earth in either a wet or dry form. The wet forms, popularly called "acid rain," can fall as rain, snow, or fog. The dry forms are acidic gases or *particulates*.

Aesthetics—The perception or appearance of visual features in relation to the sense of beauty.

Agricultural Sector—The group of non-residential customers engaged in the production of crops or livestock, forestry, fishing, hunting, or trapping.

Air Toxins—Various man-made and naturally occurring materials that are known or suspected of causing serious public health impacts, but for which no *National Ambient Air Quality Standards* exist.

Alluvial—Sediment deposited by flowing water.

Ambient—Surrounding.

Ambient Air Quality Standards—National standards set by the U.S. *Environmental Protection Agency* that are permissible concentration levels of certain pollutants (new *ozone, carbon monoxide, particulates (PM 10), sulfur dioxide, nitrogen dioxide,* and *lead*) in the *ambient* air.

Anaerobic—Life in the absence of air or free oxygen.

Aquatic—Characteristic of and/or pertaining to water.

Aquifer—A water-bearing rock, rock formation, or group of rock formations.

Archaeological Resources—Material remains of past human activity.

Attainment Areas—Those areas that meet all *National Ambient Air Quality Standards* as determined by monitoring of air pollutant levels.

B

Benthic Invertebrates—An animal lacking a backbone or spinal column and living on lake bottoms.

Benthos—Organisms that live on or in the first few inches of mud, sand, gravel, or other materials that make up the bottom of streams and lakes, e.g. worms, snails, crayfish, mussels, clams.

Biodiversity—The diversity of life in all its forms and all its levels of organization. Also termed "biological diversity".

Biomagnification—The bioaccumulation of chemicals in organisms beyond the concentration expected if the chemical was in equilibrium between the organism and its surroundings. Biomagnification can occur in both terrestrial and *aquatic* environments.

Biomass—Organic material. Often involves the harvesting of stands of close-growing whole trees, truck transport, tree storage, and drying using air heated by boiler flue gas and combustion of whole trees in a special deep-bed burner at the bottom of the furnace.

Buffering Capacity—Ability of a stream to absorb acids and bases without altering the stream *pH*.

C

Canopy—Refers to the layer of foliage in a forest formed by the crowns of trees.

Carbon Dioxide (CO_2)—A colorless, odorless, nonpoisonous gas that results from fossil fuel combustion and is normally a part of the *ambient* air. Increasing levels of *carbon dioxide* in the atmosphere are contributing to the *greenhouse effect.*

Carbon Monoxide (CO)—A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

Cedar Glades—Distinctive plant communities occurring where certain types of limestone weather to produce bare rock outcrops or thin layers of soil.

CFCs—*Chlorofluorocarbons.*

CH_4—*Methane.*

Chlorofluorocarbons (CFCs)—A family of inert, nontoxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging, and insulation or as solvents and aerosol propellants. Because *CFCs* are not destroyed in the lower atmosphere, they drift into the upper atmosphere, where their chlorine components destroy *ozone.*

Class I Areas—Areas designated by the Prevention of Significant Deterioration section of the *Clean Air Act Amendments of 1977* that includes national parks and wilderness areas, providing special protection for air quality and air quality-related values.

Clean Air Act Amendments of 1970—Enabling legislation which instructs the *Environmental Protection Agency (EPA)* to set air quality standards for pollutants of concern.

Clean Air Act Amendments of 1977—Legislation that provides greater regulatory authority and sets specific provisions to protect national parks and wilderness areas designated as *Class I areas.*

Clean Air Act Amendments of 1990—Legislation that adds additional regulatory authority to enforce compliance in *nonattainment areas.* Also sets new requirements for *acid rain, hazardous air pollutants,* and monitors and reports air *emissions.*

Climate Change Action Plan—The principal utility industry component of the U.S. Department of Energy's Climate Change Action Plan, provides for a voluntary reduction of *greenhouse gases* (primarily *carbon dioxide emissions*).

CO—*Carbon Monoxide.*

CO_2—*Carbon Dioxide.*

Community—An assemblage of plants, animals, bacteria, and fungi that live in an environment and interact with one another, forming a distinctive living system with its own composition, structure, environmental relations, development, and functions.

Criteria—Used in integrated resource planning. They are derived from issues or concerns. Examples include concerns over future rates, acceptable levels of environmental impacts, etc.

E

Ecosystem—Any unit that includes all organisms (i.e., the *community*) in a given area interacting with the physical environment. The flow of *energy* leads to a clearly defined trophic structure, biotic diversity and material cycles (i.e., exchange of materials between living and nonliving parts within the system).

Effluent—Wastewater—treated or untreated—that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Electric and Magnetic Fields (EMF)—Two types of *energy* fields which are emitted from any device that generates, transmits, and uses electricity.

Embayment—A body of water forming a bay.

EMF—*Electric and Magnetic Fields.*

Emission—Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Endangered Species—Any species in danger of extinction throughout all or a significant portion of its range or territory.

Energy—The amount of power consumed over a period of time, measured in watt hours, *kWH*, *MWh*, or *GWh*.

Environmental Protection Agency (EPA)—A federal agency established to permit coordinated and effective governmental action for protection of the environment by the systematic abatement and control of pollution through integration of research monitoring, standard setting, and enforcement activities.

EPA—*Environmental Protection Agency.*

Erosion—The process by which soil particles are detached and transported by water and gravity to some downslope or downstream point.

F

Fly Ash—The small ash particles that are carried out of a combustor with the existing flue gas. These particles are collected by appropriate equipment prior to discharging the flue gas to the atmosphere.

Forest Cover Type—A descriptive classification of forest land based on present occupancy of an area by tree species (also known as "forest type"), such as:

- **Oak-hickory.** Forests in which upland oaks and/or hickory, make up the majority of trees.
- **Oak-pine.** Forests in which hardwoods (usually upland oaks) constitute the majority of trees but in which pines

account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow poplar.)

Fossil Fuel Power Plant—A plant using coal, oil, natural gas or other fossil fuel as its source of *energy*.

G

Geography—Belonging to or characteristic of a particular region.

Global Warming—The theory that certain gases such as *carbon dioxide (CO_2)*, *methane (CH_4)*, and *chlorofluorocarbon (CFC)* in the earth's atmosphere effectively restrict radiation cooling, thus elevating the earth's *ambient* temperatures.

Greenhouse Effect—The build-up of *carbon dioxide* or other trace gases that allows light from the sun's rays to heat the Earth but prevents a counterbalancing loss of heat.

Greenhouse Gas Emissions—A gas whose presence in the upper atmosphere contributes to the *greenhouse effect* by allowing visible light to pass through the atmosphere while preventing heat radiating back from the Earth from escaping. Greenhouse gases from human produced sources include *carbon dioxide, nitrous oxide, methane*, and *chlorofluorocarbons (CFCs)*. There also are even larger quantities of naturally occurring greenhouse gases, notably *ozone* and water vapor, whose concentrations may be affected by interactions with atmospheric pollutants.

Groundwater—Water within the earth or geologic stratum that supplies wells and springs.

H

Habitat—The total environmental conditions on a unit of land including food, cover, and water within the home range.

Habitat Diversity—The variety and variability of habitat types, as well as their interrelationships on a given area and scale.

HAP—*Hazardous Air Pollutants.*

Hardwoods—Angiosperms, usually broadleaf and deciduous. Soft hardwoods are soft-textured hardwoods such as boxelder, red and silver maples, hackberry, sweetgum, yellow poplar, blackgum, sycamore, black cherry, and elm. Hard hardwoods are hard-textured hardwoods such as sugar maple, hickory, dogwood, persimmon, black locust, beech, ash, black walnut, and all commercial oaks.

Hazardous Air Pollutants (HAP)—Air pollutants that are not covered by *ambient* air quality standards but that present, or may present, a threat of adverse health or environmental effects. These include an initial list of 189 chemicals designated by Congress and subject to revision by the *Environmental Protection Agency*.

Hazardous Waste—A byproduct of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special *Environmental Protection Agency* lists.

Haze—Atmospheric moisture, dust, smoke, and vapor suspended to form a partly opaque condition.

Heavy Metals—Natural elements such as lead, mercury, cadmium, and nickel. They are mined from the earth and used in numerous manufacturing processes and countless products.

High-Level Waste—Material that is highly radioactive. In a nuclear power plant high-level waste is *spent fuel*.

Historic Site—See *Archaeological Resources*.

Hydroelectric Power Generation—A dam creates an upper and a lower water reservoir. The height difference between the two reservoirs establishes potential *energy* that is used to generate electricity by allowing water from the upper reservoir to flow through a hydro *turbine* to the lower reservoir.

I

Impoundment—A body of water or sludge confined by a dam, dike, floodgate, or other barrier.

K

Karst (Topography)—The relief of an area underlaid by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins.

Karst Region—A particular geographic region of irregular limestone in which *erosion* has produced fissures, sinkholes, underground streams, and caverns.

L

Lacustrine—Living or growing in lakes; of or related to lakes.

Lead (Pb)—A *heavy metal* that is hazardous to health if breathed or swallowed. Its use in gasoline, paints, and plumbing compounds has been sharply restricted by federal regulations, but enormous quantities of

lead already released into the environment are causing significant problems.

Low-Level Waste—Radioactive material that is slightly or moderately radioactively contaminated. Low-level radioactive waste consists largely of ordinary trash and other items that have come into contact with radioactive materials.

M

Mainstream Reservoirs—Reservoirs on large rivers such as the Tennessee River.

Manganese (Mn)—A hard and brittle metallic element that resembles iron but is not magnetic.

Mature Trees—Stands of trees that have grown into the sawtimber class but have not yet begun to decline and die from natural processes.

Methane (CH_4)—A *greenhouse gas* that is colorless, nonpoisonous, and flammable and is created by anaerobic decomposition of organic compounds.

Mobile Sources—Transportation air pollution sources, primarily automobiles and trucks.

Multi-Attribute Trade-off Analysis/ Technique—An approach designed for interactive participation by a group to make dual comparisons among different attributes for many strategies. It provides an open framework for public involvement to investigate different attributes, futures, and strategies.

N

N_2O—*Nitrous Oxide.*

NAAQS—*National Ambient Air Quality Standards.*

NAPAP—*National Acid Precipitation Assessment Program.*

National Acid Precipitation Assessment Program (NAPAP)—A 10-year scientific study conducted by the federal government from 1980 to 1990 to determine the effects of, and sources contributing to, *acid deposition*.

National Ambient Air Quality Standards (NAAQS)—Uniform, national air quality standards established by the *Environmental Protection Agency* that restrict *ambient* levels of certain pollutants to protect public health (primary standards) or public welfare (secondary standards). Standards have been set for *ozone, carbon monoxide, particulates (PM10), sulfur dioxide, nitrogen, nitrogen dioxide,* and *lead*.

Native Species—Species normally indigenous to an area; not introduced by man.

Natural Resources—The elements of the natural environment that are evaluated as resources (i.e., water resources, forests).

Nitrogen Dioxide (NO_2)—The result of *nitric oxide* combining with oxygen in the atmosphere. A major component of photochemical smog.

Nitrogen or Nitrous Oxide (NOx)—A product of combustion by mobile and stationary sources and a major contributor to the formation of *ozone* in the *troposphere* and *acid deposition*.

NO_2—*Nitrogen Dioxide.*

Nonattainment Area—A geographic area that does not meet one or more of the *National Ambient Air Quality Standards* for the *criteria* pollutants designated in the Clean Air Act.

Non-Point Sources—Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm water runoff.

NO_X—*Nitrogen Oxide or Nitrous Oxide.*

O

Ozone (O_3)—A substance found in the stratosphere and the *troposphere*. In the stratosphere (the atmospheric layer beginning 7 to 10 miles above the Earth's surface) ozone is a form of oxygen found naturally that provides a protective layer shielding the Earth from ultraviolet radiation. In the *troposphere* (the layer extending up 7 to 10 miles from the Earth's surface), ozone is a chemical oxidant and a major component of photochemical smog.

Ozone can seriously affect the human respiratory system and is one of the most widespread of all the *criteria* pollutants. Ozone in the *troposphere* is produced through complex chemical reactions of *nitrogen oxides*, which are among the primary pollutants emitted by combustion sources; hydrocarbons, released into the atmosphere through the combustion, handling, and processing of hydrocarbon products and sunlight.

P

Palustrine—Relating to marshes or wetlands.

Particulate—Minute separate particles.

Particulate Collection Devices—Environmental control systems (i.e., electrostatic precipitators, baghouses) designed to remove suspended particulate matter (i.e., *fly ash*) from coal-fired boiler flue gas.

Parts per Million—The number of parts of a given substance or pollutant in a million parts of a base material; a measure of concentration.

PCBs—Polychlorinated byphenals.

pH—A measure of the acidity or alkalinity of a solution. pH is represented on a scale of 0 to 14, with 7 being a neutral state, 0 most acid, and 14 most alkaline.

Physiographic Provinces—Systematic description of areas with some point of physical geology in common.

Plume—A flowing, often somewhat conical, trail of *emissions* from a continuous *point source*.

Point Sources—A stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, for example, a pipe, ditch, ship, ore pit, or factory smokestack.

PM10—Minute separate particles equal to 10 microns or less.

Prevention of Significant Deterioration (PSD)—An *Environmental Protection Agency* program in which state or federal permits are required that are intended to restrict *emissions* for new or modified sources in places where air quality is already better than required to meet primary and secondary *ambient air quality standards*.

Primary Particulate Matter—Particles emitted directly from a source.

R

Radionuclides—Radioactive nuclides.

Regional Haze—A type of visibility impairment which is the result of dispersed and intermixed pollutants from many sources.

Residential—The group of customers to whom electricity is sold for household purposes, including space heating, water heating, air conditioning, lighting, and appliances in single-family, multifamily, and mobile homes.

River Substrate—A layer of material or substance in a river.

S

Scrubber—A device that removes *sulfur dioxide* from flue gas using lime or limestone.

Scrubber Sludge—The *effluent* from a scrubber that is then discharged and is stored in a solid landfill, principally as a calcium sulfate.

Secondary Particulate Matter—Particles formed in the atmosphere from emitted gases.

Sedimentation—The action or process of depositing sediment.

Seedling—Live trees of species less than 1.0 inch in diameter at 4.5 feet above ground that are expected to survive and develop.

Sensitive Species—Species that are listed with states as needing special management.

Short Rotation Woody Crops—Plants grown on a relatively short rotation schedule for the explicit purpose of harvesting for use in power production.

SO_2—*Sulfur Dioxide.*

Soil—A dynamic natural medium composed of mineral and organic materials in which plants grow.

Sorbent—A substance that takes up and holds or absorbs.

Species—A class of individuals having common attributes and designated by a common name.

Spent Fuel—Nuclear fuel that can no longer economically sustain a chain reaction.

Streams—A continually, frequently, or infrequently flowing body of water that follows a defined course. The three classes of streams are:

- **Ephemeral.** A channel that carries water only during and immediately following rainstorms. Also known as a "dry wash."
- **Intermittent.** A watercourse that flows in a well-defined channel during the wet seasons of the year, but not the entire year.
- **Perennial.** A watercourse that flows throughout the year or nearly so (90 percent of time) in a well-defined channel.

Succession—A process of biotic community development that involves changes in species, structure, and community processes over time.

Sulfur Dioxide (SO_2)—A heavy, pungent, colorless, gaseous air pollutant formed primarily by the combustion of fossil-fuel plants.

Surface Water—Streams, rivers, ponds, lakes, and man-made reservoirs.

Surrogate Measure—A substitute measure that varies in the same way as the pollutant and environmental effects it represents.

T

Tailwater—Water downstream from a dam, including those waters released from the dam.

Thermal Rejection— Release of heat.

Thermal Stratification—Layering of water with different temperatures, where it is warmer near the surface and colder near the bottom.

Threatened Species— Any species which is likely to become an endangered species within the foreseeable future.

Topography—The physical features of a place or region. Commonly refers to land forms and variation in elevation.

Troposphere—Lower atmosphere.

TSP—Total suspended *particulate* matter.

Turbine—A machine for directly converting the kinetic and/or thermal *energy* of a flowing fluid (air, hot gas, steam, or water) into useful rotational *energy*.

V

Visibility Impairment or Degradation— *Aesthetic* damage where the ability to discern form, color, or texture is reduced and therefore the scenic value is also diminished. Or, as stated in 40 CFR 51.30, visibility impairment is "…any humanly perceptible change in visibility (visual range, contrast, coloration) from that which would have existed under natural conditions."

Visual Quality Zones (VQZs)—Areas of the landscape denoted by specified distances from the observer. Used as a frame of reference in which to discuss landscape characteristics or activities of man, sometimes referred to as "distance zones."

Volatile Organic Compounds (VOCs)— Any organic compound that participates in atmospheric photochemical reactions except for those designated by the *Environmental Protection Agency* administrator as having negligible photochemical reactivity.

W

Water Quality—A term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose.

Watershed—The entire area that contributes to a drainage or stream.

Wetland—Area with soils saturated with water during the growing seasons and supporting plants characteristic of wet conditions.

Z

Zebra Mussel—An imported mussel which interferes with, among other things, water intake structures.

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Energy Vision

2020

2

Volume 2, Technical Document

Environmental Consequences

Summary

One of TVA's broad strategic goals is environmental responsibility. Energy Vision 2020 approaches this goal in a way that is fundamentally different than most environmental reviews—environmental concerns have been fully integrated into the planning process.

This document addresses the environmental aspects of the evaluation process and provides additional scientific and analytical, or technical, basis for comparing the impact of alternative energy strategies on the environment. Cumulative potential environmental impacts are addressed. In addition, potential socioeconomic impacts are addressed.

The assessment is made at a macro, or regional, scale rather than at a micro, site-specific scale.

Volume 2, Technical Document 2

Environmental Consequences

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SECTION 8: MITIGATION OF ADVERSE ENVIRONMENTAL AND UNAVOIDABLE IMPACTS

SECTION 9: ENVIRONMENTAL CONSULTATION, REVIEW, AND PERMIT REQUIREMENTS

Environmental Consequences

Introduction

Numerous surveys and opinion polls indicate that most Americans hold protection of the environment as very important. TVA Board Chairman Craven Crowell has emphasized that no major business activity will succeed without a high regard for the environment and that TVA must be environmentally responsible.

In keeping with these sentiments, one of TVA's broad strategic goals is environmental responsibility. Energy Vision 2020 approaches this goal in a way that is fundamentally different than most environmental reviews—environmental concerns have been fully integrated into the planning process. This has allowed TVA to reformulate energy resource strategies to mitigate potential environmental impact, lessening the need to trade off environmental protection for economic cost savings.

This document addresses the environmental aspects of the evaluation process and provides additional scientific and analytical, or technical, basis for comparing the impact of alternative energy strategies on the environment. The document also examines and compares both direct and indirect potential environmental impacts associated with each strategy. Cumulative environmental impacts are addressed. In addition, potential socioeconomic impacts are addressed.

ENVIRONMENTAL IMPACT CONTEXT

Integrated resource planning is broad and strategic; therefore, the environmental review has been programmatic rather than site-specific. When energy resource options are implemented, there can be important environmental effects, depending on how options are deployed and where they are located. These potential option and site-specific impacts will be considered in the environmental reviews that tier from the Energy Vision 2020 review. Such reviews will give TVA decision makers and the public an opportunity to consider any potentially significant impacts before decisions are made.

These site-specific reviews can avoid potentially significant impacts to wetlands, sensitive habitats, prime farmland, threatened or endangered species, cultural and historic resources, alteration of sensitive aquatic habitats, aesthetics and noise, and socioeconomic impacts. Proper site selection and detailed modeling can also avoid local air impacts such as plume impact on elevated terrain. Site selection may also influence some indirect impacts such as those from fuel sources and transportation.

Evaluation Method

The analytical approach used for Energy Vision 2020 is the multi-attribute tradeoff method. This approach allows TVA to quantitatively integrate the identified environmental impacts of proposed strategies and formulate alternative strategies to mitigate them while retaining other beneficial characteristics. The approach also allowed the public to help set the values (criteria) by which strategies were judged and to see how those values can result in tradeoffs.

TVA developed 2,000 different strategies for Energy Vision 2020. These strategies consist of different combinations of energy resource options that were first screened for acceptable performance using multiple criteria, including environmental criteria. The strategies themselves were analyzed through the use of computer models to identify those particular combinations of resource options that best meet the criteria and effectively deal with various uncertainties. In this process, the environmental performance of the strategies was fully integrated into the evaluation in the same manner as financial, rate, economics, and other criteria.

The multi-attribute tradeoff method allowed potential environmental impacts of each strategy to be compared to all other evaluation criteria and to all other strategies on an objective basis. This process identified where there were real tradeoffs among criteria. One of the most important tradeoffs occurred between better environmental performance and lower electric rates. Achieving better environmental performance (less impacts) typically produces higher rates or costs. In the past, utilities usually chose between lower costs or better environmental performance.

The integrated, multi-attribute tradeoff method allowed TVA to mitigate potential environmental tradeoffs by reformulating strategies to lessen the degree of tradeoff. Energy resource options that were primarily responsible for producing undesirable results in more favorable strategies were replaced by options that produced more desirable results. These modified strategies were then reintegrated and their performance with respect to

the evaluation criteria and tradeoffs they produce was reexamined. This was done several times until seven modified strategies were created that respond reasonably well to all Energy Vision 2020 criteria, including environmental criteria. Potential tradeoffs were sharply reduced.

As a result of this process, the final strategies have similar, although not identical, energy resource options. This tends to produce similar environmental impacts. With the final seven strategies, it is possible to meet the future needs of TVA's customers with much better environmental performance compared to other unmitigated strategies.

Environmental Protections

As stated, one of TVA's strategic goals is environmental responsibility. This leads TVA toward those energy resource options that are more environmentally friendly. Apart from this goal, environmental regulations reduce the risk of significant environmental impacts from the implementation of energy resource options. The Clean Air Act, the Clean Water Act, the Endangered Species Act, the Surface Mining Reclamation and Control Act, and the Resource Conservation and Recovery Act are just a few of the major laws in this country that are formulated to prevent or lessen various environmental impacts. In addition, as a federal agency, TVA must consider the potential environmental impacts of proposed decisions under the National Environmental Policy Act.

No major energy resource can be constructed without complying with a substantial number of federal, state, and local environmental requirements. These regulatory processes typically provide multiple opportunities for public comment and participation. Most federal environmental laws allow citizens to bring suit to enforce compliance with requirements, and various federal, state, and local environmental regulatory agencies exist to police compliance.

Although these environmental laws and their implementing regulations do not eliminate all risk of environmental impacts, they substantially reduce impacts. Consequently, the risk of significant impacts associated with the implementation of any of the final strategies identified in Energy Vision 2020 is lessened substantially. Moreover, such impacts should be identified in the subsequent environmental reviews that TVA will conduct before it decides to put specific resource options in place.

SECTION 1: DESCRIPTION OF ALTERNATIVE STRATEGIES

Purpose

This section describes TVA's final seven alternative strategies developed through the integration process and the reference, or "No Action," strategy. In addition, the general features of the strategies that distinguish them from one another are described. As a result of the integration process discussed in the preceding section, most of the strategies are very similar and differences in their environmental performance are relatively small.

Note that, for purposes of the National Environmental Policy Act, the terms "strategy", "alternative", and "alternative strategy" should be considered synonymous.

Elements of a Strategy

As described in Volume 1, Chapter 9, Resource Integration/Alternative Strategy Comparisons, each strategy includes some component of each of the elements described below. Understanding these elements will help understanding of why there are environmental differences among the strategies.

SUPPLY PROFILE

The supply profile refers to actions TVA may take to provide for generation of electricity for its customers. These "supply side" options vary by fuel type, technology, and commercial terms. Coal, natural gas, and nuclear have been the dominant fuels for electricity supply for the utility industry historically and are dominant in TVA's final strategies. However, certain renewable resources, such as biomass, wind, and landfill methane, that may either be continuously replenished or are not consumed, are also considered as viable options in the final strategies. (Hydroelectric power is also a renewable resource, but for purposes of this evaluation, is considered separately and not included in the general renewables category.) Different technologies may use the same fuel. Natural gas can be used to generate electricity from simple cycle combustion turbines, combined cycle facilities, fuel cells, etc. Also, TVA may choose to build, own, and operate a new electricity generating facility, purchase the energy from another electric utility, or purchase the energy from a non-utility independent power producer (IPP) or cogenerator.

ENVIRONMENT

While all elements of a strategy affect its environmental performance, certain decisions specifically targeting alternative ways of meeting environmental constraints have been included in this element. These decisions include the approach to complying with Phase II of the 1990 Clean Air Act Amendments and control options associated with carbon dioxide reduction and TVA's commitment to the U.S. Department of Energy's Climate Challenge.

CUSTOMER SERVICE, PRICING/RATES

The options included in this element include activities that directly influence the amount of electrical energy consumed by TVA's customers. Demand side management (DSM) includes both actions that may decrease total consumption (conservation) and those that change the time of day when consumption occurs (load shaping). Off-system sales (sales to other utilities) increase the need for electricity and can be controlled by marketing and pricing activities. Similarly, marketing and pricing programs (electric rate programs) can be put in place to either increase or decrease system consumption. For example, time-of-day pricing may be used to shape or curb consumption, while a "declining block" rate structure that lowers price as consumption increases may be an inducement to increase consumption. Beneficial electrification options (for example, variable speed electric motors, electric arc steel furnaces) are intended to increase the consumption of electricity while reducing the consumption of other primary fuels with a net benefit to the environment.

TRANSMISSION

Options that represent improvements to the TVA electricity transmission system by reducing transmission losses were included. None of the final strategies being evaluated include these transmission improvement options.

Strategy Definition

Figure T2-1 defines the reference strategy, or “No Action” strategy (Strategy D) and the seven alternative strategies evaluated in Energy Vision 2020 in general terms by strategic element.

For purposes of comparison, Strategy D is the reference or “No Action” strategy for Energy Vision 2020. The “No Action” strategy was to identify those resource options which TVA would most likely have employed to meet demand in the absence of the information and analysis produced as a result of the Energy Vision 2020 process. Taking into account the difficulties TVA has encountered in completing the nuclear units that it has had under construction, it was determined that TVA would likely have looked to some mix of combined cycle combustion turbines, new coal-fired units and limited amounts of purchased power. These became the core elements of the

FIGURE T2-1. **Characteristics of Final Energy Vision 2020 Strategies, Resource Options Embedded in Each Strategy**

Strategy	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls
Strategy D Combined Cycle, Purchased Power, Coal (Reference)	Supply-side options emphasize a blend of TVA-built, Independent Power Producers, and cogenerators to reduce production cost and debt • Combustion turbines • Combined cycle • Independent Power Producers and cogeneration natural gas combined cycle • Independent Power Producer coal • Clean coal [1]	Low-price block of Demand-Side Management (block one) reduces demand with minimum rate increase	Sulfur Dioxide • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing fossil units
Strategy J Bellefonte Coproduct, Renewables, Independent Power Producers	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Independent Power Producer combined cycle • Landfill and coalbed methane • Clean coal • Hydro modernization	Low-price block of Demand-Side Management (block one) reduces demand with minimum rate increase	Sulfur Dioxide • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units Carbon Dioxide and other fossil emissions • A customer service level of biomass (waste wood) cofiring of 0.3%
Strategy M Combined Demand-Side Management and Off-System Sales	Supply-side options mix emphasizes coal expansion and low-cost renewables for low production cost • Combustion turbines • Pulverized coal at an existing plant • Clean coal • Landfill and coalbed methane • Pulverized coal with scrubbers • Hydro modernization	Low-price and low-cost Demand-Side Management (two blocks) reduces need for generation Off-system sales	Sulfur Dioxide • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units Carbon Dioxide and other fossil emissions • A customer service level of biomass (waste wood) cofiring of 0.3%

[1] Clean coal technologies include integrated gasification - combined cycle and integrated gasification - cascaded humidified advanced turbine.

FIGURE T2-1. **Characteristics of Final Energy Vision 2020 Strategies, Resource Options Embedded in Each Strategy** *CONTINUED*

Strategy	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls
Strategy O Bellefonte Coproduct, More Demand-Side Management, More Off-System Sales	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Independent Power Producer combined cycle • Landfill and coalbed methane • Clean coal • Hydro modernization	Low-price and low-cost block of Demand-Side Management (two blocks) reduces need for generation Off-system sales	Sulfur Dioxide • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units Carbon Dioxide and other fossil emissions • A customer service level of biomass (waste wood) cofiring of 0.3%
Strategy Q Flexible Strategy with External Options	Supply-side expansion features purchase options with rights, but not obligations, to purchase power • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Independent Power Producers combined cycle • Purchase of peaking capacity • Flexible base capacity purchase • Flexible peaking capacity purchase • Landfill and coalbed methane • Clean coal • Hydro modernization	Low-price block of Demand-Side Management (block one) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales	Sulfur Dioxide • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units Carbon Dioxide and other fossil emissions • A customer service level of biomass (waste wood) cofiring of 0.3%
Strategy R Flexible Strategy with Internal Options	Supply-side expansion features preplanning, design, and siting work to support flexible start dates of TVA-built options • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Independent Power Producer combined cycle • Combined cycle • Purchase of peaking capacity • Flexible base capacity purchase • Landfill and coalbed methane • Clean coal • Hydro modernization	Low-price block of Demand-Side Management (block one) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales	Sulfur Dioxide • Scrubbers are added at several existing fossil units • Switching to lower sulfur coals at several existing units Carbon Dioxide and other fossil emissions • A customer service level of biomass (waste wood) cofiring of 0.3%

FIGURE T2-1. **Characteristics of Final Energy Vision 2020 Strategies, Resource Options Embedded in Each Strategy** *CONTINUED*

Strategy	Supply-Side Characteristics	Customer Service Characteristics	Environmental Controls
Strategy S Low Cost, Low Rates, Improved Environment	Supply-side expansion features an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Combustion turbines • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Independent Power Producers combined cycle • Landfill and coalbed methane • Clean coal • Hydro modernization	Low-price block of Demand-Side Management (block one) reduces demand with minimum rate increase Low-level beneficial electrification provides improved rate impact Off-system sales spread fixed cost over more sales	Sulfur Dioxide • Scrubbers are added at several existing units • Switching to lower sulfur coals at several existing units Carbon Dioxide and other fossil emissions • A customer service level of biomass (waste wood) cofiring of 0.3%
Strategy T Low-Cost Renewables, Low-Price Demand-Side Management, Repowering, Bellefonte Coproduct Partnership	Supply-side expansion relies on low emission options, renewables, and an integrated coal gasification plant that produces a high-value chemical coproduct, projected for siting at Bellefonte Nuclear Plant • Natural gas combined cycle repowering of several existing coal units • Bellefonte conversion to integrated gasification combined cycle with chemical coproduct • Combustion turbines • Independent Power Producers combined cycle • Clean coal • Compressed air energy storage • Landfill and coalbed methane • Wind • Pulverized coal • Hydro modernization	Low-price block of Demand-Side Management (block one) reduces demand with minimum rate increase	Sulfur Dioxide • Gas repowering of some existing units • Switching to lower sulfur coals at several existing units Carbon Dioxide and other fossil emissions • Carbon dioxide penalty added to assumed cost of generation options to shift generation to lower emission sources • A customer service level of biomass (waste wood) cofiring of 0.3%

Energy Vision 2020 "No Action" strategy and formed the reference strategy for purposes of analysis and benchmarking integration results across alternative strategies.

TVA considered but rejected a second approach to defining the "No Action" strategy. This approach was to cease acquiring new resources to meet future demand for electricity from the TVA system. Except for additional demand that could be met through more efficient use of the energy generated by TVA's existing resources, future demand (new loads) would not be met. This is the approach used to define a "No Action" alternative by the Bonneville Power Administration in its February 1993 resource plan environmental impact statement. Because of TVA's statutory responsibilities and duty to serve demand in its region as a public utility, such a "no-serve" approach was considered fictitious and rejected in favor of the first approach.

Figure T2-2 provides an example of how each strategy might be implemented, based on the results of the computer modeling evaluations described in Volume 1, Chapter 9, Resource Integration/Alternative Strategy Comparisons and Volume 2, Technical Document 8, Resource Integration. While it is highly unlikely that the actual implementation of the strategies would follow the exact sequence given in this figure, these implementation strategies represent credible sequences for resource selection and form the basis for the analysis and comparisons that follow.

FIGURE T2-2. **Implementation of Final Energy Vision 2020 Strategies, Cumulative Capacity Additions (Megawatts)**

		YEAR				
Strategy	**Resource Option**	**2000**	**2005**	**2010**	**2015**	**2020**
D-Reference	Combustion Turbines	1,050	2,550	3,750	4,800	5,700
	Combined Cycle—Independent Power Producer	0	450	750	750	750
	Integrated Gasification—Combined Cycle	0	0	735	2,205	3,675
	Combined Cycle	470	1,880	2,820	2,820	2,820
	Integrated Gasification—Cascaded Humidified Advanced Turbine	0	0	420	1,260	2,100
	Combined Cycle—Cogeneration	0	175	175	175	175
	Coal-Independent Power Producer	0	300	300	300	300
	Total Capacity	**1,520**	**5,355**	**8,950**	**12,310**	**15,520**
J	Bellefonte IGCC Conversion with Coproduct	0	484	484	484	484
	Coalbed Methane Recovery	0	250	1,000	1,000	1,000
	Combustion Turbines	1,500	2,550	3,900	4,950	5,850
	Hydroelectric Improvements	0	0	162	162	162
	Integrated Gasification—Combined Cycle	0	0	735	2,940	4,410
	Integrated Gasification—Cascaded Humidified Advanced Turbine	0	0	420	1,260	2,100
	Independent Power Producer	150	1,650	1,950	1,950	1,950
	Landfill Methane Recovery	0	500	500	500	500
	Total Capacity	**1,650**	**5,434**	**9,151**	**13,246**	**16,456**
M	Coal	0	1,610	1,610	1,610	1,610
	Coalbed Methane Recovery	0	0	250	1,000	1,000
	Combustion Turbines	1,050	2,400	3,600	4,800	5,550
	Hydroelectric Improvements	0	0	162	162	162
	Integrated Gasification—Combined Cycle	0	0	735	2,205	3,675
	Integrated Gasification—Cascaded Humidified Advanced Turbine	0	0	420	1,260	2,100
	Landfill Methane Recovery	0	0	500	500	500
	Shawnee Fossil Plant Unit 11	0	168	168	168	168
	Total Capacity	**1,050**	**4,178**	**7,445**	**11,705**	**14,765**
O	Bellefonte IGCC Conversion with Coproduct	0	484	484	484	484
	Coalbed Methane Recovery	0	0	750	1,000	1,000
	Combustion Turbines	1,050	2,550	3,750	4,950	5,700
	Hydroelectric Improvements	0	0	162	162	162
	Integrated Gasification—Combined Cycle	0	0	735	2,940	4,410
	Integrated Gasification—Cascaded Humidified Advanced Turbine	0	0	420	1,260	2,100
	Independent Power Producer	0	900	1,050	1,050	1,050
	Landfill Methane Recovery	0	500	500	500	500
	Total Capacity	**1,050**	**4,434**	**7,851**	**12,346**	**15,406**

Combustion Fuel Use

A comparison of the combustion fuel used in implementing each strategy provides useful information that directly relates to the comparison of environmental consequences. *Figure T2-3* identifies the capacity and electricity generation by fuel for each strategy in the years 2005 and 2020. Note that every energy strategy uses coal and natural gas. Also, most strategies employ renewable fuels (co-fired wood used along with fossil fuel in a boiler, landfill methane recovery and coal seam methane recovery) in differing amounts. The table in *Figure T2-4* gives the coal and co-fired biomass average annual tonnage and gas volume for each strategy. Biomass refers to wood and perennial grasses used for fuel. Coal use increases from the current level of 35 to 40 million tons annually to 46 to 52 million tons for all strategies including the reference, or "No Action," strategy. Strategy T uses the

FIGURE T2-2. **Implementation of Final Energy Vision 2020 Strategies, Cumulative Capacity Additions (Megawatts)** *CONTINUED*

		YEAR				
Strategy	**Resource Option**	**2000**	**2005**	**2010**	**2015**	**2020**
Q	Bellefonte IGCC Conversion with Coproduct	0	484	484	484	484
	Coalbed Methane Recovery	0	500	1,000	1,000	1,000
	Combustion Turbines	0	900	3,000	4,050	4,800
	Flexible Baseload	0	1,189	289	289	289
	Flexible Peakload	900	900	0	0	0
	Hydroelectric Improvements	0	0	162	162	162
	Integrated Gasification—Combined Cycle	0	0	2,205	3,675	5,145
	Integrated Gasification—Cascaded Humidified Advanced Turbine	0	0	840	1,680	2,520
	Independent Power Producer	300	300	300	300	300
	Landfill Methane Recovery	0	500	500	500	500
	Peak Power Purchases	300	900	900	900	900
	Total Capacity	**1,500**	**5,673**	**9,680**	**13,040**	**16,100**
R	Bellefonte IGCC Conversion with Coproduct	0	484	484	484	484
	Combined Cycle	0	470	470	470	470
	Coalbed Methane Recovery	0	500	1,000	1,000	1,000
	Combustion Turbines	750	2,100	3,150	4,200	4,950
	Flexible Baseload	0	289	289	289	289
	Hydroelectric Improvements	0	0	162	162	162
	Integrated Gasification—Combined Cycle	0	0	1,470	3,675	5,145
	Integrated Gasification—Cascaded Humidified Advanced Turbine	0	0	840	1,680	2,520
	Independent Power Producer	150	300	300	300	300
	Landfill Methane Recovery	0	500	500	500	500
	Peak Power Purchases	900	900	900	900	900
	Total Capacity	**1,800**	**5,543**	**9,565**	**13,660**	**16,720**
S	Bellefonte IGCC Conversion with Coproduct	0	484	484	484	484
	Coalbed Methane Recovery	0	750	1,000	1,000	1,000
	Combustion Turbines	1,500	2,850	4,050	4,950	5,850
	Hydroelectric Improvements	0	0	162	162	162
	Integrated Gasification-Combined Cycle	0	0	1,470	3,675	4,410
	Integrated Gasification- Cascaded Humidified Advanced Turbine	0	0	840	1,680	2,520
	Independent Power Producer	300	1,050	1,050	1,050	1,050
	Landfill Methane Recovery	0	500	500	500	500
	Total Capacity	**1,800**	**5,634**	**9,556**	**13,501**	**15,976**
T	Bellefonte IGCC Conversion with Coproduct	0	484	484	484	484
	Compressed Air Energy Storage	0	0	1,011	1,011	1,011
	Coal	0	0	0	710	710
	Coalbed Methane Recovery	0	0	0	500	1,000
	Combustion Turbines	1,050	2,550	3,750	3,900	4,800
	Hydroelectric Improvements	0	0	162	162	162
	Integrated Gasification—Cascaded Humidified Advanced Turbine	0	0	0	420	1,260
	Independent Power Producer	0	450	450	450	450
	Landfill Methane Recovery	0	0	500	500	500
	Repowering Existing Coal-Fired Plants	1,410	3,045	3,045	4,320	5,170
	Shawnee Fossil Plant Unit 11	0	0	0	168	168
	Wind Turbines	0	800	2,000	2,000	2,000
	Total Capacity	**2,460**	**7,329**	**11,402**	**14,625**	**17,715**

FIGURE T2-3. **Strategy Matrix – Capacity and Energy by Fuel Type**

Strategy	Year	Nuclear (MW)	Nuclear (GWH)	Coal (MW)	Coal (GWH)	Natural Gas (MW)	Natural Gas (GWH)	Hydro and Storage (MW)	Hydro and Storage (GWH)	Renewables (MW)	Renewables (GWH)	Purchases (MW)	Purchases (GWH)	Demand-Side Management (MW)	Demand-Side Management (GWH)
Existing System	2005	5,577	30,171	14,968	96,212	2,292	1,009	5,498	19,268	0	0	1,800			
Existing System	2020	5,577	32,414	14,968	100,654	2,292	1,403	5,498	20,780	740	5,898.5	1,000			
D-Reference	2005	5,577	32,778.4	14,968	108,471.8	6,722	7,652.3	5,498	20,426.8	0	0.0	2,725	6,163.5	-997	2,934.6
	2020	5,577	32,778.4	20,743	149,405.5	10,812	10,549.1	5,498	20,854.4	0	0.0	2,225	6,845.9	-517	1,481
J	2005	5,577	32,778.4	15,452	109,999.5	4,842	2,502.5	5,498	20,426.8	750	6,180.7	3,450	5,258.6	-998	2,934.6
	2020	5,577	32,778.4	21,962	151,251.9	8,142	3,780.2	5,660	20,857.9	1,500	12,361.4	2,950	3,979.7	-517	1,481
M	2005	5,577	32,778.4	16,746	116,322.6	4,692	2,885.5	5,498	20,426.8	0	0.0	1,800	725.3	-2,047	8,194.8
	2020	5,577	32,778.4	22,521	150,338.7	7,842	4,602.6	5,660	20,857.9	1,500	12,361.4	1,000	78.8	-957	1,481
O	2005	5,577	32,778.4	15,452	109,112.1	4,842	2,884.3	5,498	20,426.8	500	4,120.5	2,700	3,169.4	-2,049	8,194.8
	2020	5,577	32,778.4	21,962	150,196.2	7,992	4,572.4	5,660	20,857.9	1,500	12,361.4	2,050	2,279.9	-958	1,481
Q	2005	5,577	32,778.4	15,452	110,182.6	3,192	1,454.0	5,498	20,426.8	1,000	9,240.9	5,089	7,444.8	-999	1,404.9
	2020	5,577	32,778.4	23,117	154,951.1	7,092	4,169.2	5,660	20,857.9	1,500	12,361.4	2,489	1,519.4	-517	1,481
R	2005	5,577	32,778.4	15,452	110,364.9	4,862	3,466.7	5,498	20,426.8	1,000	8,240.9	3,289	4,984.4	-999	1,404.9
	2020	5,577	32,778.4	23,117	155,148.6	7,712	4,339.7	5,660	20,857.9	1,500	12,361.4	2,489	1,988.0	-517	1,481
S	2005	5,577	32,778.4	15,452	109,099.8	5,142	3,011.9	5,498	20,426.8	1,250	10,304.0	2,850	3,819.8	-999	1,404.9
	2020	5,577	32,778.4	22,382	151,793.4	8,142	4,778.0	5,660	20,857.9	1,500	12,361.4	2,050	2,334.5	-517	1,481
T	2005	5,577	32,778.4	13,521	100,215.7	8,517	18,585.2	5,498	20,426.8	0	0.0	2,250	3,882.9	-998	2,934.6
	2020	5,577	32,778.4	15,659	116,157.0	13,042	29,929.6	6,672	25,307.4	2,500	15,111.0	1,450	3,366.0	-517	1,481

MW= Megawatts
GWH= Thousands of Megawatt-Hours

least amount of coal and the largest amount of natural gas. All remaining strategies use 51.7 to 52.2 million tons of coal annually.

Strategy T uses 162 billion standard cubic feet of natural gas annually (one standard cubic foot of natural gas contains approximately 1,000 Btu). The range of natural gas use of other strategies extends to a minimum of 41 billion standard cubic feet, which is 75 percent less than Strategy T. Landfill methane recovery and coalbed methane recovery use vary from a low of 23.4 to a high of 48.9 billion standard cubic feet. Methane recovery varies from 15 to 80 percent of the natural gas used for the same strategy.

FIGURE T2-4. **Combustion Fuel Required for Each Strategy (Annual Average Mass or Volume)**

Strategy	Coal (Millions of Tons)	Biomass Cofiring (Tons)	Landfill/ Coalbed Methane (Billions of Standard Cubic Feet)	Natural Gas (Billions of Standard Cubic Feet)
D-Reference	52.1	0	0	93.5
J	51.3	184,643	45.8	64.9
M	52.2	187,909	34.8	41.0
O	51.2	184,493	44.2	53.9
Q	51.7	186,227	48.9	68.4
R	51.9	186,956	48.9	63.4
S	51.8	186,903	49.4	59.2
T	45.9	186,903	23.4	162.0

No generating facilities specifically designed for short rotation woody crops or refuse-derived fuels are found in the seven strategies. However, significant co-firing of wood with coal in existing boilers is used in all strategies.

Both wood and landfill methane are renewable energy sources. Additionally, the use of coalbed methane recovery, landfill methane recovery, and wood waste fuel reduces the greenhouse warming potential of these emissions. This is a result of using captured or recovered methane as a fuel source. When methane, with a radiative forcing function of 21, is combusted, the resultant emissions are carbon dioxide with a radiative forcing function of one. The radiative forcing potential for any greenhouse gas is an indication of the relative effect of the gas on potential global warming compared to carbon dioxide, which has a radiative forcing potential of one. For example, methane

has a radiate forcing potential of 21, which means its effect on potential global warming is 21 times greater than that of an equivalent weight of carbon dioxide. Similarly, wood waste left to decay converts about 25 percent of the carbon mass to methane; thus, when burned, a methane release is avoided. The table in *Figure T2-5* presents the fuels on an energy content basis. The chart in *Figure T2-6* shows how the annual average combustion fuel energy use varies with each strategy for the entire period of the study.

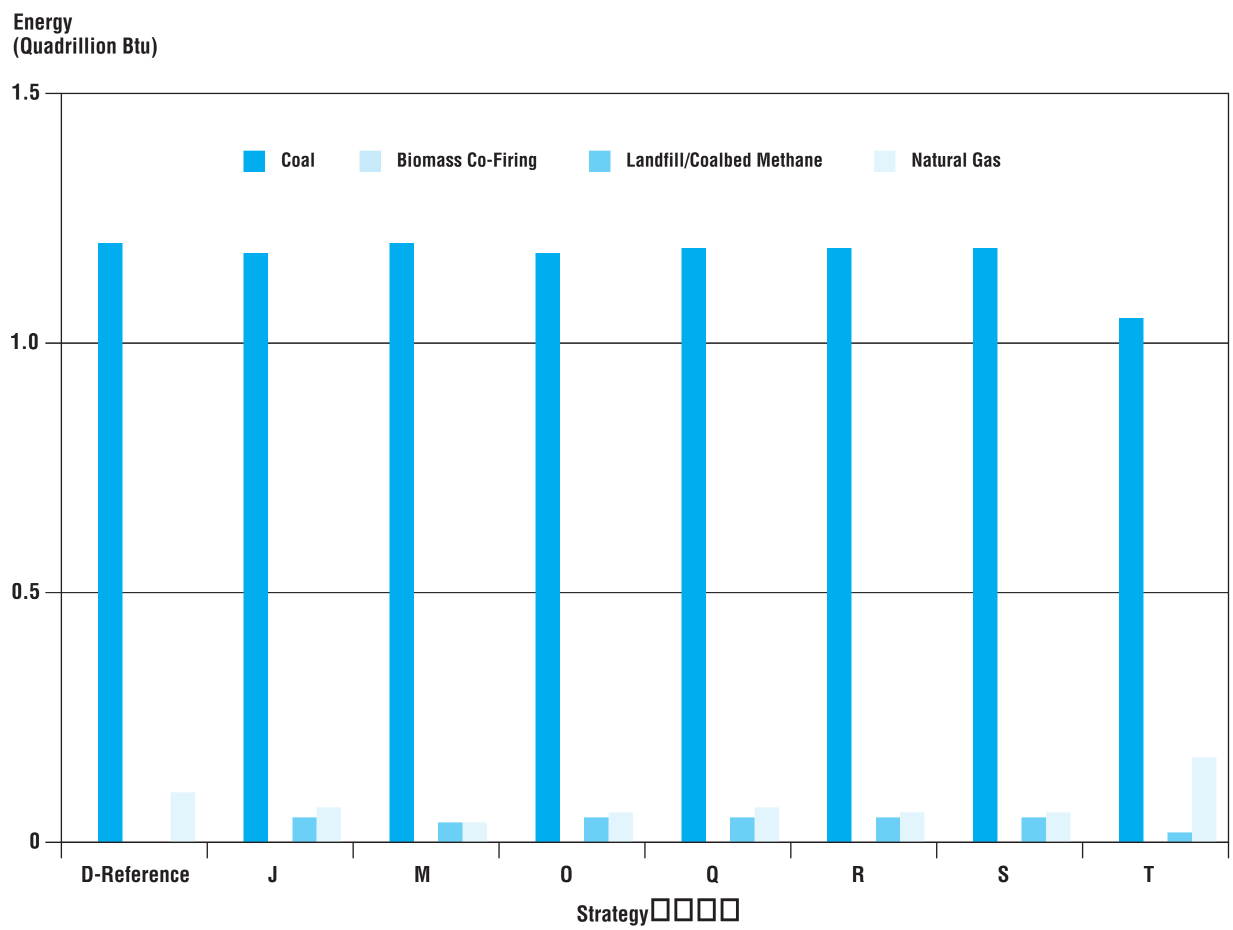
On an energy basis, 1.05 to 1.2 quadrillion Btu's of fuel energy is supplied by coal in each strategy. The energy content of the other combustion fuels combined is 0.1 to 0.2 quadrillion Btu's per strategy. Total combustion fuel energy use is between 1.25 and 1.31 quadrillion Btu's.

All strategies expand TVA's use of combustion fuels over present levels, while diversifying the types or sources of these fuels.

FIGURE T2-5. **Combustion Fuel Energy Use for Each Strategy (Annual Average)**

Strategy	Coal (Quadrillion Btu)	Biomass Cofiring (Quadrillion Btu)	Landfill/ Coalbed Methane (Quadrillion Btu)	Natural Gas (Quadrillion Btu)
D-Reference	1.20	0.00000	0.0000	0.0955
J	1.18	0.00166	0.0468	0.0664
M	1.20	0.00169	0.0356	0.0419
O	1.18	0.00166	0.0452	0.0551
Q	1.19	0.00168	0.0500	0.0699
R	1.19	0.00168	0.0500	0.0648
S	1.19	0.00168	0.0505	0.0605
T	1.05	0.00168	0.0239	0.1660

FIGURE T2-6. **Combustion Fuel Energy Use for Each Strategy (Annual Average)**



Sources of Energy Supply by Strategy

Every energy strategy includes TVA's existing resources plus proposed new resources. Each strategy depends on coal-fired, natural gas-fired, nuclear, and hydroelectric, including pumped storage, energy supply options. Certain strategies depend to differing degrees on landfill methane and coalbed methane combustion, wood waste co-firing, wind turbine operation, and demand-side management programs.

The table in *Figure T2-7* quantifies the different types of energy sources included in the strategies to meet the need for power in 2020. There are six groupings: coal, nuclear, natural gas, hydroelectric (including pumped storage), renewables, and demand-side management. The chart in *Figure T2-8* shows how the use of each energy supply group varies for the strategies. Coal-fired generation is the dominant supply source, varying from 55 percent for Strategy T to 64 percent of all energy supplied for the

FIGURE T2-7. **Energy Sources Used to Meet the Need for Power in 2020 (Megawatt-Hours)**

Strategy	Coal	Nuclear	Natural Gas	Hydroelectric/ Storage	Renewables	Demand-Side Management	Total
D-Reference	120,139	32,557	11,743	20,406	0	2,387	187,232
J	119,545	32,557	7,273	20,406	7,252	2,387	189,420
M	121,382	32,557	3,817	20,406	5,521	6,318	190,002
O	119,607	32,557	5,614	20,406	7,005	6,318	191,507
Q	122,142	32,557	6,450	20,406	7,746	1,346	190,647
R	122,080	32,557	6,549	20,406	7,746	1,346	190,685
S	121,924	32,557	6,248	20,406	7,829	1,346	190,310
T	104,677	32,557	20,518	22,338	6,961	2,387	189,439

FIGURE T2-8. **Energy Sources to Meet the Need for Power in 2020**

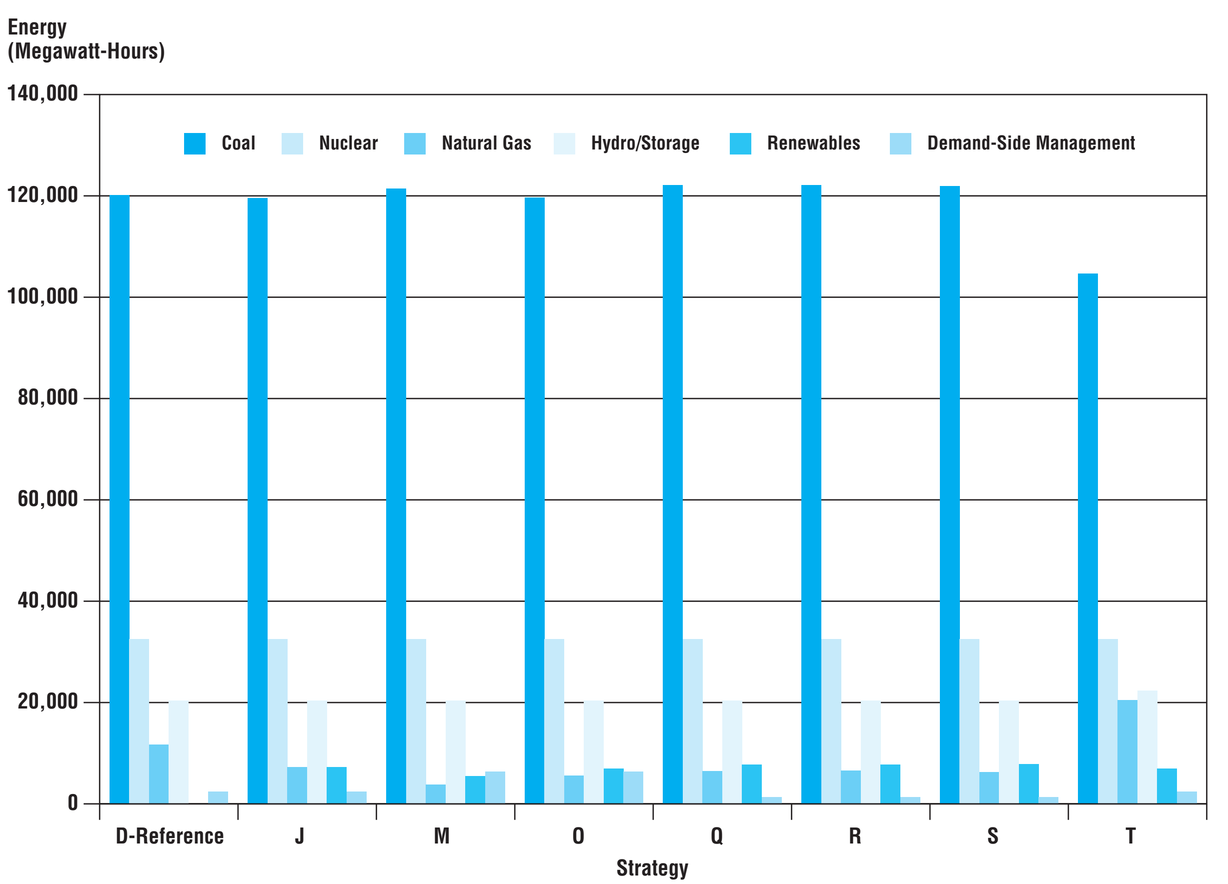


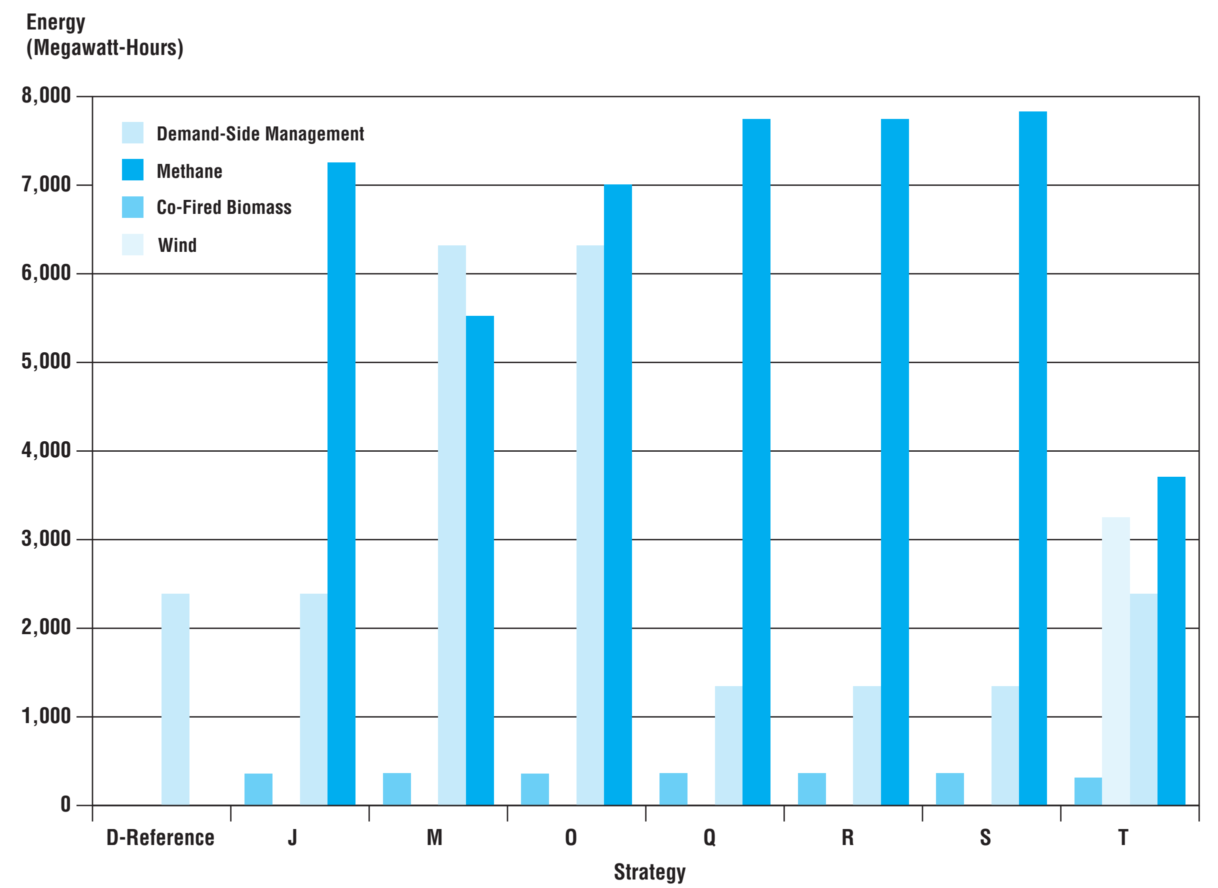
FIGURE T2-9. **Energy Supplied in 2020 by Renewable and Demand-Side Management Options (Megawatt-Hours)**

Strategy	Wind	Methane	Demand-Side Management	Total
D-Reference	0	0	2,387	2,387
J	0	7,252	2,387	9,639
M	0	5,521	6,318	11,839
O	0	7,005	6,318	13,323
Q	0	7,746	1,346	9,092
R	0	7,746	1,346	9,092
S	0	7,829	1,346	9,175
T	3,252	3,708	2,387	9,347

reference, or "No Action," strategy. Nuclear is about 17 to 19 percent of energy supplied, followed by hydroelectric, and pumped storage, with 11 percent. Natural gas-fired generation varies from 2 percent for Strategy M to 11 percent for Strategy T. Renewables are 3 to 4 percent of energy supplied. Demand-side management provides 0.7 to 3.3 percent of energy supplied.

The table in *Figure T2-9* gives the breakout of the energy supplied by demand-side management and various renewable energy options that vary with each strategy. The chart in *Figure T2-10* graphically illustrates the variation of different types of renewables and demand-side management across strategies.

FIGURE T2-10. **Energy Supplied in 2020 by Renewable and Demand-Side Management Sources**



Energy Savings by Strategy

The amount of energy saved in the various strategies is due to improved power system efficiency, as well as demand-side management programs. The reference strategy uses 1.29 quadrillion Btu's of non-renewable combustion fuels and Strategy T uses 1.22 quadrillion. Compared to the reference strategy, Strategy T represents an annual savings of 0.07 quadrillion Btu's, which is the maximum savings for any strategy. The fuel energy savings for each strategy is given in *Figure T2-11*. The electric energy reductions of demand-side management vary from 1,346 to 6,318 thousand kilowatt-hours as given in *Figure T2-9*.

FIGURE T2-11. **Energy Savings of Non-Renewable Combustion Fuel**

Strategy	Coal and Natural Gas Fuel Energy Used (Quadrillion Btu)	Energy Reduction From the Reference Strategy (Quadrillion Btu)
D-Reference	1.29	0.00
J	1.25	0.05
M	1.24	0.05
O	1.23	0.06
Q	1.26	0.03
R	1.26	0.04
S	1.25	0.04
T	1.22	0.07

SECTION 2: SOCIOECONOMIC IMPACTS OF ALTERNATIVE STRATEGIES

Economic Development

Energy Vision 2020 defines economic development as growth in regional economic activity. Measurement criteria include total personal income in "constant" 1994 dollars (i.e., with inflation accounted for) and total non-farm employment. These provide measures for the effects of various Energy Vision 2020 strategies on the overall, long-term health or welfare of the economy for the next 25 years. This analysis concentrates on changes to the welfare of the overall economy due to Energy Vision 2020 strategies. It does not address changes to the distribution of income or employment.

Three types of factors associated with Energy Vision 2020 options affect regional economic development:

- Direct expenditures for labor and materials incurred in the Tennessee Valley during the construction and operation phases of an energy resource option
- Changes to TVA electric rates resulting from implementation of a particular option
- Changes to customers' disposable income as a result of increased or decreased costs from the implementation of a particular option in a distinct Energy Vision 2020 strategy (changes could be caused either by customer expenditures or electric bills)

In general, the greater the direct regional expenditures associated with a particular option, the more positive are the effects on regional economic development. This can be offset, however, by the fact that higher rates caused by higher costs have a negative effect on regional economic development. Thus, an option that has high expenditures in the Tennessee Valley compared to other options may also have high costs and high rates. The overall effect on economic development of a particular option may be positive or negative compared to other options, depending on the net sum of the expenditure effects and the rate and cost effects.

This section describes the methodology used to calculate how alternative strategies affect economic development. The final strategies analyzed in Energy Vision 2020 are described in *Figures T2-1* through *T2-3*. The tables in *Figures T2-12* and *T2-13* present the results of analysis for each Energy Vision 2020 strategy in terms of changes in income and employment compared with a base case reference, or "No Action," strategy (Strategy D).

FIGURE T2-12. **Economic Development Impacts (Annual Average, 1996-2020), IRP Strategies Relative to Strategy D - Reference or "No Action" Case**

Strategy	Category/Rank [2]		TOTAL IMPACT Employment	TOTAL IMPACT Income [1]	IMPACTS DUE TO OPTION EXPENDITURES (DIRECT AND INDIRECT) Employment	IMPACTS DUE TO OPTION EXPENDITURES (DIRECT AND INDIRECT) Income [1]	IMPACTS DUE TO RATES Employment	IMPACTS DUE TO RATES Income	IMPACTS DUE TO TOTAL RESOURCE COSTS Employment	IMPACTS DUE TO TOTAL RESOURCE COSTS Income
D- Reference	poor	14	0	0	0	0	0	0	0	0
J	good	5	16,569	739,482	4,176	184,171	9,787	420,773	2,606	134,537
M	moderate	8	11,884	529,624	6,232	273,954	4,146	176,989	1,506	78,681
O	good	4	19,976	893,436	5,484	240,868	11,256	482,723	3,236	169,844
Q	good	2	23,970	1,046,616	6,806	297,746	15,104	641,810	2,060	107,060
R	good	1	24,240	1,060,647	6,934	302,862	15,187	647,444	2,119	110,341
S	good	3	21,288	927,450	6,222	269,018	13,383	570,775	1,683	87,657
T	good	6	15,743	692,771	2,509	105,974	11,090	476,690	2,144	110,107

[1] Income in thousands of 1994 $

[2] Out of 21 strategies

METHODOLOGY

The indirect effects of direct expenditures and rate and total resource cost changes were calculated using TVA's Regional Economic Simulation Model. This model maps the Valley's economic structure, its inter-industry linkages, and responses to TVA rate and cost changes In addition to being used for Energy Vision 2020, the model is also used to provide the economic outlook for TVA's load forecasting. Volume 2, Technical Document 5, Load Forecast, contains more information about this model. The analysis includes data on direct expenditures in terms of applicable payrolls, material and supply purchases, and fuel costs for all energy resource options which comprise a particular strategy. It also includes data on TVA rates and total resource cost resulting from each strategy. A three-step process calculated the total economic development effects for each strategy:

- Direct expenditures for options were evaluated for both the construction and operation periods, and combined into the overall strategies.
- The economic model was used to calculate the indirect effects associated with the direct expenditures resulting from each strategy.
- The results of these analyses were combined with the projections from the model of direct economic development effects due to rates and costs for each strategy.

CONSTRUCTION PERIOD EVALUATION

Only supply-side options, including independent power producers, had project construction associated with them. Data on payroll income for the construction period associated with each option was used as the input into the economic model for the construction phase analysis. The model measures two types of indirect effects:

- The increase in goods manufactured in the Valley as a result of the material and supply purchases in the region associated with a project
- The additional income generated in the regional economy resulting from spending by workers hired as a result of the construction activity

Model results were evaluated in terms of changes in the Valley's income and employment between strategies involving construction compared to a strategy that had no construction activity, the "No Action" strategy.

TVA verified model projections by comparing them with available figures regarding material and supply purchases. It was estimated that 20 to 40 percent of purchases could be regional. The economic model captured regional increases due to purchases relative to payrolls for an average construction project. If a project had a ratio of purchases to payrolls significantly different than the average, the model results would not produce a correct accounting of the regional purchase effect without being adjusted. The increase in regional manufacturing evidenced in model results for the options was not significantly different than the average. Thus, the model results did not have to be adjusted for the analysis.

OPERATIONS PERIOD EVALUATION

Both supply-side and demand-side options had operational activities associated with them. The analysis of operations was similar to that for construction. Data on payrolls for the option was

FIGURE T2-13. **Direct and Indirect Economic Development Impacts Due to Option Expenditures (Annual Average, 1996-2020), IRP Strategies Relative to Strategy D - Reference or "No Action" Case**

	Impacts Due to Option Expenditures (Direct and Indirect)		Direct Impacts Due to Option Expenditures		Indirect Impacts Due to Option Expenditures	
Strategy	Employment	Income [1]	Employment	Income	Employment	Income
D- Reference	0	0	0	0	0	0
J	4,176	184,171	675	29,553	3,501	154,618
M	6,232	273,954	1,469	62,242	4,762	211,711
O	5,484	240,868	1,082	45,831	4,402	195,037
Q	6,806	297,746	1,314	56,189	5,492	241,557
R	6,934	302,862	1,340	56,936	5,593	245,926
S	6,222	269,018	1,189	50,663	5,033	218,355
T	2,509	105,974	-43	-1,981	2,552	107,955

[1] Income in thousands of 1994 dollars

entered into the economic model, and changes in income and employment between strategies including the project and those without the project were calculated. Estimates provided for material and supply purchases in the region served as a check against model results. In this case, several options had purchase estimates that were higher than those calculated by the model. To compensate, supplemental regional expenditures were added to the model results for these options.

Since fuel adds another cost factor to operations, TVA also analyzed fuel purchase patterns to determine what purchases would occur within the region. Natural gas comes from outside the region, and coal purchases generally come from the part of Kentucky outside the region. Of the final strategies, only the reference strategy had regional fuel effects which were generated by lignite assumed to be purchased within the region. For the reference strategy, the fuel purchases were entered into the economic model as part of operations to calculate the overall economic development effects.

TOTAL ECONOMIC DEVELOPMENT EFFECTS FOR ENERGY VISION 2020 STRATEGIES DUE TO OPTION EXPENDITURES

Once each option had been evaluated over both the construction and operation period, the direct payroll effects for each option were compiled by strategy and year. This data was input into the economic model and included any necessary accounting for above average purchases and regional fuel purchases during operations. The model was then run for each strategy in order to measure the overall economic development effects for each strategy, including indirect effects. Model results were evaluated in terms of changes in the Valley's income and employment for each strategy compared with the reference, or "No Action," strategy.

TOTAL ECONOMIC DEVELOPMENT EFFECTS FOR ENERGY VISION 2020 STRATEGIES DUE TO RATES AND COSTS

Effects upon economic development due to differences in rates among strategies were evaluated by entering data on rates by year for each strategy before running the model. The economic model captures the effects on the economy due to TVA rate changes to manufacturing customers and the impact of these changes upon the overall economy.

The analysis also estimated the effects of total resource cost differences among strategies. Differences in electric bills and other costs, such as participant costs of demand-side management programs, affect the amount of available disposable income. Net cost changes add to or subtract from the spending capacity of customers and thus affect the amount of disposable income available for spending. This is known as the "re-spending effect," since disposable income when returned to the economy generates additional economic growth.

Estimates of annual total resource costs for each strategy were used to estimate net cost differences among strategies. These were used with the TVA regional economic simulation model to compute the re-spending effects of each strategy.

TOTAL ECONOMIC DEVELOPMENT EFFECTS FOR ENERGY VISION 2020 STRATEGIES

Total economic development effects were calculated by adding the income and employment effects due to direct expenditures, rates, and total resource costs for each strategy by year and then calculating annual averages. Overall economic development effects were rated relative to the reference, or "No Action," strategy. Three possible rankings estimated the degree of economic development impact of each strategy (good, moderate, and poor). *Figure T2-12* shows the total economic development effects for each strategy. *Figure T2-13* shows the effects due to expenditures broken out with direct and indirect effects.

Environmental Justice

Executive Order No. 12898 directs certain federal agencies to consider environmental justice in the environmental reviews of their programs and activities. Although TVA is not one of the agencies designated in the executive order, it has considered the issue of environmental justice in the context of Energy Vision 2020.

Environmental justice refers primarily to ensuring that no segment of the population bears a disproportionate burden of health and environmental impacts of society's activities. Some studies suggest that poor, predominantly minority populations are exposed disproportionately to adverse health and environmental impacts because hazardous waste management facilities and other industrial facilities with potentially impactive air and water releases are sited in their communities. Other studies dispute these findings.

In the context of the generation and transmission of electric energy, various populations can be affected in a number of ways. The environmental analysis done for Energy Vision 2020 indicate that air pollution from the combustion of coal probably poses the greatest risk of adverse health and environmental impacts. Many air pollutant impacts, however, occur on a regional scale and do not affect any population segment disproportionately. Depending upon the situation, however, measurements have revealed that there can be more localized effects associated with short-term exposures to higher pollutant concentrations due to plume downwash. TVA's coal-fired plants

are located in largely rural settings, and except for TVA's Allen Fossil Plant, the surrounding populations are largely white. Incomes in rural areas, however, tend to be at the low-median level for the region. Allen Fossil Plant is located in Memphis, Tennessee, one of the areas in the TVA region that has a higher non-white population.

The siting of industrial facilities has raised the most concern with respect to environmental justice. Because Energy Vision 2020 is a programmatic-level review, the siting of energy resource options is not addressed in detail. When putting discrete options in place is proposed in the future, additional environmental reviews will be conducted and environmental justice concerns and effects will be addressed in those reviews as appropriate. Depending on the nature of the particular resource option and the kinds of impacts it may have, TVA will make a special effort to involve potentially affected low-income and minority populations in the review of options.

Concerns have been expressed nationally about rate impacts due to the implementation of some demand-side management programs. Depending on how demand-side management programs are structured, nonparticipants could subsidize the costs of programs delivered to participants who enjoy the benefits of such programs. Low-income electricity users can be affected in this way. However, measures can be taken to lessen the risk of this happening. TVA has designed a number of its demand-side management programs to avoid this, as explained in Volume 1, Chapter 8, Customer Service Options.

SECTION 3: AIR QUALITY IMPACTS OF ALTERNATIVE STRATEGIES

Understanding Air Quality Impacts

This section discusses the differences among TVA's final energy strategies with respect to potential impacts on air resources.A description of these strategies can be found in *Figures T2-1* through *T2-3*.

Air impacts to be considered in the evaluation of TVA's future energy alternatives are (1) human health, (2) visibility, (3) crop and forest productivity, (4) materials damage, and (5) greenhouse gases. Volume 2, Technical Document 1, Comprehensive Affected Environment provides an overview of air quality issues, emissions contributions, air pollution trends, and current impacts. The term "ambient air" is used to describe the surrounding air. These analyses conclude that the health and environmental impacts of greatest concern at current ambient exposures in the Tennessee Valley are:

- Potential impacts to health of sensitive individuals due to fine particles in the air, ozone, or potentially from short-term sulfur dioxide exposures
- Ozone impacts to crop and forest health and productivity
- Acid deposition impacts to sensitive forest and aquatic ecosystems
- Visibility impairment due to fine particles in the air
- Some degradation of material surface due to acid deposition or ozone

Ambient air loadings of hazardous air pollutants to which TVA is a contributor are of low risk to human health and the environment in the Tennessee Valley. Impacts of greenhouse gases are scientifically uncertain. Levels of emissions of greenhouse gases are tracked as an indirect measure of potential impacts.

As discussed in Volume 2, Technical Document 1, Comprehensive Affected Environment, many variables affect the relationships between emissions, exposures, and impacts. Typically, assessments of source contributions are done through meteorological and atmospheric chemistry modeling. However, these models require accurate meteorological, land cover, topographic (physical geography), emissions, and background air quality data. Modeling TVA contributions to impacts at specific receptors would require:

- Detailed emissions inventories for all contributing sources
- Atmospheric modeling of secondary pollutant formation and transport as a function of specific meteorological conditions
- Quantitative assessment of the relationships between exposures and the impacts of concern

Much of these data are not available at a regional scale, and exposure and impact relationships are also not always well understood. Consequently, simplifying assumptions were made to estimate TVA's contribution to air pollutant levels in the Tennessee Valley. These are discussed in Volume 2, Technical Document 1, Comprehensive Affected Environment.

Source-specific atmospheric modeling was also not undertaken in the Energy Vision 2020. TVA's purpose in Energy Vision 2020 is to select a preferred future energy supply strategy and does not include site-specific details of how that strategy might be implemented. The current analysis focuses on probable differences in impacts among candidate strategies and is based on projected future emissions and estimated TVA contributions to total pollutant loadings. When TVA considers site-specific actions to implement selected options, it will, as appropriate, conduct more detailed source-specific atmospheric modeling.

ASSUMPTIONS FOR FUTURE REGULATIONS

The Environmental Protection Agency is currently considering revising the national ambient air quality standards for ozone, particulate matter, and sulfur dioxide, and establishing a new acid deposition standard. Any of those regulatory decisions could require further reductions in TVA's sulfur dioxide and nitrogen oxides emissions. However, these reductions would most likely impact TVA's existing coal-fired power plants more than future new power supply sources, since standards for new plants or sources are more stringent than those for existing plants.

The Environmental Protection Agency is also currently considering whether utility emissions of hazardous air pollutants should be regulated. Mercury is receiving specific regulatory consideration. If mercury emissions from utility sources are regulated, controls would likely be national in scope and include TVA sources.

TVA has already voluntarily committed to limit potential increases in its carbon dioxide emissions. Legislation has been proposed to stabilize or reduce carbon dioxide emission levels.

In projecting future emissions trends, uncertainty in future regulations was addressed by assigning probability to alternative regulatory outcomes. All energy strategies incorporate the same probabilities of future regulation. Among the strategies, the reference, or "No Action," strategy relies most heavily on fossil fuels and represents maximum probable environmental impacts of the TVA system.

Analysis of Energy Vision 2020 Strategies

AIR QUALITY INDICES FOR ALTERNATIVE STRATEGIES

TVA's existing energy resources and many of the resource options considered for Energy Vision 2020 can affect air quality in different ways. Air indices were developed to help characterize how TVA power system operations and alternative energy strategies might affect air quality impact areas which include:

- Human health - inhalation
- Visibility impairment
- Forest and crops
- Materials (structural and cultural)

Potential effects of emissions of greenhouse gases, a fifth air quality impact area of interest, is considered in a separate index.

Indices were developed to help characterize how the emissions associated with alternative strategies might contribute to these five air impact categories. *Figure T2-14* shows these indices. Results for the air indices are derived by weighting the annual average air emissions from 1996 to 2020 in each strategy by the relative importance assigned to each air emission. The relative importance was assigned based on TVA's contribution to pollutant loadings that could affect human health and the environment. Additional information about these measurements and how they were weighted can be found in Volume 2, Technical Document 1, Comprehensive Affected Environment. The indices allow the emissions of greater concern for impacts to be given greater emphasis in multi-attribute analysis of alternative energy strategies.

TVA's final strategies were compared to the "No Action" strategy (Strategy D), which is the reference strategy in Energy Vision 2020. Strategy D was assigned a value of 1.0 for all indices. The values for the other final strategies then indicated whether they are better or worse than Strategy D with respect to the impact in question (a value greater than 1.0 indicates a worse effect, less than 1.0 a better effect).

The reference, or "No Action," Strategy D and Strategy M use the most coal, while Strategy T uses the least coal and the most natural gas and renewables. The air indices values (0.91) for Strategy T are the lowest compared to the reference strategy (value of 1.0) and represent a 9 percent difference in TVA contribution to total pollutant loadings compared to the reference strategy.

The differences in index values do not represent differences in ultimate impact contributions. For example, if TVA is estimated to contribute less than 25 percent of secondary pollutant load-

FIGURE T2-14. **Air Quality Impact Environmental Indices for Each Strategy and Impact Area**

Strategy	IMPACT AREAS Health-Inhalation	Visibility Impairment	Forest & Crops Productivity	Materials Damage	Greenhouse Gases
D- Reference	1.00	1.00	1.00	1.00	1.00
J	0.98	0.97	0.98	0.97	0.93
M	0.94	0.93	0.95	0.93	0.91
O	0.95	0.94	0.96	0.94	0.90
Q	0.94	0.92	0.95	0.93	0.93
R	0.95	0.94	0.96	0.95	0.93
S	0.95	0.94	0.96	0.95	0.93
T	0.91	0.91	0.91	0.91	0.87

Air indices have been developed for health-inhalation impacts, visibility impairment, forest and crop productivity, materials damage, and greenhouse gases.

ings in the Tennessee Valley, a 9 percent difference in TVA's contribution might result in a 2.25 percent difference in total exposures. Such a difference would be difficult to measure given the large annual variability in secondary pollutant formation caused by climate conditions. For individual episodes of highest pollutant loadings, differences in loadings due to differences in TVA strategies may be detectable.

All strategies improve on the index for greenhouse gases compared to the reference strategy. Improvements range from 7 percent for strategies J, Q, R, and S to 13 percent for Strategy T.

SUMMARY OF EMISSIONS AS A FUNCTION OF ENERGY STRATEGIES

TVA's emissions of sulfur dioxide and nitrogen oxides are the primary measures that can be used to differentiate among impacts of TVA future energy strategies. However, TVA's sulfur dioxide, nitrogen oxides, particulate matter, hazardous air pollutants, and carbon dioxide emissions are all primarily functions of the annual amount of coal burned. Strategies that rely on existing coal-fired power plants are more likely to have higher sulfur dioxide and nitrogen oxides emissions than new coal-fired sources because new sources have more efficient emission controls. Regulatory actions that lower permitted emissions are likely to raise the costs of operating existing sources and may shift economics to favor new generation.

If other factors are equal, energy strategies that reduce projected coal use will have lower air quality impacts. Natural gas has negligible sulfur dioxide emissions and all strategies incorporate natural gas for new energy supply. Natural gas also has lower nitrogen oxides emissions than coal. Energy supply requirements that are met by renewables and demand-side management will have lower air emissions than equivalent supply from fossil fuels. If other factors are equal, these supply options will have positive benefits to the environment in proportion to their usage in various strategies.

The air indices do not address differences due to siting of future energy supply resources. New or expanded sources of emissions located in the eastern Tennessee Valley might contribute more to ozone in the southern Appalachians than sources sited in the western Valley. New or expanded sources located in western Tennessee could impact ozone levels and nonattainment conditions in the Nashville metropolitan area and potentially affect sulfate loading in southern Appalachia. The indices also do not address where impacts will occur. Impacts to visibility in Class I areas have greater legal implications than degraded visibility in urban areas of the Tennessee Valley. Power supplied by purchases outside the Tennessee Valley could have impacts on resources in areas other than the Tennessee Valley.

When specific energy supply strategies are implemented affects the timing of emission reductions and differs among the strategies considered. Earlier emission reductions are assumed to be environmentally preferable to equivalent reductions occurring later over the period 2000 to 2020. For example, earlier reduc-

FIGURE T2-15. **Emissions and Percent Changes Between 1996 and 2020 by Strategy**

	SULFUR DIOXIDE			NITROGEN OXIDES			MERCURY			CARBON DIOXIDE		
	Tons		%	Tons		%	Pounds		%	Thousands of Tons		%
Strategy	1996	2020	Change	1996	2020	Change	1996	2020	Change	1996	2020	Change
D-Reference	810,000	483,176	-40.35	468,530	452,866	-3.34	4,884	5,669	16.07	103,144	157,126	52.34
J	810,000	429,003	-47.04	468,530	436,944	-6.74	4,884	5,218	6.84	103,144	141,380	37.07
M	810,000	412,232	-49.11	468,530	429,493	-8.33	4,884	4,897	0.00	103,144	140,593	36.31
O	810,000	421,120	-48.01	468,530	433,653	-7.44	4,884	5,134	5.10	103,144	139,698	35.44
Q	810,000	396,791	-51.01	468,530	423,914	-9.52	4,884	4,915	0.63	103,144	141,486	37.17
R	810,000	398,084	-50.85	468,530	424,402	-9.42	4,884	4,929	0.42	103,144	141,682	37.36
S	810,000	421,123	-48.01	468,530	433,614	-7.45	4,884	5,152	5.49	103,144	142,382	38.04
T	810,000	448,843	-44.59	468,530	409,504	-12.60	4,884	5,032	3.03	103,144	128,853	24.93

FIGURE T2-16. **Average Annual Emissions and Change From the Reference Strategy**

	SULFUR DIOXIDE		NITROGEN OXIDES		MERCURY		CARBON DIOXIDE	
Strategy	Tons	% Change From Ref	Tons	% Change From Ref	Pounds	% Change From Ref	Thousands of Tons	% Change From Ref
D-Reference	563,048	0	455,804	0	5,490	0	130,352	0
J	541,563	-4	450,220	-1	5,335	-3	120,531	-8
M	511,777	-9	439,000	-4	5,159	-6	119,041	-9
O	518,733	-8	442,052	-3	5,299	-3	116,811	-10
Q	508,166	-10	439,015	-4	5,163	-6	121,351	-7
R	522,283	-7	443,399	-3	5,266	-4	121,639	-7
S	522,499	-7	443,366	-3	5,270	-4	121,261	-7
T	516,696	-8	411,742	-10	5,014	-9	115,042	-12

tions in nitrogen loading as a function of TVA energy supply strategies could result in earlier improvement in ozone impacts to human health, crop and forest productivity, and materials. Earlier reductions in nitrogen oxides could also result in improved soil nutrient content at sensitive receptors where nitrogen saturation has negative environmental impacts. However, for most crops and forests in the Tennessee Valley, current levels of nitrogen deposits have neutral to positive impacts. Earlier reductions in sulfate could produce earlier benefits to human health, visibility, aquatic impacts from acid deposition, and materials.

SUMMARY OF TRENDS IN TVA EMISSIONS

The trends in TVA's emissions during the Energy Vision 2020 period provide additional information about the potential effect of Energy Vision 2020 strategies that is not reflected in the indices. For each strategy, *Figure T2-15* gives the amount of the first and last year emissions and the percentage change from the first year of the study period (1996) to the last year (2020). (Because impacts from fine particulate matter are related more to secondary particles than primary particulate emissions, trends in primary particulate emissions are not considered here.) The graphs in *Figure T2-17* through *T2-20* illustrate the emissions trend for each strategy over the study period. Sulfur dioxide and nitrogen oxides emissions are projected to decrease between 1996 and 2020 for all strategies, despite increases in coal usage in all strategies. Mercury emissions remain the same or increase while carbon dioxide emissions increase in all strategies between 1996 and 2020. (*See Figure T2-15.*)

The table in *Figure T2-16* differs from *Figure T2-15* in that *Figure T2-16* indicates the total emissions for each of the final strategies averaged over the 25-year study period. This table also differs from *Figure T2-15* in presenting the percent change in average emissions for each final strategy compared to the reference strategy. Since the total emissions averaged over the study period best indicate total emissions, these quantities (*Figure T2-16*) are used in calculating the air quality impact indices shown in *Figure T2-14*.

Sulfur Dioxide

When comparing emissions at different points in time, sulfur dioxide emissions in the reference strategy are projected to be reduced from 1996 levels by about 40 percent in 2005 with smaller reductions after 2005. All other strategies have larger reductions in sulfur dioxide emissions than the reference strategy. (See *Figure T2-15.*) *Figure T2-17* projects trends in sulfur dioxide emissions for each strategy.

When comparing total emissions averaged over the study period against the reference strategy, sulfur dioxide emissions for all final strategies are 4 to 10 percent lower compared to the reference strategy (*Figure T2-16*).

- The reductions in sulfur dioxide would lead to reductions in sulfate contributing to acid deposition and fine particulate matter. However, reductions in sulfate concentrations would be less than projected TVA sulfur dioxide reductions. For example, sulfate formation can be limited by availability of oxidants (e.g., hydrogen peroxide or ozone) that react with the sulfur dioxide to form sulfate. Also, TVA is only one contributor to sulfur dioxide emissions that contribute to sulfate formation.
- Some improvement in TVA's contribution to potential impacts on human health, visibility, and rates of degradation of materials are expected for all strategies, due to reductions in TVA sulfur dioxide emissions. However, these benefits may not occur within the Tennessee Valley but at some distance beyond it, since the rate of sulfate production is slow and the air mass into which the sulfur dioxide is emitted may travel outside the Tennessee Valley before the sulfate is produced.
- Potential benefits to crops and forests from projected reductions in TVA emissions of sulfur dioxide are expected to be

small because sulfur is a less important pollutant than nitrogen for these systems.

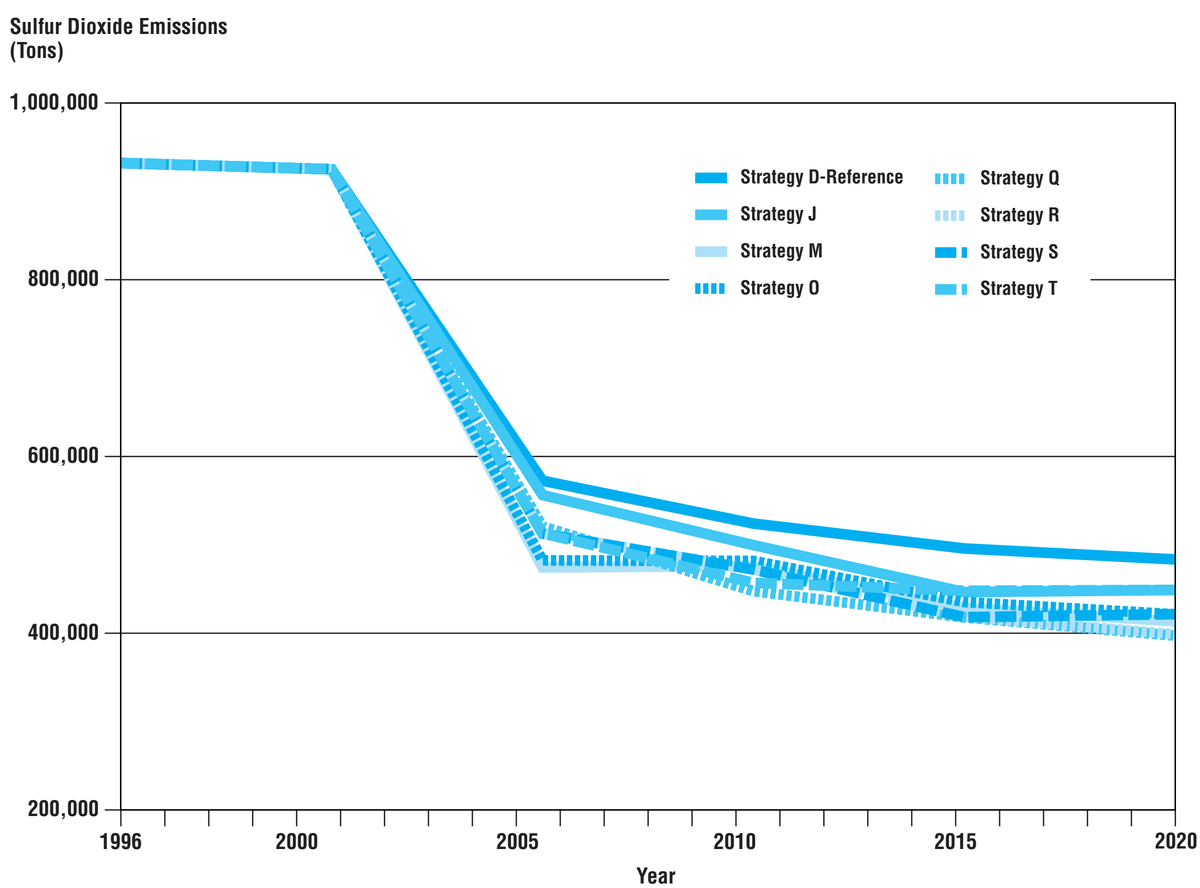
Nitrogen Oxides

Nitrogen oxides emissions are projected to drop from 10 to 20 percent, depending upon the strategy, between 1996 and 2000 due to implementation of Phase II controls under the 1990 Amendments to the Clean Air Act. After the year 2000, nitrogen oxides emissions are projected to increase for all strategies as a function of increasing generation. Emissions are projected, however, to remain 3 to 13 percent lower than 1996 levels (*Figure T2-15*). *Figure T2-18* shows the nitrogen oxides emissions trend for each strategy.

When comparing total emissions averaged over the study period against the reference strategy, the strategy with the lowest emissions, Strategy T, has 10 percent lower nitrogen oxides emissions than the reference strategy (*Figure T2-16*).

- Reductions in TVA emissions of nitrogen oxides could lead to an improvement in ozone (a chemical oxidant that can affect the respiratory system of exercising unmedicated asthmatics) exposures in the Tennessee Valley if TVA reductions are not offset by increases in nitrogen oxides emissions from other sources. For example, emissions from automobiles and other mobile sources are likely to increase substantially during this same period.
- For all strategies, benefits to human health could occur as a result of TVA reductions of nitrogen oxides emissions. Small benefits to visibility, crop and forest productivity, and materials could also result.
- In the immediate vicinity of TVA coal-fired power plants (within about 20 kilometers), where ozone is consumed in the plume, TVA nitrogen oxides emission reductions could actually increase ambient ozone levels.

FIGURE T2-17. **Yearly Sulfur Dioxide Emissions for Each Strategy**



Mercury

When comparing emissions at the beginning and end of the study period, mercury emissions are projected to increase 16 percent in the reference strategy (*Figure T2-15*). All other strategies either have no increase or smaller increases. *Figure T2-19* projects the trend for mercury emissions for each strategy.

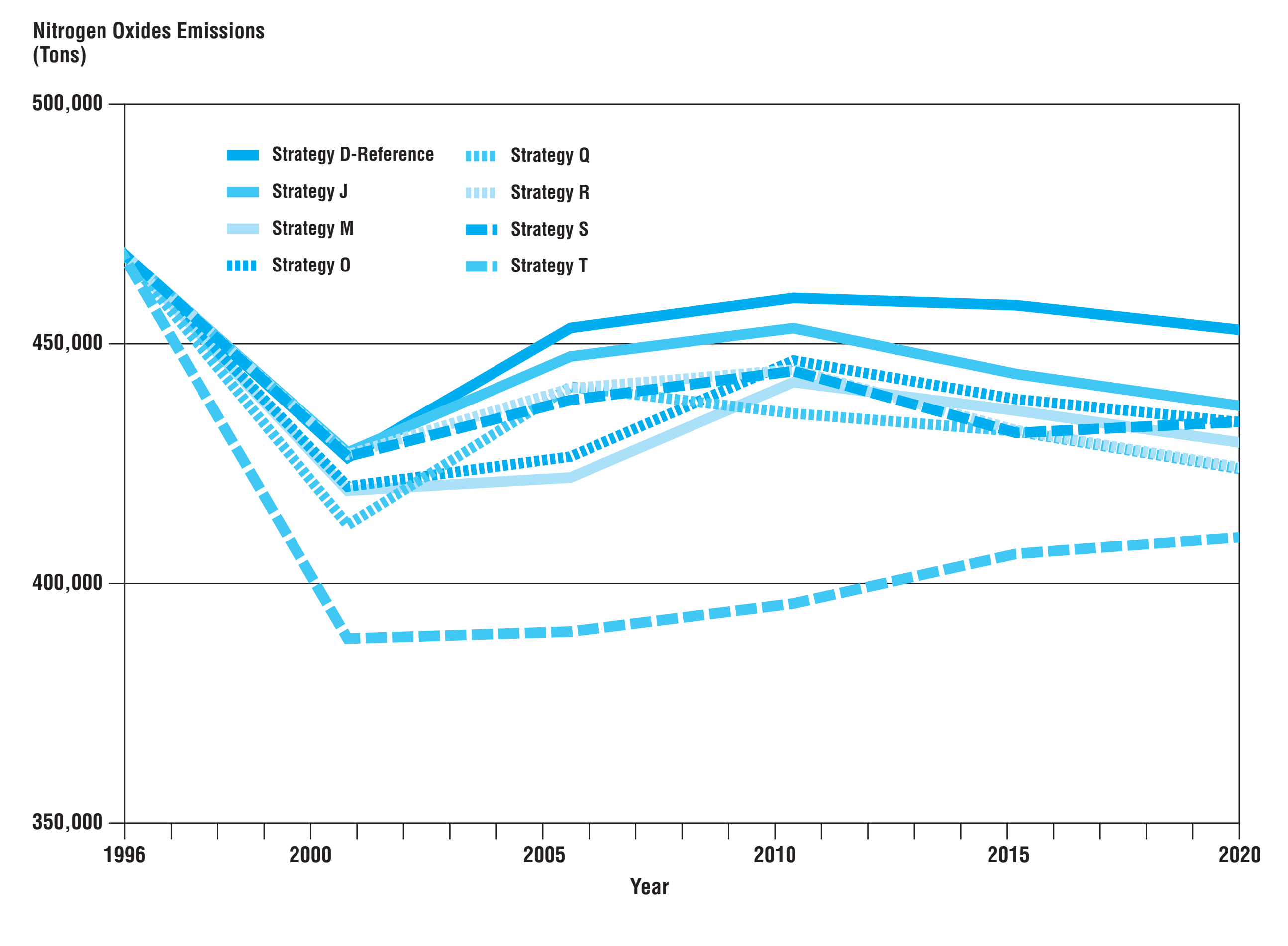
When comparing total emissions for all final strategies averaged over the study period against the reference strategy, mercury emissions are 3 to 9 percent lower compared to the reference strategy (*Figure T2-16*).

Differences in mercury loadings in the Tennessee Valley due to TVA future energy strategies may be detectable. However, because impacts of atmospheric deposition of mercury in the Tennessee Valley are small, changes in impacts as a function of TVA strategies would be very small. TVA emissions are a very small fraction of total mercury impacting sensitive ecosystems outside the Tennessee Valley; thus, these differences in mercury levels are not expected to be detectable at sensitive receptors.

Carbon Dioxide

There remains considerable uncertainty regarding the possible effect of carbon dioxide and other emissions on global climate. However, at the Earth Summit in Rio de Janeiro, Brazil in June 1992, the United States and over 150 other nations signed the United Nations Framework Convention on Climate Change, establishing the objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous manmade interference with the climate system. In October 1993, the President announced the Climate Change Action Plan which has the goal of returning United States greenhouse gas emissions to 1990 levels by the year 2000. As part of this action plan the United States Department of Energy initiated the Climate Challenge

FIGURE T2-18. **Yearly Nitrogen Oxides Emissions for Each Strategy**



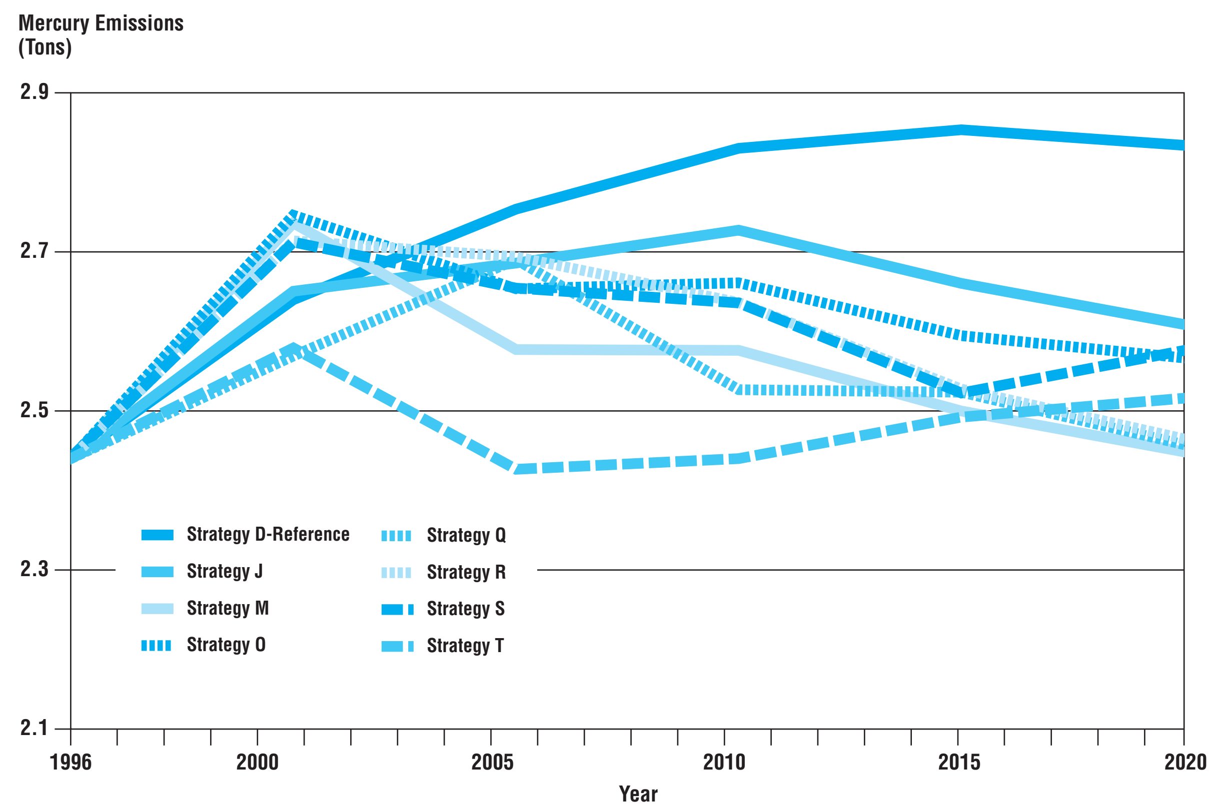
which is a voluntary program to manage United States electric utility greenhouse gases through reduction, avoidance, or sequestering of greenhouse gases.

On April 20, 1994, the Climate Challenge Memorandum of Understanding was signed by the Department of Energy, four utility organizations, and TVA. Subsequently, 104 individual Climate Challenge Participation Accords have been signed with the Department of Energy that represent 487 utilities including TVA. The efforts taken by TVA and the other 450 plus Climate Challenge participants will mitigate possible negative effects utility emissions may have on global climate in a more cost-effective manner than other control measures such as emissions regulations or carbon taxes. A 22.7 million ton reduction in carbon dioxide by the year 2000 is committed to in TVA's Climate Challenge Participation Accord. These reductions are projected from TVA's 1987 to 1990 baseline emissions and the emissions projected by a year 2000 modified reference case. Primarily, TVA greenhouse gas reductions by the year 2000 come from increased use of nuclear power, biomass cofiring, demand-side management programs, fossil-fueled power plant efficiency improvements, transmission system improvements, and hydroelectric power plant modernization.

Although actual carbon dioxide emissions increase under all strategies *(see Figure T2-20)*, the rates of increase have been mitigated by the Climate Challenge actions and are also less than increases under the Energy Vision 2020 reference strategy. Additionally, the carbon dioxide emitted per unit of electric energy produced would be 10 to 15 percent lower than TVA's present power system *(see Figure T2-24)* by the year 2005. This increase in efficiency throughout the planning period is due to: (1) increased production of nuclear power, (2) hydroelectric power plant modernization; (3) addition of more efficient fossil-fired plants, (4) increased use of renewables, and, (5) in some strategies, the repowering of existing coal-fired plants with more efficient energy conversion systems.

The possibility of future carbon dioxide regulation was

FIGURE T2-19. **Yearly Mercury Emissions for Each Strategy**

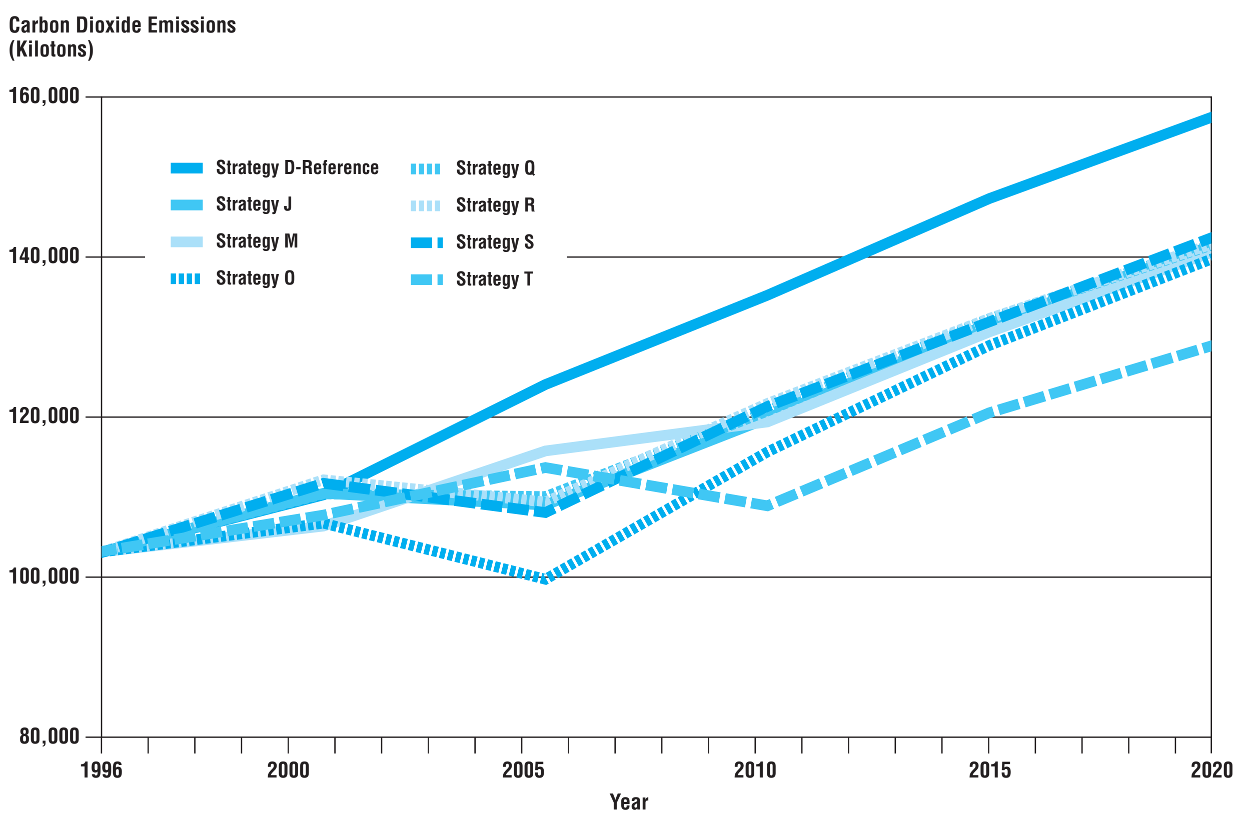


also evaluated in Energy Vision 2020 as an uncertainty. It was assumed for purposes of this uncertainty that there would be a cap on carbon dioxide emissions beginning in the year 2000 at 1990 levels. Any carbon dioxide emissions above this cap could be purchased at $10 per ton of carbon dioxide and any emissions below the cap could be sold for the same price. Because of this cap there would be a direct reduction of carbon dioxide emissions of 2 million to 3 million tons per year on the TVA system. Also, long-term costs were increased sufficiently to reduce emissions to 1990 levels assuming a cost of $10 per ton of carbon dioxide. The cost of this emission reduction averaged $257 million per year for TVA.

Improvements in greenhouse gas emissions (primarily carbon dioxide) for a strategy results from conservation of energy, use of a lower carbon content fuel (e.g., natural gas), the use of noncombustion energy sources, and specific options or measures that offset greenhouse gas releases. Demand-side management programs conserve energy and avoid combustion of fuels, thus reducing the release of carbon dioxide. More efficient power plant cycles also reduce combustion fuel use. Hydroelectric and renewable energy sources, such as wind, supply electricity without combustion of fuels.

Another renewable energy source, landfill methane recovery, has a different advantage. Methane is a greenhouse gas that has 21 times more potential to absorb solar radiation than carbon dioxide. Combustion of landfill methane for energy production releases carbon dioxide, but greenhouse gas impacts are 21 times less than the methane that would have otherwise been released to the atmosphere from the landfill through natural losses. Also, use of wood waste as a cofired fuel at coal-fired power plants recycles carbon dioxide that trees have removed from the atmosphere, rather than the one-way release of carbon dioxide from fuels such as coal and natural gas. Additionally, the methane released to the atmosphere from natural wood waste decomposition in disposal areas is avoided by combustion of the wood waste. Because of the carbon dioxide offsets, equivalent carbon diox-

FIGURE T2-20. **Yearly Equivalent Carbon Dioxide Emissions for Each Strategy**



ide emissions were computed. *Figure T2-25* gives the weightings of various pollutants to obtain the equivalent of carbon dioxide for purposes of considering greenhouse gas emissions.

Greenhouse gas credits and offsets are assigned equivalent carbon dioxide values and are included in the values shown for each strategy, including the index values in *Figure T2-26*.

When comparing emissions at the beginning and end of the study period, equivalent carbon dioxide emissions are projected to increase by 52 percent in the reference strategy (*Figure T2-15*). No strategy provides a decrease in carbon dioxide equivalents when comparing emissions in 1996 and 2020. Carbon dioxide emission trends, including equivalent levels of other greenhouse gases, are projected in *Figure T2-20* for all final strategies.

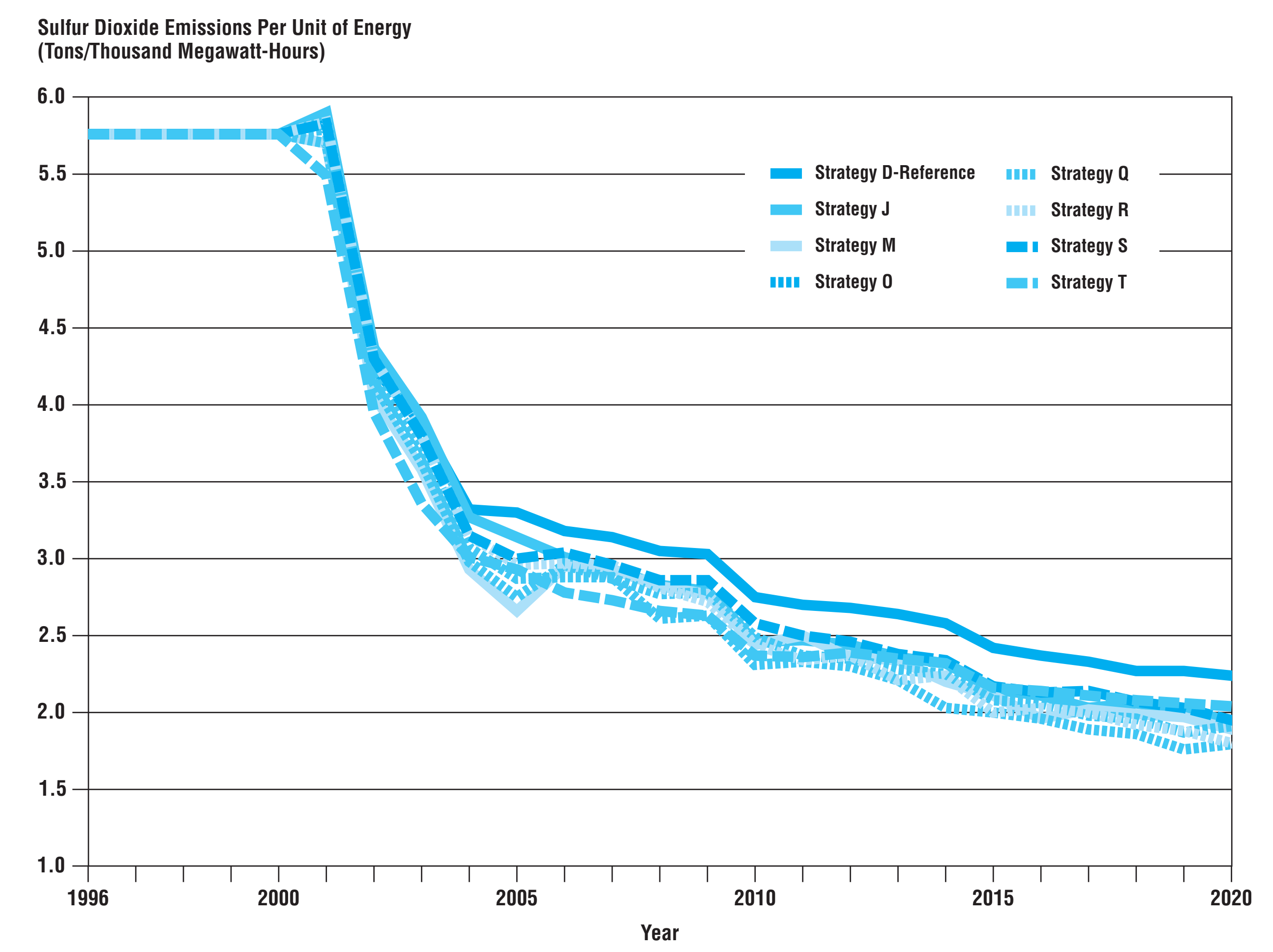
When comparing total emissions averaged over the study period against those for the reference strategy, the smallest increase is forecast for Strategy T with 12 percent lower emissions than the reference strategy (*Figure T2-16*).

Increased use of natural gas-fueled resources, renewables, and demand-side management in Strategy T results in lower levels of greenhouse gas emissions, Gas-fueled resources have 40 percent lower carbon dioxide emissions per unit of energy consumed than the coal-fired plants they re-power. Current scientific understanding is insufficient to project impacts of these increases in the Tennessee Valley.

Emissions Control Efficiencies

The ratio of emissions per unit of electric energy production is a measure of the efficiency of emission controls or the efficiency of energy production itself. All strategies have similar expansion in electric energy production over the planning period so the simple ratio of emissions to unit of electric energy production can be compared. This ratio is shown over the period 1996 to 2020 for sulfur dioxide, nitrogen oxides, mercury, and equivalent carbon dioxide in *Figures T2-21* through *T2-24*. These ratios for sul-

FIGURE T2-21. **Yearly Sulfur Dioxide Emissions for Each Strategy per Unit of Energy Generated**



fur dioxide, nitrogen oxides, and mercury improve over the planning period. These improvements reflect increased plant efficiency, increased use of natural gas, and environmental controls.

As shown in *Figure T2-24*, all strategies have small improvements in efficiencies of carbon dioxide emissions by the year 2000. After 2000, the reference strategy maintains a near-constant ratio of carbon dioxide equivalent emissions to energy production while all other strategies further decrease the ratio. Strategy T has the lowest ratio during the last 10 years of the planning period. These ratios indicate that the projected increases in carbon dioxide equivalents are a function of increased generation.

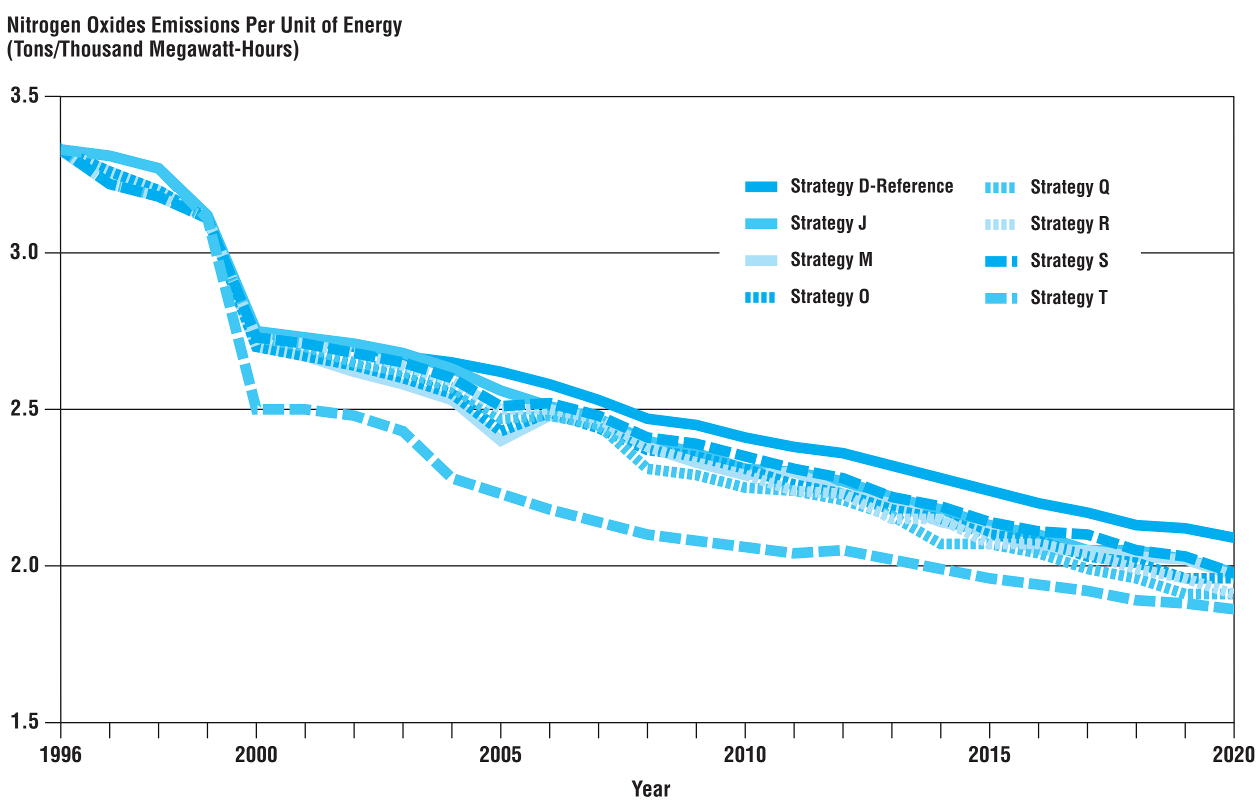
STRATEGY-BY-STRATEGY COMPARISON OF AIR IMPACTS

Air quality impacts related to each energy strategy are addressed separately in this section. *Figures T2-1* to *T2-3* describe each strategy in terms of proposed energy production facilities. Pollutants from all energy resources are considered, including those from purchased power. Levels of TVA emissions of primary particulate matter and volatile organic compounds are negligible compared to emissions from other sources and are not considered in the discussions of specific strategies.

One of the most important conclusions to be drawn from TVA's Energy Vision 2020 evaluation is that TVA's existing coal-fired units are responsible for most of TVA's contribution to the identified environmental impacts. TVA's coal-fired plants produce air pollution, water pollution, and solid waste. These environmental outputs are associated with a number of environmental problems.

TVA's contribution to many environmental problems has been substantially reduced over the years and is being reduced still further. For example, TVA's sulfur dioxide emissions from its coal-fired units have been reduced by over 60 percent since the mid-1970s and will be reduced still further to comply with the

FIGURE T2-22. **Yearly Nitrogen Oxides Emissions for Each Strategy per Unit of Energy Generated**



Clean Air Act Amendments of 1990. These reductions lessen TVA's contribution to such impacts as acid rain and visibility impairment. However, compared to most new energy resource options, TVA's existing coal-fired units are significantly worse environmental performers.

Energy Vision 2020 focuses primarily on what additional energy resource options, if any, should be added to TVA's system in the future. Consequently, repowering of selected less-efficient coal-fired units is one of the better options for reducing emissions.

Any new sources that are constructed, regardless of the type, will meet all applicable federal, state, and local air quality regulations. Thus, new sources will have minimal air quality impacts on the local (within 50 kilometers) scale. Construction of facilities creates temporary local impacts, such as fugitive particle emissions and volatile organic compound emissions from construction equipment. Regional impacts are difficult to project without site-specific information on emissions.

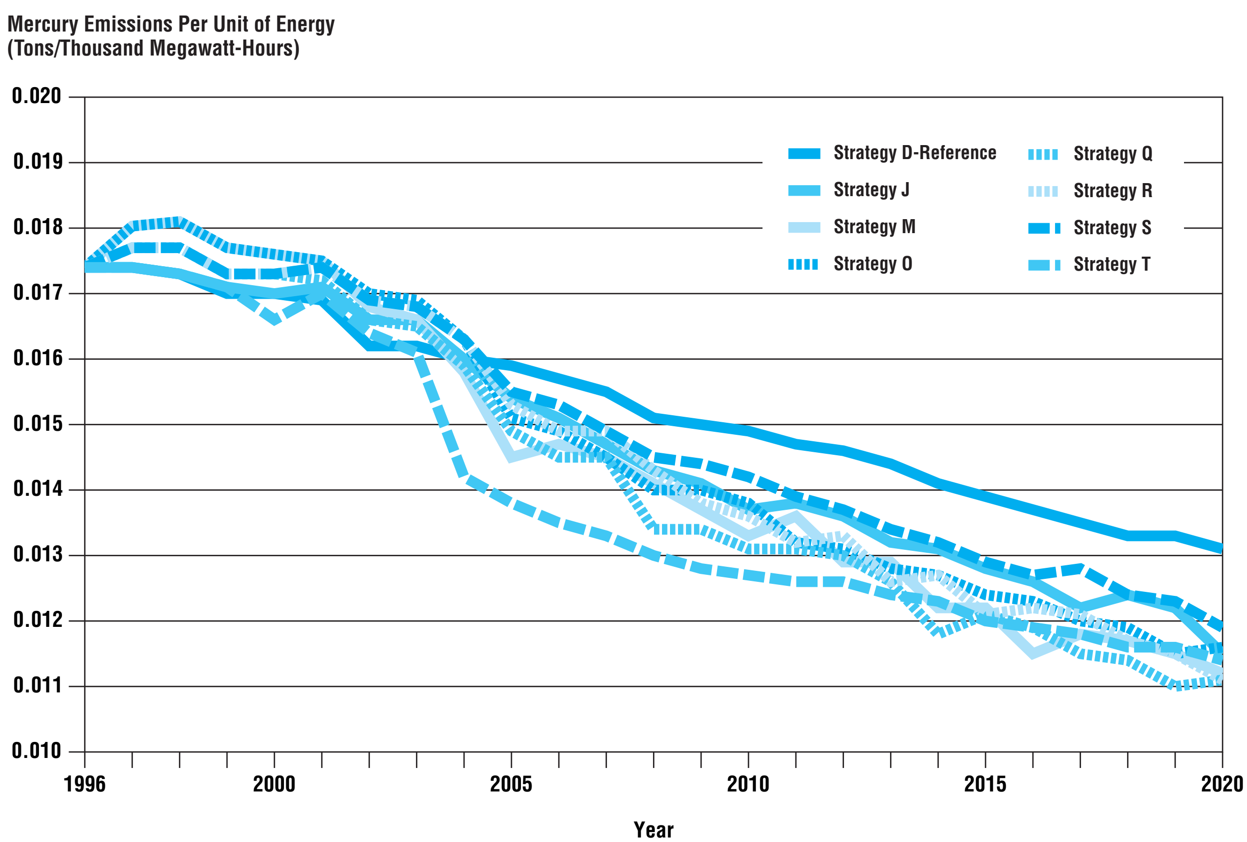
Strategy D – Reference, or "No Action" Strategy

Under Strategy D, existing facilities would continue to operate, although emissions would be reduced from those in 1996 in response to the 1990 Clean Air Act Amendments. New capacity would come primarily from gas-fired turbines fueled by natural gas or gas from coal-gasification facilities.

Sulfur Dioxide

The reference strategy has the highest average annual sulfur dioxide emissions of all the final strategies, greater than 560,000 tons, as shown in *Figure T2-16*. However, all final strategies, includ-

FIGURE T2-23. **Yearly Mercury Emissions for Each Strategy per Unit of Energy Generated**

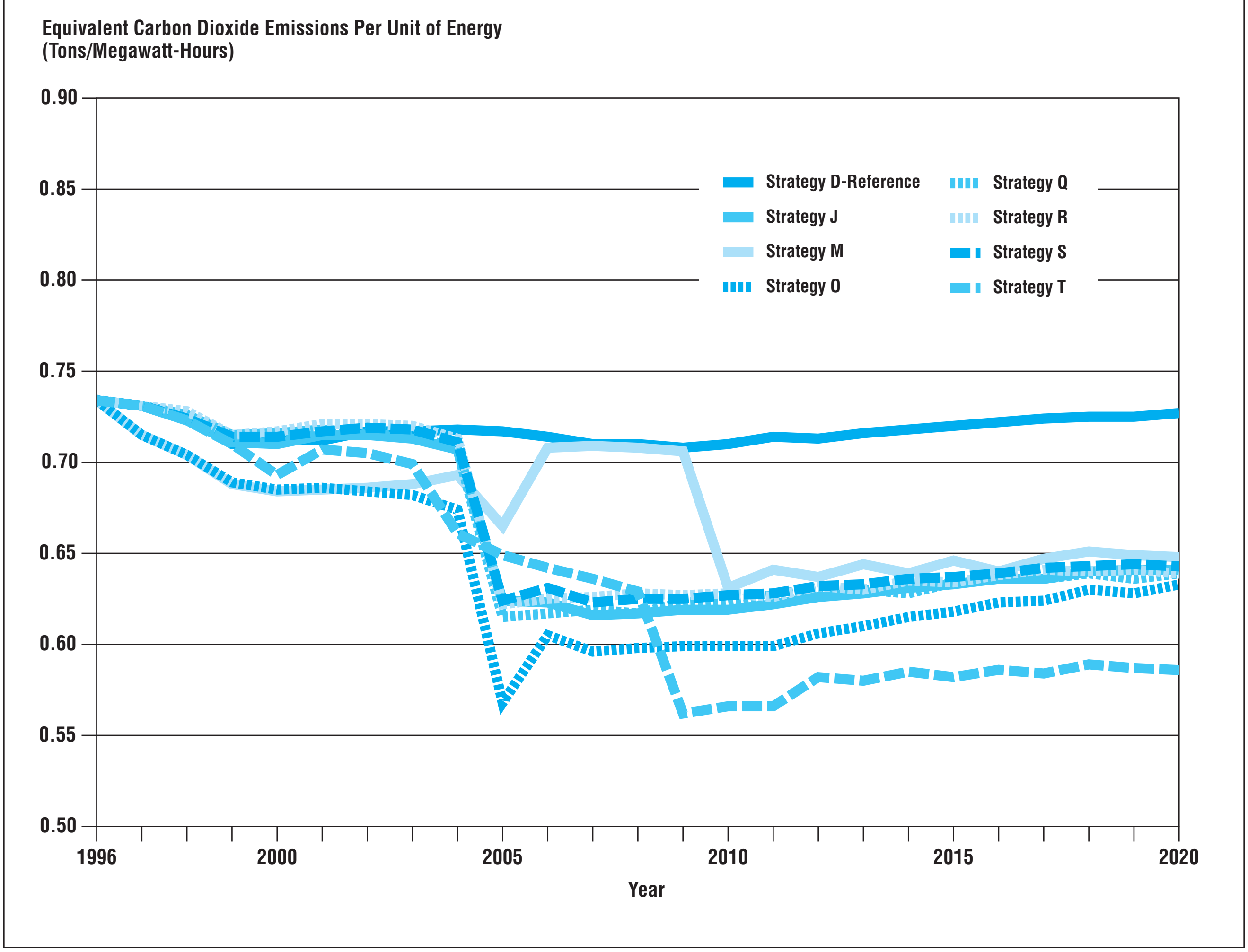


ing the reference strategy have large reductions in sulfur dioxide emissions compared to current emissions (*Figure T2-15*). These reductions would result in a proportional decrease (varying for each facility) in ambient sulfur dioxide concentrations around TVA plants where the reductions occur. This would also be expected to benefit air quality in areas that are sensitive to acid deposition and visibility impairment. However, the magnitude of the benefit is not directly proportional to the emission reductions. For example, a 50 percent reduction in sulfur dioxide emissions would yield less than a 50 percent reduction in acid deposition in the southern Appalachian Mountains. This is due to the fact that TVA emissions are only a fraction of the total sulfur dioxide emissions affecting the southern Appalachians. In addition, some of the proposed emission reductions would be at TVA plants too close to the southern Appalachians to have substantial effect in terms of acid deposition or visibility impairment. Locations further downwind to the east/northeast would derive the most benefit from emission reductions at TVA plants in east Tennessee.

Likewise, because the relationship between "light extinction" and atmospheric particle concentration is highly non-linear, there would be a less than 50 percent improvement in visibility. ("Light extinction" refers to reduced atmospheric light due to the absorption and scattering of light by gas molecules and particles.) If TVA emissions are assumed to be 20 percent of total sulfate loadings at sensitive receptors in southern Appalachia, then a 50 percent reduction in TVA emissions would result in a 10 percent improvement in sulfate loadings. That improvement should be detectable in improved visibility and reduced sulfate in deposition.

Strategy D represents the smallest reduction in sulfur dioxide; therefore, all other strategies should have greater benefits.

FIGURE T2-24. **Yearly Carbon Dioxide Emissions for Each Strategy per Unit of Energy Generated**



Nitrogen Oxides

The reference strategy has the highest average annual nitrogen oxides emissions of all the final strategies, greater than 455,000 tons, as shown in *Figure T2-16*. However, all final strategies, including the reference strategy, have reductions in nitrogen oxides emissions compared to current emissions (*Figure T2-15*). Any changes in ozone exposures resulting from this strategy are likely to be small because proposed nitrogen oxide reductions are small. Also, other sources of nitrogen oxides are projected to increase (e.g. vehicular traffic) and could offset any reductions by TVA. Assuming TVA contributes 25 percent of total nitrogen oxides contributing to ozone formation, and that nitrogen oxide levels limit ozone formation, a 10 percent reduction in TVA contribution would result in a 2.5 percent reduction in ozone exposures, depending on the location. Improvement could be much greater than this average for individual episodes or specific receptors when TVA emissions contribute more than 25 percent of total nitrogen oxides emissions. Within 20 kilometers of TVA power plants, ozone levels could actually increase. (Ozone is consumed in the conversion of nitric oxide to nitrogen dioxide.)

Lower nitrogen oxides emissions would also lead to a slight decline in regional levels of nitrate aerosols. Because nitrogen oxides contribute to ozone and because ozone facilitates the conversion of sulfur dioxide to sulfate, lower nitrogen oxide emissions could also lead to slightly lower sulfate levels. However, the effect on visibility would probably be difficult to perceive. In addition, small improvements of nitric acid in acid deposition could also result.

Mercury

The reference strategy has the highest average annual mercury emissions, almost 5,500 pounds, as shown in *Figure T2-16*. All final strategies, including the reference strategy, represent the same or an increase from current mercury emissions (*Figure T2-15*).

The quantity of mercury emissions is a function of the quantity of coal burned and whether flue gas desulfurization devices (scrubbers) are installed that are partially effective in removing mercury. TVA emissions increases may be detectable in the Tennessee Valley if other sources remain constant or decrease. However, because impacts of atmospheric mercury deposition to natural resources in the Tennessee Valley are small, impacts of increases in TVA emissions are likely to be very small. TVA emissions may contribute to total mercury deposition at sensitive receptors outside the Tennessee Valley. Specific atmospheric modeling would be required to determine if TVA's contribution and increases in TVA emissions would be detectable at sensitive receptors, but this is not likely.

Carbon Dioxide

The reference strategy has the highest average annual equivalent carbon dioxide emissions of all final strategies, over 130,000 tons, as shown in *Figure T2-16*. All final strategies, including the

FIGURE T2-25. **Weighting Factors to Obtain Carbon Dioxide Equivalents for Considering Greenhouse Gas Emissions**

Environmental Measure	Units	Greenhouse Gases Total Equivalent Carbon Dioxide
Carbon Dioxide Emission	Annual Average Thousands of Tons	1
Coalbed Methane Emissions Avoided	Annual Average Tons	-21
Natural Gas Methane Emissions	Annual Average Tons	21
Landfill Methane Recovered	Annual Average Tons	-21
Wood Waste Methane Avoided	Annual Average Tons	-21
Wood Waste Carbon Dioxide Avoided	Annual Average Thousands of Tons	-1
Short Rotation Woody Crops Carbon Dioxide Avoided	Annual Average Thousands of Tons	-1

FIGURE T2-26. **Equivalent Carbon Dioxide Index**

Strategy	Total Equivalent Carbon Dioxide (Millions of Tons)
D-Reference	1.00
J	0.93
M	0.91
O	0.90
Q	0.93
R	0.93
S	0.93
T	0.87

reference strategy, represent an increase from current equivalent carbon dioxide emissions (*Figure T2-15*). The greenhouse gas index for the reference strategy includes effects from existing demand-side management programs.

Strategy J – Bellefonte Coproduct and Renewables Strategy

The resource option differences between Strategy J and the reference, or "No Action," strategy lie in converting Bellefonte Nuclear Plant to an integrated gasification combined cycle plant and relying more on renewable fuel sources.

Because the integrated gasification combined cycle at Bellefonte is proposed in Strategy J, there would be nitrogen oxides emissions from the site that would not have existed under Strategy D. Thus, nitrogen oxides concentrations would increase within about 20 kilometers of Bellefonte and ozone concentrations would likely decrease. Beyond this distance, ozone concentrations would increase at a rate dependent on plant size, design, and other factors. However, the Bellefonte site is not sufficiently near any ozone non-attainment areas to materially affect attainment efforts. Also, the nitrogen oxides emissions from gasification are very low. Emissions from such a Bellefonte facility could theoretically contribute to ozone levels in the southern Appalachians, but this contribution would probably be small. The reason is the distance (about 210 kilometers) and the complex topography between Bellefonte and the southern Appalachians. Both factors act to increase pollutant dispersion and keep low the concentrations that could eventually reach sensitive receptor sites. Moreover, any new facility at Bellefonte would coincide with nitrogen oxides emission reductions in other parts of the TVA system. Detailed site-specific ambient air quality modeling may be required if a non-nuclear Bellefonte option were proposed to be implemented.

Strategy J has the least average annual sulfur dioxide, nitrogen oxides, and mercury reductions (with Strategy O also having the least mercury reductions) compared to the reference strategy (*Figure T2-16*).

For all impact areas other than greenhouse gases, this strategy produces the smallest air quality benefits of all the final strategies relative to Strategy D (the "No Action" strategy) because the fuels mix is so similar. (Air quality indices of 0.98 or 0.97 compared to 1.0 for Strategy D, see *Figure T2-14*).

The greenhouse gases index rating for equivalent carbon dioxide is 0.93, lower than the 1.00 for the reference strategy, Strategy D. The equivalent carbon dioxide emission decrease results from demand-side management (517 megawatts), hydroelectric improvements (163 megawatts), landfill methane capture (500 megawatts), coalbed methane capture (1000 megawatts) and 0.3 percent biomass co-firing for coal-fired facilities.

Strategy M – Combined Demand-Side Management and Off-System Sales Strategy

Strategy M emphasizes natural gas and demand-side management early in the planning period. It includes a new coal-fired unit at the Shawnee plant site, and additional power purchases from independent power producers. Sulfur dioxide and nitrogen oxides emissions from the new Shawnee unit would be more than offset by reductions elsewhere in the TVA system under this strategy. Changes in local air quality impacts around Shawnee and regional air quality impacts, including health impact changes, of this strategy are expected to be small. Site-specific environmental evaluations would be performed before putting a new coal-fired unit at Shawnee in place.

Among the final strategies, Strategy M offers neither the smallest nor the largest average annual emissions reductions for any pollutant when compared to the reference strategy (*Figure T2-16*).

For all impact areas other than greenhouse gases, air quality indices range between 0.93 to 0.95, neither the smallest nor the largest impacts, compared to 1.0 for the reference strategy *(Figure T2-14)*.

The greenhouse gases index rating for Strategy M is 0.91, lower than 1.0 for the reference strategy. The equivalent carbon dioxide emission decrease results from demand-side management (958 megawatts), hydroelectric improvements (163 megawatts), landfill methane capture (500 megawatts), coal field methane capture (1000 megawatts), and 0.3 percent biomass co-firing for coal-fired facilities.

Strategy O – Bellefonte Coproduct, Demand-Side Management Blocks One and Two, and More Off-System Sales Strategy

Strategy O is similar to Strategy M, but includes an integrated gasification combined cycle plant at Bellefonte rather than the Shawnee coal-fired unit. Among the final strategies, Strategy O offers the smallest average annual emissions reductions (along with Strategy J) when compared to the reference strategy (*Figure T2-16*).

For all impact areas other than greenhouse gases, index values range from 0.94 to 0.96, neither the smallest nor the largest impacts, compared to the reference strategy of 1.0 (*Figure T2-14*).

The greenhouse gases index rating for Strategy O is 0.90, the second best rating for all final strategies. The decrease in equivalent carbon dioxide emissions results from use of the resource options identified in the discussion of Strategy M.

Strategy Q – Flexible Strategy with External Options

Strategy Q is similar to Strategy O, but with more emphasis placed on off-system power purchases. This strategy (along with Strategies R and S) produces the smallest average annual

reduction in carbon dioxide compared to the reference strategy. It has, however, the greatest annual reductions in average annual sulfur dioxide emissions compared to the reference strategy (*Figure T2-16*).

For all air impact areas other than greenhouse gases, air quality indices range from 0.92 to 0.95, neither the largest nor the smallest impacts, compared to the reference strategy of 1.0 (*Figure T2-14*).

The greenhouse gases index rating for Strategy Q is 0.93, neither the largest nor the smallest impacts, compared to 1.00 for the reference strategy. The decrease in equivalent carbon dioxide emissions results from use of demand-side management (492 megawatts), hydroelectric improvements (163 megawatts), landfill methane capture (500 megawatts), coal field methane capture (1000 megawatts), and 0.3 percent biomass co-firing for coal-fired plants.

Strategy R – Flexible Strategy with Internal Options

Strategy R is similar to Strategy Q, except that one gas-fired combined cycle unit is added and off-system purchases are de-emphasized. Among the final strategies, Strategy R (along with Strategies Q and S) has the smallest average annual equivalent carbon dioxide emissions reduction compared with the reference strategy (*Figure T2-16*).

For all impact areas other than greenhouse gases, air quality indices range from 0.94 to 0.96, neither the smallest nor the largest impacts, compared to the reference strategy *(Figure T2-14*).

The greenhouse gases index rating for Strategy R is 0.93 as compared to 1.00 for the reference strategy. The equivalent carbon dioxide emission decrease results from demand-side management (492 megawatts), hydroelectric improvements (163 megawatts), landfill methane capture (500 megawatts), coal field methane capture (1000 megawatts), and 0.3 percent biomass co-firing for coal-fired plants.

Strategy S – Low Cost, Low Rates, and Improved Environment Strategy

Strategy S is similar to Strategy O, with the exception that off-system purchases are increased short-term and coal-gasification, mid-term. Among the final strategies, Strategy S (along with Strategies Q and R) have the smallest average annual emission reductions for equivalent carbon dioxide when compared with the reference strategy (*Figure T2-16*).

As shown in air quality indices in *Figure T2-14*, impacts from this strategy are neither the largest nor the smallest impacts when compared to the reference strategy.

The greenhouse gases index rating for Strategy S is 0.93 compared to 1.00 for the reference strategy. The equivalent carbon dioxide emission decrease results from demand-side management (492 megawatts), hydroelectric improvements (163 megawatts), landfill methane capture (500 megawatts), coal field methane capture (1000 megawatts), and 0.3 percent biomass co-firing for coal-fired plants.

Strategy T – Low-Cost Renewables, Low Price Demand-Side Management, Repowering, and Bellefonte Coproduct Partnership Strategy

Strategy T relies heavily on renewable energy sources, new gas-fired turbines (natural gas or coal-gasification), and natural gas repowering at some coal-fired units. Also included is a small amount of new coal-fired capacity and an integrated gasification combined cycle plant at the Bellefonte site. Impacts from the integrated gasification combined cycle plant are addressed under Strategy J. This strategy projects the lowest average annual nitrogen oxides, mercury, and equivalent carbon dioxide emissions compared to the reference strategy (*Figure T2-16*). A large shift to natural gas combustion is an important factor. (Gas combustion produces only about 60 percent as much nitrogen oxides as coal combustion per unit of heat energy produced.) Low mercury emissions correlate with a low reliance on coal combustion.

Because the air quality indices are tied strongly to system-wide nitrogen oxides and sulfur dioxide emissions, this strategy has the best ratings (0.91) for all impact areas compared to the reference strategy of 1.0. The reduction in potential air quality impacts as a result of implementing this strategy would be the largest of all strategies considered. (See *Figure T2-14*.)

The greenhouse gases index rating for Strategy T is 0.87, the best rating of all final strategies when compared to the reference strategy with 1.0. The equivalent carbon dioxide emission decrease results from demand-side management (517 megawatts), hydroelectric improvements (162 megawatts), compressed air energy storage (1011 megawatts), landfill methane capture (500 megawatts), coal field methane capture (1000 megawatts), wind (2000 megawatts), and 0.3 percent biomass co-firing for coal-fired plants.

SECTION 4: WATER RESOURCE IMPACTS OF ALTERNATIVE STRATEGIES

Understanding Water Resource Impacts

This section summarizes the differences among TVA's final strategies with respect to potential impacts on water resources. Three water-quality impacts were considered: (1) human health impacts by ingestion, (2) impacts on water supply and waste assimilation, and (3) impacts on fish, aquatic life, and aquatic biodiversity. Volume 2, Technical Document 1, Comprehensive Affected Environment, provides an overview of water quality issues, existing water quality impacts, sources of pollutants, water pollution trends, and regulations.

All new TVA generating resources included in the strategies assume certain constraints:

- Cooling towers will be constructed as necessary to deal with significant amounts of waste heat.
- All applicable water quality standards will be met through compliance with state-issued permits under the National Pollutant Discharge Elimination System, as is the case with existing facilities.

Prior to the development of a new energy resource, a site-specific environmental review would be done that examined direct and indirect water quality effects. For major facilities, water and aquatic life systems would be carefully monitored during construction and initial operation to identify adverse effects. Possible effects of construction and operation of new facilities on sensitive environmental resources such as wetlands or threatened or endangered aquatic species would be addressed in these site-specific reviews.

FUTURE REGULATORY TRENDS

The U.S. Congress is in the process of reauthorizing the Clean Water Act (P. L. 92-500, as amended), the Safe Drinking Water Act (P. L. 93-523, as amended), the Endangered Species Act (P. L. 93-205, as amended), and Superfund (P.L. 96-100, as amended). Changes proposed for all of these laws have the potential to affect the regulation of water resources (surface water and groundwater). Proposed changes to the Clean Water Act include clearer delineation of what constitutes a wetland, repeal of the current stormwater permitting program, greater latitude for the states in reducing nonpoint pollution sources, and the use of risk assessments and cost-benefit analysis in the Environmental Protection Agency rule- making process. These changes have the potential to affect the permits currently held by operating TVA power plants as well as the siting of new facilities, including transmission lines.

Most of the debate surrounding reauthorization of the Safe Drinking Water Act centers around the issue of risk. Currently the Environmental Protection Agency's rulemaking policy is one of zero risk. Opponents argue that the stringent drinking water standards resulting from this policy are too costly and without justifiable health benefits. How drinking water standards are set can affect the environmental siting process and ultimately the level to which contaminated groundwater must be cleaned.

The Endangered Species Act is under review. Opponents believe it goes too far in protecting the habitats of threatened and endangered species, infringes on property rights, and adversely affects federal land management policies. Loosening of the Act's provisions could affect the siting of new plants and transmission lines.

Almost everyone involved in the Superfund debate believes reform is needed. Some want major changes to the law's liability structure and cleanup standards while others favor more modest changes. The result of this debate in the Congress has the potential to significantly affect the cost of cleanup of contaminated sites associated with power production and transmission facilities.

Analysis of Energy Vision 2020 Strategies

WATER QUALITY INDICES FOR ALTERNATIVE STRATEGIES

TVA developed water quality indices to help characterize how alternative energy resource strategies may contribute to:

- Human health
- Water supply and waste assimilation
- Fish and aquatic life and biodiversity

The final strategies are described in *Figures T2-1* through *T2-3*. *Figure T2-27* shows the values for the water indices. Volume 2, Technical Document 1, Comprehensive Affected Environment (Section 4, Water Resources), contains detailed information about the measures used in deriving these water quality indices and a discussion of how they were weighted.

In developing the indices, TVA used eight weighted measures to evaluate the three impact areas above. There were three direct measures:

- Heat released
- Water consumed, (i.e., when water is not returned to the originating source)
- Water used (i.e., when water is returned to the originating source)

FIGURE T2-27. **Water Quality Impact Environmental Indices for Each Strategy and Impact Area**

	IMPACT AREAS		
Strategy	Health-Ingestion	Water Supply and Waste Assimilation	Fish and Aquatic Life and Biodiversity
D - Reference	1.00	1.00	1.00
J	1.00	1.00	0.99
M	1.01	1.00	1.00
O	1.00	0.99	0.99
Q	1.01	0.99	0.99
R	1.01	1.00	1.00
S	1.01	1.00	1.00
T	0.92	0.99	0.96

Water indices have been developed for health-ingestion, water supply and waste assimilation, and fish and aquatic life and biodiversity.

Surrogate measures were also used. (A surrogate measure is one that moves in the same direction as another that is more difficult to measure.)

- Coal burned
- Power produced by nuclear, coal, and hydroelectric plants
- The number of new power plants constructed

Three of the measures received most of the weighting for the impact areas:

- Hydroelectric peaking power production
- Coal power production
- Coal burned

The water health-ingestion index uses three weighted measures:

- Power production from nuclear
- Coal-fired
- Peaking hydro

Hydro peaking and nuclear power production are constant for all final seven strategies as well as the reference strategy. As a result, differences in coal-fired (existing plants) power production governs the index. Strategies M, Q, R, and S all have increased coal-fired power production from existing plants compared to the reference strategy. This results in index values slightly greater than 1.0.

SUMMARY OF FINDINGS

TVA's final strategies are compared to the "No Action" strategy or the reference strategy for Energy Vision 2020 (Strategy D). As indicated, there are only slight differences among TVA's final seven strategies and Strategy D for most water resource effects. Because less coal is burned under Strategy T (low-cost renewables) and coal use produces some water resource-related consequences, only this strategy shows a noticeable improvement. The following major conclusions have been reached:

- The effects of damming rivers, including operation of existing hydroelectric units, is responsible for the more important water resource impacts. However, since no new dams are proposed in the final strategies or the reference strategy, this impact is the same across all strategies.
- Increasing the capacity of TVA's existing hydroelectric plants is environmentally beneficial. This produces new capacity without constructing new plants. New plant construction, particularly a new hydroelectric dam, is more environmentally damaging. Also, new turbine designs used in increasing the capacity of existing hydroelectric plants may also incorporate technology that introduces oxygen and helps combat the low dissolved oxygen problem that exists today below a number of TVA dams.
- TVA's existing coal-fired plants are responsible for most of TVA's contribution to water pollution. As described in the section on Air Resource Impacts, cost-effective repowering of selected less-efficient coal-fired units provides some of the best options for water quality.
- Repowering or adding capacity at any existing facility is preferable from a water resource perspective because it lessens the risk of impacts to those resources. Generally, from a water quality viewpoint, repowering of existing units is preferable to construction of new plants because the repowered units would have less of an impact on aquatic resources than the older units they replaced. Also, there is a risk of adverse effects from construction runoff and the disturbance of small streams associated with construction of new plants at sites that have not yet been developed. Construction of additional transmission lines on new rights of way could affect aquatic communities in small streams crossed by the lines. However, these construction effects can be greatly reduced or avoided through the use of construction best management practices that properly control contaminated runoff.
- Strategies that include increased use of coal, either for combustion or gasification, will result in increased risk of environmental impacts on water resources. This is due primarily to adverse effects in the fuel cycle, including those resulting from sediment runoff from strip-mined land and acid mine drainage. Streams in Appalachia and western

Kentucky are currently degraded by coal mining and increased use of coal may, without proper mitigation, result in continued degradation. However, various regulatory processes are in place to reduce the risk of adverse impacts and to require the appropriate use of mitigative measures. This includes the regulations implementing the Surface Mining Control and Reclamation Act.

- Unlike coal combustion, coal gasification does not produce large quantities of ash, which can adversely affect surface and groundwater during handling and disposal. Coal gasification produces an inert glass-like slag that can be used as a construction material.
- Generally, new capacity from demand-side management will result in few, if any, negative water resource impacts.
- The production and disposal of contaminated groundwater during the collection of coalbed or coal seam methane can pose problems and unless handled appropriately could affect water quality and aquatic communities.

STRATEGY-BY-STRATEGY COMPARISON OF WATER IMPACTS

Strategy D: Reference, or "No Action" Strategy

Strategy D is considered the "No Action" strategy, or TVA's most likely course of action for adding new capacity during the next 25 years had the Energy Vision 2020 process not been undertaken. Well over half of the new capacity added during that time would come from new gas-fired simple-cycle combustion turbines and combined cycle combustion/steam turbines. More than a third would be produced by integrated gasification combined cycle and coal gasification systems. Seven percent would be purchased from independent power producers using gas-fired simple and combined cycle cogeneration systems. Demand-side management, as a percentage of new capacity, would steadily decrease from 30 percent in 2000 to 3 percent in 2010. Since this reference strategy would not involve decommissioning or repowering existing facilities, any operational or fuel cycle aquatic effects from existing facilities would remain unchanged.

Under the "No Action" strategy, effects on water quality and aquatic communities would tend to be localized and associated with construction and operation of new facilities at undeveloped sites. Fuel cycle effects from drilling and mining at remote locations could be expected, albeit the significance of such effects would be reduced through the operation of various regulatory processes. Localized or site-specific effects would be addressed in subsequent reviews of specific resource options that are proposed.

Construction impacts are generally associated with the erosion/runoff of disturbed soil during storm events. The suspended soil entering a stream or river can carry contaminants (e.g., cleaning solvents, fuels) spilled during construction activities. Suspended material in a stream or river can also absorb heat and increase ambient temperature. Discharges of small amounts of chemicals used in cleaning of equipment and sewage treatment plant effluents (wastewater) could also have minor impacts. New gas pipelines would be required for some options and possibly barge unloading facilities for the coal gasification options.

Siltation can affect aquatic life by clogging fish gills, smothering fish eggs and benthic organisms, and reducing photosynthesis of phytoplankton and aquatic plants. Dredging destroys benthic (i.e., bottom-dwelling) organisms in dredged areas, and chemicals can cause direct toxic effects or indirect effects through bioaccumulation in the tissues of aquatic organisms. Sewage effluents (wastewater) contain human pathogens and oxygen-demanding substances. However, all of these potential effects on the aquatic environment can be minimized or avoided through the use of appropriate site management practices and proper treatment of effluents.

Operational aquatic effects in receiving waters can be caused by thermal discharges, process discharges, coal and ash handling, and small amounts of chemical and sanitary wastes. This reference strategy and nearly all the strategies being considered envision a large portion of new power from integrated coal gasification combined cycle technologies. While integrated coal gasification combined cycle plants are an attractive alternative to conventional power production methods, a number of challenges remain, one of which is water and wastewater management.

Overall, there is very little information generally available on the treatment of integrated coal gasification combined cycle wastewater, and only a limited amount of commercial experience in treating such wastewater. Gasifier design and type of coal used are the principal variables that determine the composition of gasification wastewater. Gas treatment after gasification produces wastewater that may contain organic material, phenolics, cyanides, sulfides (and other reduced forms of sulfur), and ammonia. These are not present in wastewater from conventional coal-fired power plants. Many of these compounds are highly toxic to aquatic life and would pose a significant threat without adequate treatment and removal.

However, technology is available to treat integrated coal gasification combined cycle wastewater to meet the most stringent standards. All operational impacts would be mitigated through the states' National Pollutant Discharge Elimination System permitting processes. In most, if not all, cases these facilities would be considered "new sources" under the Clean Water Act. As such, they would be subject to effluent limitations under New Source Performance Standards for steam electric power plants and chemical manufacturing plants where co-production is planned.

These would be more stringent standards than those at existing plants.

Possible effects of heated effluents on aquatic life that have been suggested include mortality, advanced fish spawning, increased toxicity of certain pollutants, and shift of phytoplankton populations toward less desirable species. Since any new facilities would likely dissipate waste heat through cooling towers, the possibility of these impacts occurring at new TVA facilities is minimized. However, if cooling systems at new facilities are operated in closed cycle, elevated levels of dissolved solids (including metals) will occur in discharged recirculation water through evaporative concentration of solids (including metals). The significance of this would depend on site-specific factors such as speed of mixing, degree of dilution, and metal concentrations in intake water.

National Pollutant Discharge Elimination System permits strictly regulate chemical and sanitary wastes. The use of various oxidizing and non-oxidizing chemicals for control of biofouling organisms can be expected to increase at existing power facilities due to the recent introduction of the zebra mussel *(Dreissena polymorpha)* into surface waters in the TVA service area. The permitting process will establish appropriate limits on biofouling control chemicals to protect aquatic resources, but increased use of such chemicals poses an increased risk of adverse effects. Such controls will also be required at new facilities, but careful advance planning can reduce the threat of zebra mussels and minimize the need for control chemicals.

Aquatic life could be affected by killing or injuring adult fish by impinging (colliding) on intake screens and entraining (drawing through equipment) plankton and fish larvae contained in intake cooling water. Factors such as the location and design of intake structures, the volume of water used, and other site-specific factors would alter the magnitude of such effects. Careful attention during the planning and design phases of facility construction can reduce these potential impacts to acceptable levels.

Aquatic effects associated with coal ash disposal at existing coal-fired units would be minimized in the proposed coal gasification schemes. The process would convert ash to an inert glass-like slag that is non-leachable and suitable for use as a construction material. Mining of high sulfur coal used to fuel the integrated coal gasification facilities could result in some aquatic environmental effects from acid and chemical drainage, land destabilization, and erosion. This would occur both inside and outside the TVA service area. Coal deposits are usually accompanied by pyretic materials that, when exposed to air and water, form sulfuric acid. This and other chemical compounds from mining can pollute water and affect aquatic organisms. There are, however, regulatory processes that are formulated to reduce or eliminate such possible effects. Similarly, activities associated with drilling for natural gas can cause localized aquatic effects, primarily from physical disturbance of habitats and disposal of co-produced groundwater, which may be high in salinity.

Measurements for surface and groundwater environmental evaluation criteria relating to (1) human health (ingestion), (2) water supply and waste assimilation, and (3) fish and aquatic life and biodiversity have been combined and summarized into indices for each of these areas. The score of 1.00 represents the effects of Strategy D, the "No Action" strategy. Based on this analysis, the water impacts of all of the alternatives presented vary only slightly from the reference, or "No Action," strategy, except Strategy T, which is somewhat better in all three areas. The reference, or "No Action," strategy and the final seven strategies analyzed are described in *Figures T2-1* to *T2-3*.

Strategy J – Bellefonte Coproduct and Renewable Strategy

In this strategy, about half of the new capacity in 2020 would be natural gas-based, from either TVA-owned simple cycle turbines or purchased from combined cycle plants owned by independent producers. About 40 percent would be coal gasification combined cycle, including converting Bellefonte to integrated gasification combined cycle with methyl tertiary butyl ether as a marketable coproduct. The other resource options that make up this strategy include renewables (landfill and coalbed methane) and modernization of hydroelectric plants. There would be no repowering or retiring of existing operating plants. Therefore, there would be no reduction in existing water quality or aquatic life impacts due to selection of this strategy.

Off-site impacts on groundwater related to natural gas drilling operations would have the greatest potential for aquatic resource impacts under this alternative. Some potential surface water effects could occur as a result of gas pipeline construction. Also, the construction of new facilities could cause localized effects from erosion of disturbed soils. These impacts would generally be limited to the transport of adsorbed contaminants during rainfall/runoff events. Contaminants of concern would be those spilled or uncontrolled during construction activities (e.g., solvents, fuels). These impacts would be reduced or avoided through the utilization of appropriate erosion control practices.

Operational effects on water quality can be caused by the discharge of heated cooling water and small amounts of chemical and sanitary wastes. The discharge of these contaminants would be regulated by the state National Pollutant Discharge Elimination System's permitting process and potential impacts would be minimized or avoided.

The primary difference between this and Strategy D (the "reference" strategy) is the conversion of the partially constructed Bellefonte Nuclear Plant to an integrated coal gasification combined cycle plant with a facility for coproduct-production of methyl tertiary butyl ether. As discussed, gasification process wastewaters may contain toxic components not associated with conventional coal-fired power plants and therefore may be potentially more damaging to aquatic life in receiving waters. The specifics of the water and wastewater characteristics of this plant would be detailed in a site-specific environmental analysis that would be prepared if this option were selected. In any case, integrated coal gasification combined cycle wastewater is treatable and discharges would be strictly controlled under National Pollutant Discharge Elimination System permits. That would also be true of wastewater associated with a methyl tertiary butyl ether co-production facility.

The additional hydroelectric generation in this strategy would be obtained by undertaking additional modernization projects at existing hydroelectric plants. No new hydroelectric plant construction is contemplated. Of the renewable options, only coalbed methane poses major wastewater disposal problems. This is primarily due to contaminated coproduced groundwater that could affect surface water resources. Coproduced water is often disposed of by returning it to the source from which it was drawn.

Water quality indices for Strategy J are identical to the reference, or "No Action," strategy except for the fish and aquatic life and biodiversity index. This index is rated 0.99, which indicates a very slight improvement over the reference, or "No Action," strategy. This improvement is due to a reduction in the amount of coal burned, relative to the reference strategy.

Strategy M – Combined Demand-Side Management and Off-System Sales Strategy

Strategy M emphasizes natural gas and demand-side management in the near term with a shift toward more coal combustion and coal gasification options in the long term. Coalbed and landfill methane recovery options also come into play in the later years of the study. Shawnee Fossil Plant would add one new unit to its existing 10 coal-fired units.

Increases in natural gas usage could impact off-site groundwater and surface water. Drilling operations could affect the former, gas pipeline construction the latter. Similarly, additional coal utilization could add impacts from increased mining activities. Aquatic effects from the construction of new facilities would also be a possibility. However, there are regulatory processes and best management practices that would reduce or eliminate the risk of such impacts.

Increased coal usage can affect ground and surface water quality due to coal-ash disposal. The integrated coal gasification combined cycle and related options generate complex and potentially toxic wastewaters. The coalbed methane option also presents a potential threat to aquatic communities because of the possible coproduction of contaminated groundwater that would require disposal. The state discharge permitting process would mitigate or avoid impacts to surface waters. Groundwater impacts, however, are much more difficult to control and costly physical mitigation measures may be required, such as synthetic liners for treatment or holding ponds.

The water quality indices are identical with the reference, or "No Action," strategy, except for the health ingestion index. This index is rated at 1.01, which indicates a slightly higher impact than the reference, or "No Action," strategy. The water health ingestion index uses three weighted surrogate measures: power production from nuclear (5%), coal-fired (60%), and peaking hydro (35%). Hydro peaking and nuclear power production are constant for all final seven strategies as well as the reference strategy. As a result, differences in coal-fired (existing plant) power production governs the index. This strategy, as well as strategies Q, R, and S, have increased coal-fired power production from existing plants relative to the reference strategy which results in index values slightly greater than 1.0.

Strategy O – Bellefonte Coproduct, Demand-Side Management Blocks One and Two, and More Off-System Sales Strategy

This strategy is similar to Strategy M in that it also emphasizes demand-side management in the near term and gas and coal gasification in the long term. It includes converting Bellefonte Nuclear Plant to a coal gasification process with coproduction of methanol and its derivatives. Other resource options include landfill and coalbed methane recovery. Unlike Strategy M, however, no new pulverized coal units are included, and there is a greater emphasis on independent power purchases.

Potential impacts on water quality under this strategy include those listed in Strategy M. Additional impacts could be associated with converting Bellefonte Nuclear Plant to coal gasification as described under Strategy J. Construction effects generally tend to be localized and temporary and can be minimized with appropriate materials handling and erosion controls.

Landfill and coalbed methane utilization could impact water quality through facility and pipeline construction and disposal of coproduced contaminated groundwater.

The water quality index for health-ingestion for Strategy O is identical to the reference strategy. The fish and aquatic life and biodiversity index and the water supply and waste assimilation index are rated 0.99, which is only a very slight improvement over the reference, or "No Action," strategy. The fish and

aquatic life improvement is due to a reduction in the amount of coal burned and the water supply index improvement is due to reductions in thermal discharges and water consumption relative to the reference strategy.

Strategy Q – Flexible Strategy with External Options

This strategy essentially duplicates the options in Strategy O with the addition of purchased power and flexible options that involve the off-system purchase of options to buy power at a certain time and price. Strategy Q includes only about half as much demand-side management as Strategy O.

This strategy differs from Strategy O in its off-system power purchase and management, which do not affect water quality in the Tennessee Valley, but could pose risks to water resources where they are located. The water quality index for health-ingestion for Strategy Q is rated 1.01, which indicates a very slightly increased risk for impacts, for the reasons noted above for Strategy M. The water supply and waste assimilation index and the fish and aquatic life and biodiversity index are rated at 0.99, which indicates a very slight improvement over the reference, or "No Action," strategy. The fish and aquatic life improvement is due to a reduction in the amount of coal burned, and the water supply index improvement is due to reductions in thermal discharges and water consumption relative to the reference strategy.

Strategy R – Flexible Strategy with Internal Options

This strategy contains the same options as Strategy Q with the same capacities, except for one new gas-fired combined cycle unit, and a considerably reduced reliance on off-system power option purchases.

Potential impacts on water quality under this strategy are identical to Strategy Q, except for additional impacts that may be associated with a gas-fired combined cycle unit. These potential ground and surface water impacts could result from off-site drilling operations and facility construction. The water quality indices for Strategy R are the same as for the reference, or "No Action" strategy, except for health-ingestion. This index is rated 1.01, which indicates a very slight increased risk, as discussed under Strategy M.

Strategy S – Low Cost, Low Rates, and Improved Environment Strategy

This strategy contains the same options as Strategy O, with more purchased power in the short term, a higher level of coal gasification generation in the middle years, and about half as much demand-side management overall.

Potential impacts on water quality under Strategy S are indexed identically to the reference, or "No Action," strategy, except for health-ingestion. This index is rated at 1.01, which indicates a very slight increased risk over the reference, or "No Action," strategy, for the reasons outlined under Strategy M.

Strategy T – Low-Cost Renewables, Low-Price Demand-Side Management, Repowering, and Bellefonte Coproduct Partnership Strategy

Much of the new capacity added by 2020 under this strategy would be from new natural gas-fired turbines, natural gas repowering of some existing coal-fired units, and coal gasification. A number of renewable and energy storage options, including wind, landfill and coalbed methane, hydroelectric plant improvement, and compressed air energy storage, make up about 25 percent of all new capacity. A small amount of capacity would result from new pulverized coal units.

This is the most diverse mix of generating options among the strategies under consideration. By virtue of its emphasis on renewables and repowering of old coal-fired units, this strategy is the one likely to result in the least overall impact on aquatic ecosystems. The environmental indices for this mix are 0.92 for health-ingestion, 0.99 for water supply and waste assimilation, and 0.96 for fish and aquatic life and biodiversity. This represents the greatest improvement compared to the reference strategy. The improvement in the health index is due to an 8 percent reduction in total fossil generation, the fish and aquatic life improvement is due to a reduction in the amount of coal burned, and the water supply index improvement is due to reductions in thermal discharges and water consumption relative to the reference strategy.

Under this strategy, water quality effects from the use of natural gas could occur in association with off-site drilling operations (groundwater effects) and potentially from the construction of facilities and pipelines (surface water effects). Construction impacts would tend to be localized, temporary, and generally in association with storm runoff. Mitigation of construction effects could be accomplished with the implementation of best management practices.

Additional coal-fired units could have potential impacts on ground and surface water mainly in association with ash disposal. Chemical contaminants in coal-ash are dependent on the type of coal, and the potential effects are well documented. Mitigation could involve physical measures, such as disposal pond lining to protect groundwater. The repowering of older coal-fired units to natural gas-fired combined-cycle units would tend to have an overall mitigating effect on coal-related impacts because new sources are held to more stringent requirements than the old sources they replace. All surface water discharges from plants would be regulated under state National Pollutant Discharge Elimination System permitting limitations.

SECTION 5: LAND RESOURCE IMPACTS OF ALTERNATIVE STRATEGIES

Understanding Land-Related Environmental Impacts

Volume 2, Technical Document 1, Comprehensive Affected Environment, provides an overview of land resource issues and land use. Because land resource impacts tend to be so site-specific in nature, developing indices for such impacts was not practical. Land resource impacts can be more fully and meaningfully evaluated when proposals to implement specific energy resource options are made in the future. These impacts will be addressed in subsequent environmental reviews.

However, certain conclusions or observations can be made at this programmatic level of review based on the generic attributes of various energy resource options.

Factors such as siting of generation facilities, siting of transmission facilities, fuel sources, and waste disposal, all affect land use. Resulting impacts can include:

- Long-term loss of land use
- Loss of plant and animal habitats
- Long-term aesthetic loss
- Fragmentation of forests
- Electric and magnetic fields exposure

Figure T2-28 gives the estimated total land requirements that would likely be required by TVA's final strategies and Strategy D, the reference strategy. Land use estimates range from 10,300 acres for the reference strategy to 62,000 acres for Strategy T. The larger amount of land used for Strategy T is due primarily to the extensive acreage that is needed to support wind turbines. *Figures T2-1* to *T2-3* describe the final strategies considered in the analysis.

The construction of new power generating facilities has greater potential for directly affecting land resources than does retrofitting or altering power sources for existing generation facilities. A new plant would consume additional land acreage, whereas altering existing facilities would not likely require significant additional acreage.

This section deals primarily with the direct effects to land resources resulting from the implementation of new power generating facilities. Discussion has been restricted to a general level. More detailed analysis and discussions will result from the environmental reviews performed for new facilities as they are sited. Specific issues such as endangered species, wetlands, and other site-specific concerns would be examined in these reviews. Discussion in this section deals with issues such as land consumption, land use changes, and land disturbance.

FIGURE T2-28. **Estimates of Direct Land Use for Plant Siting, Power Transmission, and Plant Access for Each Strategy**

Strategy	Capacity in Year 2020 (Megawatts)	Total Land Use (Acres)
D-Reference	15,520	10,336
J	16,456	17,711
M	14,765	16,299
O	15,406	16,080
Q	16,100	15,335
R	16,720	15,685
S	15,976	16,541
T	17,715	61,957

The analysis of potential impacts on land resources was conducted at two levels:

- Potential effects resulting directly from the siting of the power plant itself
- Potential consequences associated with fuel sourcing, power generation, and waste

This analysis is also based on fuel sources, rather than on specific strategies. Potential consequences of siting various types of generating facilities were analyzed based on fuel source. This approach simplifies comparison of individual strategies. The fuel sources (i.e., fuel cycles) evaluated include:

- Coal
- Natural gas
- Biomass
- Hydroelectric
- Solar and wind
- Nuclear

Environmental consequences from the plant "footprint" (i.e., the area occupied by the plant proper) are difficult to quantify. In general, these "footprint" effects are comparable, but not identical, across fuel options. Potential effects relate to the total acreage required and the acreage occupied by buildings, parking areas,

switchyards, coal piles, and other elements. Additional acreage to provide visual or noise buffers increases overall plant acreage considerably over the actual amount of acreage required for the plant itself. These buffer lands may continue to have uses such as pasture, forest management, or row crops thus reducing impacts.

The construction of new generating facilities can bring with it the construction of a distribution network of transmission lines, substations, and switchyards. Since a distribution network would be necessary regardless of power generation method, potential effects from these facilities would not likely differ by fuel source.

Considerable acreage of land is required for transmission line rights-of-way. A 100-foot wide right-of-way occupies about 12.1 acres per mile of transmission line. Permanent woody vegetation is not permitted within the rights-of-way, but pasture and agricultural land uses are allowed. When rights-of-way cross large forested areas, forest fragmentation can occur. Aesthetic impacts can occur in situations where rights-of-way are especially noticeable or visible.

The following summary sections, which focus on fuel types, describe potential "footprint" effects and operational effects resulting from fuel sourcing, power generation, and waste.

SUMMARY OF DIRECT LAND-USE IMPACT FINDINGS

- Resource options that involve expansions at existing plants or the repowering of existing units may have little or no land resource impacts. These include options at the Bellefonte Nuclear Plant site, co-generation options, some option purchase agreements, hydroelectric plant improvements, repowering that makes existing plants more efficient, and generating units added at existing coal plants.
- Coalbed methane may require a network of access roads to install and maintain the gas wells, collection rights-of-way piping, and smaller generating units distributed over larger areas. Factors such as the remoteness of the area, distance between wells, size and distribution of power plants, and installation of transmission lines to connect the power plants to the TVA power system influence land use. Five acres per megawatt was assumed for the analysis as a conservative estimate of land use for access and transmission. However, coalbed methane recovery from existing mines would impact land resources less.
- The 2,000 megawatts of wind energy capacity in Strategy T is estimated to require 50,000 acres of land at high elevations. Wind turbines have a lower power output per acre of land use compared to most generation options. Groups of wind turbines, termed a wind farm, are interconnected to a common switchyard. These turbines are often located in remote regions because wind is best at higher elevations on ridgelines and bluffs. Large-scale use of wind energy would require extensive tracts of land for locating hundreds of visually prominent wind turbines. Since wind resources are limited in the Tennessee Valley, the likelihood of disturbing sensitive ecological areas increases with the amount of wind power produced.
- Methane gas collected from landfills is a renewable energy source that prevents the release of this greenhouse gas to the atmosphere. Methane collection and its use as decentralized or distributed power returns these lands to a productive use, but would have effects similar to those associated with the infrastructure needed to support use of coalbed methane. However, landfill methane recovery would have lesser impacts than coalbed methane recovery since roads and transmission lines may already be in place. Landfill methane recovery and coalbed methane recovery are both considered direct land use, since power generation is integrated into the collection activity.
- There is sufficient land in the TVA region to allow energy resource options to be put in place without impacting sensitive land resources such as wetlands or endangered species. Land resources should not be a constraint on the deployment of any of the energy resource options identified in TVA's final strategies, with the possible exception of wind turbines.
- Other land-use conditions potentially impacted are aesthetics, electric and magnetic field exposure, and noise. Conventional power plants, typically located in rural areas, are out of character with their surroundings. Local topography, site layout and natural buffering, plant design, and population density and distribution all determine the kinds of potential site-specific impacts.

SUMMARY OF INDIRECT LAND-USE IMPACT FINDINGS

- Fuel acquisition and waste disposal are involved in power generation and affect indirect land use. Coal mining, particularly surface mining, is a disruptive land use activity. All of TVA's final strategies, including the reference strategy, expand TVA's use of coal. Total coal use rises about 35 percent from present levels for most strategies. Only Strategy T is significantly different, using about 12 percent less coal than the reference, or "No Action," strategy but still 21 percent more coal than current levels.
- Coal-fired plants have a waste stream of combustion byproducts. The byproducts—fly ash, bottom ash, and slag—are all marketable, depending on both their quality and market conditions. Unmarketed byproducts must either be stored or disposed of. This typically requires long-term land use and management.
- Natural gas drilling is typically less environmentally disruptive than coal surface mining activity for equivalent energy supply.

Also, gas-fired plants have no significant solid waste by-product. All the strategies make significant use of natural gas. Strategy T uses the most, 1.7 to 4 times more than the other strategies. Natural gas is used for repowering of existing coal-fired units. This provides additional benefits by eliminating coal byproduct production and increasing plant efficiency.
- Use of residue or waste wood fuel would reduce landfill requirements and some methane production.

SUMMARY OF NATURAL RESOURCE IMPACT FINDINGS

- Most potential impacts on land resources are site or project-specific, and would be assessed in siting studies and environmental reviews for generation and transmission facilities. These potential impact areas include threatened and endangered species, plant and animal habitats, sensitive or important ecosystems, forest fragmentation, and aesthetics.
- There may be air pollution impacts on land remote from a plant site. These impacts are addressed in the air resources section of this document.

Analysis of Fuels Used In Energy Vision 2020 Strategies

FUEL SOURCING

Fuel sourcing for hydroelectric, solar, and wind power plants are not addressed in this section because these power sources create energy from water, sunlight, and wind, respectively, and as a fuel generally do not have land resource impacts. (The creation of hydroelectric dams can have significant land resource impacts but the "fuel," water, is produced by rainfall.) Only the coal, biomass fuel for co-firing, and nuclear sections address waste-related effects, since natural gas, hydroelectric, solar, and wind power plants do not produce waste byproducts.

COAL-FIRED PLANT IMPACTS

The coal-related environmental impacts for the various strategies are affected by the amount of coal used by each strategy. Use of coal by strategy is shown in *Figure T2-29*. The environmental impacts of coal as a fuel are discussed in the following section.

Site Effects

Coal-fired generating plants tend to require relatively large acreage. They need coal-loading facilities, a coal pile, and ash disposal facilities that require many acres of land, and visual screens or noise buffering. Existing TVA coal-fired plants are located along navigable waterways to provide barge access for transporting coal to the plant and/or as a source of boiler and cooling water.

FIGURE T2-29. **Coal Use for Each Strategy (Annual Average)**

Strategy	Tons
D-Reference	52,073,962
J	51,253,835
M	52,163,285
O	51,187,739
Q	51,669,092
R	51,883,575
S	51,847,911
T	45,860,676

Aesthetic effects of a coal plant are difficult to address because such effects tend to be subjective. However, unless the plant is remote or obscured by hills, its facilities tend to be noticed by the public. Tall flue gas stacks, which are typical of coal-fired plants, can be seen from large distances depending on the stack height and surrounding terrain and often result in degradation of aesthetic character. Especially tall stacks may be visible for several miles. Strobe lights mounted on stacks are effective safety measures, but result in further aesthetic effects. Coal-fired plants can also have cooling towers. Natural draft cooling towers may be as tall as the stacks and have visible water vapor plumes during most weather conditions.

Operational Effects

Noise is almost always a concern in power generation from fossil sources. However, plant designs normally accommodate noise concerns. New plant construction would also meet any applicable noise and emission limitations; however, such limitations are rare in the Valley.

Other than potential impacts due to air pollutants, coal-fired generation options do not directly impact land resources as a result of their operation. However, coal plants can have fuel sourcing and waste generation effects. These are described below.

Fuel Sourcing Effects

TVA purchases about 35 to 40 million tons of coal per year to fuel its 11 existing fossil plants. The process of obtaining this coal involves land disturbances. Obviously, coal must be removed from the earth. According to recent figures, about 75 percent of TVA's current coal demands are supplied from subterranean mines (i.e., underground or "deep mines"), while the remainder comes from surface (i.e., strip) mines. Coal supplied from deep mines results in minimum surface land disturbance. Supplying coal from strip mines results in surface disturbance. However, current mining regulations require coal operators to

FIGURE T2-30 **Combustion Byproduct for Each Strategy (Annual Average)**

Strategy	Tons
D-Reference	6,166,437
J	5,809,790
M	6,663,316
O	5,826,405
Q	5,964,794
R	5,929,001
S	5,921,821
T	5,238,745

FIGURE T2-31. **Natural Gas and Methane Recovery Use for Each Strategy (Annual Average)**

Strategy	Landfill and Coalbed Methane (Billions of Standard Cubic Feet)	Natural Gas (Billions of Standard Cubic Feet)	Total (Billions of Standard Cubic Feet)
D-Reference	0	93.5	93.5
J	45.8	64.9	110.7
M	34.8	41.0	75.9
O	44.2	53.9	98.1
Q	48.9	68.4	117.3
R	48.9	63.4	112.3
S	49.4	59.2	108.6
T	23.4	162.0	185.4

restore the land to its original approximate contour, which helps to reduce potential impacts.

The amount of surface acreage affected by supplying coal varies and depends mainly on the thickness of the coal seam. For comparison, a coal seam one foot thick yields about 1,800 tons per acre. Assuming the average TVA coal-fired plant requires 3.4 million tons of coal per year (37 million tons for 11 plants), and that 25 percent of this total comes from surface mines, then about 840,000 tons of coal per year comes from surface mines. At a yield of about 1,800 tons per acre (for a 1-foot thick seam), approximately 465 acres per year would be required. Thicker seams would reduce this acreage accordingly (i.e., a two-foot thick seam would result in approximately 235 acres being disturbed).

The table in *Figure T2-29* gives the annual average coal use for the planning period for each strategy. All strategies use about 35 percent more in an average year than the FY 1994 procurement level of 38 million tons. Compared to the reference strategy, only Strategy T has a significant difference in coal usage, 45 million tons less, or 12 percent less coal.

Once mined, coal must be moved to the power plant. This can require the construction of new roads and/or rail lines and the consumption of additional acreage. From a fuel transportation standpoint, coal removed from existing mines would not likely result in additional effects to land resources. Because much of the coal is currently delivered via rail, construction of any new coal plants at greenfield sites could result in construction of new rail lines to those plants.

Waste

Coal-fired power plants generate various amounts of ash and other solid byproducts. For fiscal year 1995, TVA estimates that existing coal facilities will generate about 3 million tons of fly ash, 1.25 million tons of bottom ash/slag, 1.2 million tons of gypsum (from flue gas desulfurization control equipment - scrubbers), and 1 million tons of coal wash refuse. The amount and type of solid waste depend on the technology used to collect this material, as well as the characteristics of the coal burned. All these plants generate ash of some sort, which must be discarded or used. This material is usually placed in ash ponds, slurried, or dry stacked. Ash disposal areas are typically located on-site or adjacent to the generation facility. The acreage required for disposal depends on the net ash generation rate of the facility and the per-acre storage capacity of the disposal area.

Not all ash must be stored or disposed of on-site. Markets exist for coal combustion or pollution control byproducts. Depending on the ash collection system and the quality of the ash, this material may be used in the manufacture of building materials, mainly gypsum products such as wall board (i.e., sheetrock), or as soil amendments, and as filler in paving and construction materials (e.g., concrete). Some existing coal plants dispose of a large proportion of their ash via commercial markets.

A range of disposal site lifetimes exists at TVA's existing coal-fired plants. The rate of byproduct production and use contributes to the lifetimes of the disposal/storage sites. Additional land acquisition and/or land use may be required over the life of the plants.

The alternative energy strategies have a range of annual average byproduct production from 5,238,745 tons for Strategy T to 6,166,437 tons for the reference strategy during the 1996-2020 planning period shown in the table in *Figure T2-30*. TVA has an average byproduct utilization rate of 25.4 percent. By the year 2000, the rate is projected to be over 33 percent. The current national average is about 21.8 percent.

TVA analyzed a full range of possible byproduct applications based on the chemical and radiological properties and behavior of ash and slag from its plants in an environmental assessment. The assessment concluded that none of the applications examined would create significant environmental impacts. No

significant environmental impacts are anticipated from new storage or disposal areas that are permitted as landfills by the states. However, site-specific environmental reviews would be done for any new disposal or storage area.

NATURAL GAS-FIRED AND METHANE RECOVERY PLANT IMPACTS

The environmental impacts of natural gas for the various strategies vary with the amount of natural gas and methane recovery. (See *Figure T2-31* for strategy use of natural gas and methane recovery.) The environmental impacts of natural gas and methane fuels are discussed in the following section.

Site Effects

Acreage required for natural gas-fueled power generating plants is comparable to that required for a coal-fired plant with similar capacity. The overall facility "footprint" would be somewhat smaller than for a coal-fired facility with the same generating capacity because fuel off-loading facilities (i.e., railyards, etc.) and ash disposal areas are not required. Flue gas stacks are typically the most prominent feature of gas-fired plants but are typically not as tall as stacks for coal-filled plants. Strobe lights mounted on stacks are effective safety measures, but result in further aesthetic detractions. These plants would not have cooling towers if an existing coal-fired plant is repowered. Mechanical draft cooling towers would be used at a new plant and would have a visible vapor plume during most weather conditions.

Operational Effects

The operation of gas-fired generation facilities causes few effects to land resources. Ash disposal areas are not required and there is very little solid waste (e.g., ash), compared to coal-based generation. Power generation by natural gas-fueled facilities also causes minimal potential impact on land resources.

Noise-related effects are similar to those for coal plants. Potential noise effects would be accommodated by plant design and siting criteria.

Fuel Sourcing Effects

Natural gas is a mixture of gaseous hydrocarbons, mostly methane, which occurs naturally in the earth. Natural gas deposits often accompany petroleum deposits and are found in various locations across the United States. An extensive network of pipelines distributes natural gas to users.

Drilling, exploration activities, and delivery systems (pipelines) have the greatest potential for effects to land. This analysis assumes that delivery to the plant site would be by pipeline.

Because there is an abundance of natural gas reserves, including capped wells, the likelihood of additional impacts to land resources from increased demand for natural gas is reduced. Nevertheless, drilling for natural gas is relatively innocuous and is not necessarily detrimental to land resources.

Methane, the major component of natural gas, can be collected from landfills. Energy Vision 2020 considers this option. Landfill-generated methane is typically of lower quality (i.e., less pure methane) and has a lower energy yield than naturally occurring methane. Depending on its quality, landfill-derived methane may have to be purified to meet emission standards before use. Nevertheless, use of methane from this source would provide an alternative natural gas source and would have an overall beneficial environmental effect.

Coalbed methane recovery is another technology for supplying gas-fired plants. Gas wells are drilled into a coal seam to recover the naturally generated methane. A system of wells would feed gas through a network of collection piping to a small generating unit such as a fuel cell or diesel generator. This method of fuel sourcing could be land intensive, requiring access roads to reach well heads, rights-of-way for collection piping, and power transmission lines to decentralized power plants. Methane can also be recovered from existing coal mines. This would require less additional land area.

The need to construct new gas pipelines as a result of building new gas-fired plants or repowering existing plants is difficult to determine. For economic reasons, repowering of existing generating facilities with natural gas would most likely occur at those plants currently near transmission pipelines.

Gas pipelines are usually located underground for safety reasons. On the land surface, a fixed right-of-way is maintained to prevent establishment of permanent woody vegetation. The right-of-way is maintained in a pasture-like condition or used for row crop agriculture; trees are not allowed. This situation does not preclude the use of the right-of-way for productive uses. However, forest fragmentation can occur if the pipeline crosses extensive forest areas. A pipeline requires approximately the same

FIGURE T2-32. **Biomass Cofiring for Each Strategy (Annual Average)**

Strategy	Tons
D-Reference	0
J	184,643
M	187,909
O	184,493
Q	186,227
R	186,956
S	186,903
T	186,903

acreage as a transmission line right-of-way, and potential effects are generally comparable to transmission line rights-of-way.

Figure T2-31 shows the range of natural gas and recovered methane in the alternative energy strategies. Strategy M uses 19 percent less gas than the reference, or "No Action," strategy. Strategy T has the lowest coal use and the highest gas use, 185 billion standard cubic feet, or 98 percent higher than the reference strategy.

BIOMASS-FUEL IMPACTS

Biomass-related environmental impacts of the various strategies vary with the annual average tons of wood co-firing detailed in *Figure T2-32*. Wood co-firing in coal-fired plants is the only type of biomass included in the final strategies analyzed. However, this section discusses the environmental impacts of wood waste as a fuel, as well as other biomass.

Site Effects

Biomass fuels are usually mixed with coal as a supplement, and biomass fuel options typically involve modification of existing coal-fired plants. Therefore, there would be few, if any, additional site-related impacts. Wood waste storage would have to be established, but such a facility would be compatible with the other industrial-type uses found at coal-fired power plants.

Operational Effects

Operational effects of burning biomass fuels are essentially the same as those for coal-firing because biomass fuels would likely constitute only a small or moderate percentage of the fuel burned in the boiler. Thus, any unique emissions associated with biomass fuels would tend to be lost in the much larger emission volumes resulting from burning coal. Potential changes in emissions are one of the issues that would be examined in more detail in site-specific reviews.

Fuel Sourcing Effects

Fuel Types

Wood waste is the primary biomass fuel. Mill and logging residues are byproducts that can be an inexpensive fuel source. Mill residue is the wood discarded either by primary mills, such as sawmills, or secondary mills, such as furniture companies. Residues may be in the form of chips, bark, shavings, or sawdust. The main cost involved is transportation, so residue availability depends on the number of forest product industries in a 50- to 75-mile radius of a power plant. Plants producing these residues do not always produce a consistent volume, as volume changes in response to economic conditions.

Logging residues are the unused growing stock or sawtimber volume of trees cut or killed by logging and left in the woods. Logging residues are generally composed of the tree crown (i.e., branches and limbs that are not large enough to be sold as timber). The volume of timber operations in a 50- to 75-mile plant radius would determine supply availability. Depending on soil conditions, logging residues can provide valuable nutrients to the soil as it decays. Removal of logging residues could therefore negatively impact nutrient cycling capabilities.

Short rotation woody energy crops provide a source of woody biomass. Primary species include eastern cottonwood, sweetgum, sycamore, and black locust. Since short rotation woody crops would be planted to replace conventional agricultural crops such as cotton, corn, and soybeans, a number of potential environmental benefits would result. These include: reduced erosion; reduced runoff of pesticides and nutrients; less risk of contamination of groundwater with nitrates, herbicides, and other pesticides; improved soil physical properties; increased storage of carbon above and below ground; and increased variety of microorganisms, mammals, birds, and other wildlife.

Short rotation woody crops involve intensive forestry operations such as seedling planting and fertilization and herbicide treatments (usually about once per "crop" rotation). Crop plantations would be grown on marginal-to-good former cropland with less than a 5 percent slope. Suitable areas within the Tennessee Valley region include limestone valley soils in northern Alabama, alluvial delta and coastal plain soils in northern Mississippi, and delta lands and loess belt soils in western Tennessee. Production estimates range from 2.3 to 4.3 dry tons per acre per rotation, but tonnage production is projected to double in the next decade due to genetic improvement research. Crop rotation time is expected to be 5 to 6 years.

Switchgrass may be another biomass fuel option. Although switchgrass is not currently produced for commercial sale, it may be a feasible biomass option since farm operators already own the necessary production and harvesting equipment. Production estimates range from 6 to 9 dry tons per acre per year. Energy yield is estimated to be 14.5 million Btu per dry ton.

Amount of Biomass

The amount of biomass required for power generation depends on whether it is the primary fuel or co-fired with coal. When biomass is co-fired with coal, the amount of biomass used will depend on the degree of energy input. Biomass can be a low energy input (1 to 5 percent), moderate energy input (10 to 15 percent), or high energy input (20 to 50 percent). When biomass is the primary fuel, approximately 1,000 acres of short rotation woody crop plantations per megawatt are needed for sourcing. This results in harvests of approximately 200 acres per year per megawatt.

Final strategies examined for Energy Vision 2020 were limited to wood co-firing at coal-fired plants. The reference strategy

uses no co-firing. All other strategies co-fire at a rate of 0.3 percent to the coal energy input for the existing coal-fired system.

Noise and Aesthetics

Biomass harvesting and transportation raise few concerns associated with noise. Also, there are no significant aesthetic considerations associated with mill residues, short rotation woody crops, and switchgrass. Short rotation woody crops would be harvested from recently converted traditional cropland, and would not likely result in the conversion of existing forest lands. Switchgrass is harvested like hay.

Transportation

Transportation costs would dictate that distance from source to power plant be kept to a minimum for mill and logging residues, short rotation woody crops, and switchgrass, which are high-volume, low-value commodities. Transportation costs for wood are approximately three times that for coal on a Btu basis. Current cost projections indicate that biomass sources should be within 50 to 75 miles of power plant locations. Transportation impacts would be those typically associated with large truck uses. These would include some road surface deterioration, possible traffic impediments, and increased risk of accidents. these potential problems would be examined in subsequent, option-specific environmental reviews.

Generation Effects

Most options for biomass fuel usage in Energy Vision 2020 involve co-firing with coal. Wood can be co-fired with coal in various ways:

- For low energy inputs, wood is co-pulverized with coal and fed to the boiler, along with coal.
- For moderate energy inputs, separate wood and coal handling systems and burners are required.
- High wood energy inputs perform best in fluidized-bed boilers. Use of switchgrass as a fuel may require it to be pelletized first.

Co-firing options would not result in any additional plant siting, size, noise, or aesthetic considerations beyond those discussed for coal power plants.

One option for biomass fuel usage is a whole-tree energy boiler power plant. This is a new direct combustion technology that depends entirely on short rotation woody crops as a fuel source. Siting "footprints" of a biomass-fired plant would be similar to that of a coal-fired plant. This option was not, however, included in TVA's final strategies.

Waste

Waste byproducts produced by a biomass co-fired plant are similar to those of a coal power plant, except that ash has a somewhat higher carbon content. Some coal ash byproduct is currently sold as a concrete additive. Research is underway to determine if the carbon content in biomass co-fired ash is too high to be used in concrete manufacturing. Biomass storage areas may also produce an acidic tannin leachate (mainly from wood bark), but common leachate control measures, as well as site best management practices, can satisfactorily reduce the risk of adverse impacts from such leachate.

HYDROELECTRIC PLANT IMPACTS

Only existing hydroelectric plants are included in the final strategies analyzed. The land-related environmental impacts of hydroelectric plants are discussed below.

Site Effects

Of necessity, hydroelectric plants are located at dams. Their actual plant "footprint" is typically small. In most instances, little land is consumed except for transmission facilities (e.g., switchyards), maintenance areas, and parking areas. Their visual impact is minimal, since hydroelectric generating facilities are incorporated into the dam structure. Because no new hydroelectric facilities would be built under any of the strategies considered, there would be no additional site effects.

Operational Effects

Hydroelectric facilities produce no waste materials that affect land resources. They also produce low noise levels compared to coal-fired plants. Power generation from these facilities does not have significant effects on land resources.

Fuel Sourcing Effects

For purposes of discussion, water is considered to be the "fuel" used in hydroelectric production. Hydroelectric plants depend on hydrostatic pressure (i.e., the pressure of deep water) to turn generators. This process produces electricity. A reservoir must be created to produce sufficient pressure and have the recharge capacity to maintain adequate depth at the dam.

Covering land with water to create reservoirs removes it from productive use. Typically, these river bottom lands are fertile and constitute productive forest land, farmland, and wetlands. These uses are lost by flooding. See Volume 2, Document 1, Comprehensive Affected Environment, for additional information about effects of damming rivers. Because no new hydroelectric facilities would be built under the strategies considered, there would be no additional "fuel sourcing" impacts from hydroelectric production.

WIND AND SOLAR IMPACTS

Wind is one of the renewable energy resource options included in TVA's final seven strategies. The land-related environmental impacts of wind and solar power are discussed below.

Site Effects

Wind-powered generation facilities usually have a network of windmills feeding a central switchyard. These windmills are typically located on ridge lines, ridge tops, and along bluffs where ambient wind velocities are capable of providing adequate wind power. Such locations are generally visible from a long distance. Thus, the potential for visual impact from new facilities is high.

Solar facilities require large amounts of relatively flat, open areas in order to collect adequate amounts of solar radiation. Depending on location, the visual impact of new solar facilities could be objectionable. Solar facilities produce very little noise and no waste byproducts. Wind and solar power plants do not use any fuels or produce any emissions; therefore, only generation issues are discussed.

Operational Effects

Wind

Wind-powered generation facilities are composed of a number of wind turbines connected to the utility grid system through one or more interconnections. Turbines produce approximately 0.3 megawatts and are arranged one per 1 to 2 acres. Approximately 1,250 acres would be required for a 50-megawatt power plant. Site requirements are highly specific. The best sites feature a minimum 2,000 to 3,000 foot elevation on abrupt, prominent ridges. Two areas in or adjacent to TVA's Northeast Tennessee Service Area (one on the Cumberland escarpment and another near Johnson City) together have potential for 750 megawatts of economically variable wind capacity. A nearby location in southwest Virginia has potential for another 1,250 megawatts of economically viable wind capacity.

Noise may result from wind power plants. It is caused by air moving over the turbine blades (aerodynamic noise) and by the turbine's mechanical components. However, recent blade design changes have substantially reduced aerodynamic noise. In the past, television interference near wind plants occurred when metal components of older wind turbines reflected broadcast TV signals. Composite materials are now used in many turbine components and reflection of television signals has been diminished. Cable signals are not affected by wind turbines.

Wind power plants may impact wildlife populations. Although mammals do not appear to be affected very much, bird fatalities, especially raptors (birds of prey), have been reported at some plant locations. Avian casualties are caused by several factors including electrocution from exposed contacts on the tops of riser poles and collisions with transmission lines, guy wires, and turbines. Steps can be taken to reduce bird fatalities, including capping all exposed terminals on risers.

Strips of trees cannot be used for visual or noise buffering around wind power plants because of the need for a large acreage of open land free of trees. Turbine blades are high enough to allow multiple uses of land at plant sites. Typical uses include farming, ranching, and some forestry activities. Some land is also left as open space. Typically 85 to 95 percent of the site can be used for nonpower-generating activities, depending on the turbine spacing required.

Solar

Solar-photovoltaic power facilities located in North America are most effective in lower-latitude areas with low cloud cover. In the Tennessee Valley, the Memphis region could have suitable sites. Because the best commercial solar cells operate at about 12 percent conversion efficiency, the maximum power available is about 120 watts per square meter. A typical site size would require 0.5 square mile (320 acres) of land area for a 50-megawatt power plant. There is little noise associated with solar-photovoltaic power plants.

NUCLEAR PLANT IMPACTS

Only existing nuclear plants are included in the final strategies analyzed. Environmental impacts of TVA's nuclear plants are discussed in site-specific environmental impact statements and other environmental documents.

Site Effects

No Energy Vision 2020 strategies call for building new nuclear plants. Therefore, there would be no site effects due to new construction. Some options involve converting partially-constructed nuclear plants, but these options would likely result in few additional site-specific effects.

Operational Effects

Operation of TVA's existing nuclear power plants results in several different kinds of impacts. Small quantities of radioactivity are released to the air and water. Minor quantities of heat and non-radioactive wastewater are released to the Tennessee River and major quantities of heat and water vapor can be released to the atmosphere from plant cooling towers. Because of the size of the sites and their locations, noise is typically not a nuisance. However, because cooling towers are visible, they can be aesthetically objectionable.

Waste

Compared to the wastes or byproducts generated by coal-fired energy processes, nuclear generation produces relatively little waste. Nuclear waste storage is not expected to impact additional land area in the Tennessee Valley. Currently, low-level radioactive waste is disposed at a Barnwell, South Carolina, facility. The states participating in the Southeast Compact Commission have selected North Carolina as the host state to design, license, and construct a new disposal site that is scheduled to open in 1998. TVA plans to continue to use the Barnwell facility for low-level radioactive waste disposal until the North Carolina facility is opened. Should either or both of the disposal facilities close unexpectedly, low-level radioactive waste will be stored in on-site facilities at the TVA nuclear plants. These facilities are sized to handle any anticipated storage needs for the foreseeable life of the plants. Operation of TVA's five nuclear units will produce about 115 metric tons of used fuel each year. High level radioactive waste, known as "spent fuel," is stored on-site in pools or dry storage until the Department of Energy (DOE) accepts physical custody. DOE is required by the Nuclear Waste Policy Act to take responsibility for the management and safe disposal of spent fuel that is generated in this country. DOE is to arrange shipment of spent fuel to a monitored retrievable storage facility or to an underground repository for ultimate disposal by burial. The nation's first underground high-level waste repository is not expected to be in operation until at least 2010. Current spent fuel storage capacity is sufficient at Sequoyah until 2004 and at Browns Ferry until 2007. Based on one unit operating at Watts Bar, spent fuel storage capacity will be sufficient until 2018. Several technologies are available to extend the on-site storage lives.

There are no technological impediments to the safe transportation and storage of high-level radioactive waste. The feasibility of underground waste repositories has been demonstrated in studies and test projects. Waste repositories can be designed with multiple natural and man-made barriers that ensure radioactivity does not escape into the environment. The National Academy of Sciences, the National Research Council, and the Congressional Office of Technology Assessment have endorsed deep geological repositories for storage of high-level waste. High-level waste can also be transported with minimal risk. Specially-constructed casks are used and various regulatory controls apply to such shipments.

Transmission Line Impacts

LAND USE

Construction of new generating resources at greenfield sites would require additional transmission line facilities. Prior to the decision to construct such facilities, more detailed environmental reviews would be conducted. Absent unusual site conditions, construction of transmission lines typically does not result in significant physical environmental impacts. Most vegetation on rights-of-way is removed, but there is some flexibility in locating rights-of-way and in placing structures so that impacts to sensitive resources can be avoided or minimized. The amount of new land committed to rights-of-way would be reduced by the multiple use of existing transmission line rights-of-way.

The construction of new transmission lines and the installation of energy-efficient electrical appliances could result in exposing additional individuals to EMF. Experts disagree on the potential impacts of EMF exposures. Such impacts could depend in large part on proximity to lines and field strength and would be addressed in site-specific environmental reviews.

RIGHT-OF-WAY MAINTENANCE

Safe operation of transmission line rights-of-way requires control of vegetation height. This involves mechanical cutting or mowing or the use of chemical herbicides. The method selected is determined on a case-by-case basis, taking into consideration factors such as terrain, right-of-way accessibility, type of vegetation, land use, wetland status, and economics.

If chemical control is used, only U.S. Environmental Protection Agency-registered nonrestrictive herbicides and licensed applicators would be used. Any use of herbicides must comply with Environmental Protection Agency label restrictions and TVA guidelines for herbicide applications.

"Danger" trees, those outside the right-of-way but tall enough to threaten the safety of the lines if they were to fall, are also periodically identified and selectively cut.

Estimates of Direct Land Use for All Strategies

Generation options directly affect land use. Impacts are caused by siting of the plant and the construction of transmission lines to connect the plant to the power system. Some plants will have little or no additional land requirements because they are located at an existing site. These include options at the Bellefonte Nuclear Plant, cogeneration options, some option purchase

agreements, hydroelectric improvements, and landfill methane recovery. Other options have varying site requirements that are listed in the table in *Figure T2-33*. Transmission right-of-way requirements vary widely, depending on plant location and the number of different plant sites used for an option. For the sake of simplicity, 0.5 acre per megawatt of capacity was assumed for most options not located at an existing plant site with transmission lines in place.

Two notable exceptions to this assumption are coalbed methane recovery and wind turbines. Coalbed methane may require a network of access roads to install and maintain the gas wells, collection piping, and power plants. The remoteness of the area being utilized, the distance between wells, and the size and distribution of power plants would be the primary factors in the resulting land use. Also, transmission lines would be required to connect the power plants to the TVA power system. For these reasons, 5 acres per megawatt was assumed as a conservative estimate of land use for access and transmission. Wind turbines are typically located in remote regions because the wind resource is best at higher elevations on ridgelines and bluffs. Also, wind turbines have a low power density compared to most generation options, so groups of wind turbines are interconnected to a common switchyard. Based on experience in wind turbine siting, 25 acres per megawatt was used to calculate the total of all types of land use.

The resulting land uses for the options making up each strategy are stated in the table in *Figure T2-33*. Land use estimates range from approximately 10,300 acres for the reference strategy to 62,000 acres for Strategy T, which contains 2,000 megawatts of wind turbine capacity using an estimated 50,000 acres.

Aesthetics

Transmission lines and structures are visually intrusive to most people; therefore, the addition of new transmission lines would be aesthetically impactive. The significance of such impacts would depend on the subjective views of each individual and, in part, on the aesthetic setting of a new line. Aesthetic impacts of power plants are discussed in this section under specific types of fuel.

FIGURE T2-33. **Estimates of Direct Land Use for Plant Siting, Power Transmission, and Plant Access for Each Strategy**

Strategy	Type	Capacity in Year 2020 (Megawatts)	Site Land Use (Acres/Megawatt)	Transmission/Access Land Use (Acres/Megawatt)	Total Land Use (Acres)
D-Reference	Combustion Turbines	5,700	0.05	0.50	3,135
	Combined Cycle - Independent Power Producers	750	1.22	0.50	1,290
	Integrated Gasification - Combined Cycle	3,675	0.40	0.50	3,308
	Combined Cycle	2,820	0.07	0.00	197
	Integrated Gasification - Cascaded Humidified Advanced Turbine	2,100	0.40	0.50	1,890
	Combined Cycle - Cogeneration	175	0.00	0.00	0.00
	Coal - Independent Power Producers	300	1.22	0.50	516
	D Total	**15,520**			**10,336**
J	Bellefonte IGCC Conversion with Coproduct	484	0.00	0.00	0
	Coalbed Methane Recovery	1,000	0.03	5.00	5,030
	Combustion Turbines	5,850	0.05	0.50	3,218
	Hydroelectric Improvements	162	0.00	0.00	0
	Integrated Gasification - Combined Cycle	4,410	0.40	0.50	3,969
	Integrated Gasification - Cascaded Humidified Advanced Turbine	2,100	0.40	0.50	1,890
	Independent Power Producers	1,950	1.22	0.50	3,354
	Landfill Methane Recovery	500	0.00	0.50	250
	J Total	**16,456**			**17,711**

FIGURE T2-33. **Estimates of Direct Land Use for Plant Siting, Power Transmission and Plant Access for Each Strategy** *CONTINUED*

Strategy	Type	Capacity in Year 2020 (Megawatts)	Site Land Use (Acres/Megawatt)	Transmission/Access Land Use (Acres/Megawatt)	Total Land Use (Acres)
M	Coal	1,610	1.22	0.50	2,769
	Coalbed Methane Recovery	1,000	0.03	5.00	5,030
	Combustion Turbines	5,550	0.05	0.50	3,053
	Hydroelectric Improvements	162	0.00	0.00	0
	Integrated Gasification - Combined Cycle	3,675	0.40	0.50	3,308
	Integrated Gasification - Cascaded Humidified Advanced Turbine	2,100	0.40	0.50	1,890
	Landfill Methane Recovery	500	0.00	0.50	250
	Shawnee Fossil Plant Unit 11	168	0.00	0.00	0
	M Total	**14,765**			**16,299**
O	Bellefonte IGCC Conversion with Coproduct	484	0.00	0.00	0
	Coalbed Methane Recovery	1,000	0.03	5.00	5,030
	Combustion Turbines	5,700	0.05	0.50	3,135
	Hydroelectric Improvements	162	0.00	0.00	0
	Integrated Gasification - Combined Cycle	4,410	0.40	0.50	3,969
	Integrated Gasification - Cascaded Humidified Advanced Turbine	2,100	0.40	0.50	1,890
	Independent Power Producers	1,050	1.22	0.50	1,806
	Landfill Methane Recovery	500	0.00	0.50	250
	O Total	**15,406**			**16,080**
Q	Bellefonte IGCC Conversion with Coproduct	484	0.00	0.00	0
	Coalbed Methane Recovery	1,000	0.03	5.00	5,030
	Combustion Turbines	4,800	0.05	0.50	2,640
	Flexible Baseload	289	0.00	0.00	0
	Flexible Peakload	0	0.00	0.00	0
	Hydroelectric Improvements	162	0.00	0.00	0
	Integrated Gasification - Combined Cycle	5,145	0.40	0.50	4,631
	Integrated Gasification - Cascaded Humidified Advanced Turbine	2,520	0.40	0.50	2,268
	Independent Power Producers	300	1.22	0.50	516
	Landfill Methane Recovery	500	0.00	0.50	250
	Peak Power Purchases	900	0.00	0.00	0
	Q Total	**16,100**			**15,335**
R	Bellefonte IGCC Conversion with Coproduct	484	0.00	0.00	0
	Combined Cycle	470	0.07	0.50	268
	Coalbed Methane Recovery	1,000	0.03	5.00	5,030
	Combustion Turbines	4,950	0.05	0.50	2,723
	Flexible Baseload	289	0.00	0.00	0
	Hydroelectric Improvements	162	0.00	0.00	0
	Integrated Gasification - Combined Cycle	5,145	0.40	0.50	4,631
	Integrated Gasification - Cascaded Humidified Advanced Turbine	2,520	0.40	0.50	2,268
	Independent Power Producers	300	1.22	0.50	516
	Landfill Methane Recovery	500	0.00	0.50	250
	Peak Power Purchases	900	0.00	0.00	0
	R Total	**16,720**			**15,685**

FIGURE T2-33. **Estimates of Direct Land Use for Plant Siting, Power Transmission and Plant Access for Each Strategy** *CONTINUED*

Strategy	Type	Capacity in Year 2020 (Megawatts)	Site Land Use (Acres/Megawatt)	Transmission/Access Land Use (Acres/Megawatt)	Total Land Use (Acres)
S	Bellefonte IGCC Conversion with Coproduct	484	0.00	0.00	0
	Coalbed Methane Recovery	1,000	0.03	5.00	5,030
	Combustion Turbines	5,850	0.05	0.50	3,218
	Hydroelectric Improvements	162	0.00	0.00	0
	Integrated Gasification - Combined Cycle	4,410	0.40	0.50	3,969
	Integrated Gasification - Cascaded Humidified Advanced Turbine	2,520	0.40	0.50	2,268
	Independent Power Producers	1,050	1.22	0.50	1,806
	Landfill Methane Recovery	500	0.00	0.50	250
	S Total	**15,976**			**16,541**
T	Bellefonte IGCC Conversion with Coproduct	484	0.00	0.00	0
	Compressed Air Energy Storage	1,011	0.04	0.50	546
	Coal	710	1.22	0.50	1,221
	Coalbed Methane Recovery	1,000	0.03	5.00	5,030
	Combustion Turbines	4,800	0.05	0.50	2,640
	Hydroelectric Improvements	162	0.00	0.00	0
	Integrated Gasification - Cascaded Humidified Advanced Turbine	1,260	0.40	0.50	1,134
	Independent Power Producers	450	1.22	0.50	774
	Landfill Methane Recovery	500	0.00	0.50	250
	Repowering Existing Coal-Fired Plants	5,170	0.07	0.00	362
	Shawnee Fossil Plant Unit 11	168	0.00	0.00	0
	Wind Turbines	2,000	5.00	20.00	50,000
	T Total	**17,715**			**61,957**

Injuries, Accidents, and Illnesses

There can be accidental injuries, deaths, and illnesses, both occupational and non-occupational, associated with power system activities. These activities include the direct effects of constructing and operating power system facilities and indirect effects from activities such as fuel procurement and its transportation. Accidental injury or death to the public (non-occupational) from power facility construction or operation are especially unlikely because the public is isolated from these facilities, which are generally secured from public access. One exception is boating and other water recreation near hydroelectric facility discharges where the public must take precautions and heed warnings to avoid unnecessary risk. The risk of accidental injuries and deaths and illnesses are examined for TVA's nuclear plants and pumped storage facilities in site-specific environmental impact statements (TVA 1971, 1972, 1974, 1976).

As decisions are made to add resources to the power system, project-specific environmental reviews will examine these issues to ensure that mitigation measures are considered. Because all strategies expand the power system to meet anticipated increases in power demand and energy use, it is reasonable to conclude that there may be some increase in accidental injuries, deaths, and illnesses.

SECTION 6: ENVIRONMENTAL EVALUATION OF THE PREFERRED PORTFOLIO ALTERNATIVE

Rather than selecting a discrete strategy as its long-term energy plan, TVA has identified as its preferred alternative a portfolio approach. The options in this portfolio are the options identified in the final strategies that TVA developed during the IRP process. In addition, several other options that respond particularly well to certain possible future events ("uncertainties") have been included in the portfolio. TVA believes that this portfolio approach will better achieve TVA's goals and the Energy Vision 2020 criteria than any discrete strategy.

Rationale for Portfolio Approach

After carefully analyzing 2,000 long-term energy resource strategies, TVA used the multi-attribute tradeoff technique to identify seven strategies that achieve reasonably well all of the Energy 2020 criteria, including environmental criteria. The mix of energy resource options in these seven strategies help mitigate the potential adverse environmental impacts associated with meeting the energy needs of the TVA region and result in comparably low environmental impacts.

One approach that TVA could use is to choose one of these strategies as its long-term energy plan and proceed to implement it. As events unfold, elements of the plan would be revised to account for the events (for example, an unexpected rapid increase in natural gas prices). Options in the plan would be Implemented differently than initially contemplated in the plan, or other options would be substituted for those in the plan that were better able to respond to the new event.

One of the important conclusions that TVA has reached in Energy Vision 2020 is that no strategy is likely to be robust enough to adequately respond to all of the uncertain events of the future. The world has become too uncertain. Competition in the utility industry is likely to produce far-reaching changes. Events will happen that will require changes in a chosen, discrete strategy.

This explains the importance of another conclusion that TVA reached in Energy Vision 2020. Flexibility is the key to responding to future uncertainties. The ability to alter long-term plans as events unfold (the definition of flexibility) will be critical. The final seven strategies provide hedges against key uncertainties and this allows TVA to better manage risk.

A second approach that provides more flexibility than choosing a single strategy is to maintain as many good resource options as possible for as long as possible. This would allow TVA to better respond to future events and needs. TVA's portfolio of resource options contains all of the options that make up the final set of seven strategies, as well as a few other options that respond particularly well to certain uncertainties. Much like a portfolio of stocks is chosen to manage risk and accomplish specific objectives, the portfolio approach to energy resource planning enables TVA to meet customer needs while hedging risks and balancing costs, rates, environmental impacts, debt, and economic development.

(In the broadest sense, the portfolio approach is itself a strategy. However, unlike a traditional, discrete Energy Vision 2020 strategy, TVA would not be purporting to decide to implement all of the options in the portfolio if it chooses the portfolio approach. The Short-Term Action Plan discusses the specific actions TVA will be taking in the short-term. The specific options that would actually be implemented from the portfolio would depend on future events, and would be decisions that are made later.)

Analysis of Impacts

The Energy Vision 2020 evaluation was summarized beginning on page 1 of this document. Because of the nature of the evaluation process (how strategies were developed, modified, and reanalyzed), the final seven strategies share many common characteristics, especially environmentally-important characteristics. These strategies and their potential environmental impacts are described in detail earlier in this document.

Because they share many important environmental characteristics, all of the final strategies, except Strategy T, have very similar potential environmental impacts. Strategy T would perform noticeably better environmentally than the other six strategies, except for potential land resource impacts. It has the lowest (best) air and water indices in all seven environmental impact categories. This occurs primarily because some of TVA's existing coal-fired units would be repowered with natural gas under this strategy and natural gas has fewer environmental impacts

than coal. How TVA's existing coal-fired plants are operated in the future under each strategy largely dictates how well the strategies perform environmentally.

The other important strategy presented in detail in Energy Vision 2020 is the reference strategy (TVA's "No Action" strategy, Strategy D). This strategy assumes a typical coal-based expansion of the TVA system to meet future energy needs. Because it relies heavily on coal, it would have worse air quality impacts and worse or only slightly better water quality impacts compared to any of the other final strategies.

The potential impacts associated with the portfolio approach (TVA's preferred alternative) depend on which resource options are eventually implemented, when they are implemented, and how they are implemented. Future events will dictate this. Prior to implementation of resource options, for the future, any needed additional environmental reviews would be conducted. At the implementation stage, TVA will be able to identify potential impacts on a site-specific basis, if appropriate.

Although the impacts of the portfolio approach cannot be assessed definitively at this time, the impacts identified for the final seven strategies likely bound those impacts. Because the portfolio contains all of the options that make up TVA's best seven discrete strategies, it is highly unlikely that implementation of the portfolio approach would achieve better or worse environmental performance than these discrete strategies. At best, implementation of the portfolio approach would produce the same environmental results as Strategy T if future events led TVA to deploy only the options contained in that strategy. At worse, the portfolio approach would have the worst environmental impacts associated with the other six final strategies.

All of the final strategies are expected to generally perform better environmentally than the reference, or "No Action," strategy. Unlike the seven best strategies, the "No Action" Strategy (Strategy D) was not formulated to achieve the best possible results across the Energy Vision 2020 criteria. Consequently, Strategy D performs poorly on a number of criteria, including environmental concerns. Because Strategy D contains resource options that have worse environmental impacts than the resource options contained in the portfolio, it is highly unlikely that implementation of the portfolio would produce impacts that are worse than those that would result from Strategy D.

In conclusion, the potential environmental impacts of TVA's preferred alternative (the portfolio approach) would likely be somewhat worse than those identified for Strategy T but would be no worse than those impacts identified for the other six final strategies. In all likelihood, the portfolio approach would perform better (probably much better) environmentally than Strategy D for most impacts. However, the subsequent environmental reviews that will be done at the implementation stage will more definitively identify potential impacts. The TVA decision-makers and the public can consider these impacts before implementation decisions are made.

Environmental Control Options

TVA's Energy Vision 2020 also addresses the potential environmental impacts of alternative environmental control strategies (the ways TVA could comply with Phase 2 sulfur dioxide acid rain control requirements of the Clean Air Act Amendment of 1990 and achieve greenhouse emission goals). The proposed portfolio of options contain a number of control options that could be implemented to achieve these specific environmental objectives.

The environmental control options contained in the portfolio include fuel switches, sulfur dioxide scrubbers, natural gas repowering, system improvements, and biomass cofiring. The actual implementation of specific control options depend on a number of factors that are specific to the issue of environmental controls. This includes such things as the price of sulfur dioxide emission allowances in the future, the enactment of new environmental legislation, and the promulgation of control-related environmental regulations.

Implementation of specific control options also depends in part on the energy resource options that are eventually implemented. As indicated in *Figure 9-3*, Volume 1, Chapter 9, environmental control options vary somewhat across the final seven strategies because the energy resource mix varies somewhat, particularly in Strategy T. For example, the repowering of several existing coal units with natural gas, which is an option in Strategy T, would obviate the need to add scrubbers at several existing units.

As with the process of implementing energy resource options, the implementation of specific environmental control options would be preceded by appropriate environmental reviews. These reviews would examine the site-specific impacts of proposed control.

SECTION 7: RELATIONSHIP BETWEEN PRODUCTIVITY AND RESOURCES

Relationship Between Local Short-Term Uses of the Environment and Enhancement of Long-Term Productivity

The adoption and implementation of a long-term energy resource strategy would have various short- and long-term consequences. These depend in part on the actual energy resource options that are implemented. Site-specific or option-specific environmental reviews will be conducted before final decisions are made to use certain resources and will examine potential environmental consequences in more detail.

In both the short and long term, TVA would continue to generate electric energy to serve its customers and the public. The availability of electric energy will continue to sustain the economic well-being of the region and allow it to grow. Although the demand for electricity has slowed from the 7 percent annual increases experienced in the 1960s and the early 1970s, customers in both the TVA region and nationally continue to add more electric appliances and equipment to their homes and businesses. Some of these energy uses can be met with alternative sources, such as natural gas, but most require electricity. Electricity has contributed and will continue to contribute to the enhancement of the quality of life in the Tennessee Valley both in the short and long term.

However, the production of electric energy may have both short- and long-term environmental impacts. In the short term, the public may be exposed to elevated concentrations of various air pollutants that are emitted by coal-fired power plants or radioactive releases from nuclear units. The operation of hydroelectric units can release water with low-dissolved oxygen and produce conditions detrimental to aquatic life. Other examples of potential short-term impacts are identified in this document.

Potential long-term impacts have also been identified in the environmental consequences sections of the document. These include potential decreases in the productive capacity of some agricultural lands, degradation of some building materials, and possible adverse effects on forest health. The exposure of some members of the public to certain air pollutants and electric and magnetic fields (EMF) may also have long term, adverse health consequences. Continued generation of nuclear waste will require that waste be stored safely for an indefinite period. This will require that some location or locations be devoted to long-term nuclear waste storage.

Irreversible and Irretrievable Commitments of Resources

The continued generation of electricity by TVA will irreversibly consume various amounts of fuels (natural gas, oil, coal, and uranium). Continued maintenance of TVA's existing energy resources and the construction of any new energy resources will irreversibly consume certain amounts of energy and materials. The siting of most new energy resources will essentially irretrievably commit the sites used to an industrial use because of the substantial disruptions to the sites that would occur and the relative permanence of the structures themselves. The continued generation of nuclear power will produce nuclear waste; therefore, some site or sites will have to be devoted to the safe storage of such wastes. Any such site would essentially be irretrievably committed to long-term storage of nuclear waste.

A number of resource options included in TVA's preferred portfolio strategy are demand-side management and renewable energy resources such as wind or landfill or coalbed methane. Reliance on these resources would lessen the irreversible commitment of other energy fuel sources, but would still involve the irreversible commitment of materials and sites to such resources.

SECTION 8: MITIGATION OF ADVERSE ENVIRONMENTAL AND UNAVOIDABLE IMPACTS

TVA will mitigate site-specific environmental impacts from the construction and operation of new power facilities through a combination of planning, pollution prevention, and environmental controls. However, one of the most important mitigative measures associated with Energy Vision 2020 is the multi-attribute tradeoff method used for the evaluation. This method allowed proposed strategies to be reformulated in order to reduce potential impacts.

Planning

Planning allows assessment (and possible avoidance) of direct construction impacts of the site, community infrastructure, environmental justice, and local economy. An effective planning analysis requires detailed and comprehensive knowledge about the natural resources, infrastructure, economy, and demographics in and around the site. These are the same factors that would be assessed for an environmental review under the National Environmental Policy Act. The table in *Figure T2-34* contains a partial listing of factors and information requirements in these two areas. Population growth and demographic changes, expected urbanization, and/or industrialization in the vicinity of a proposed site would also be considered.

Site selection can affect both temporary construction impacts and the long-term, cumulative impacts of operation. Also, the extent of the impacts requiring mitigation can be controlled and reduced. The site screening and selection process used by TVA evaluates the natural resources and socioeconomic factors both in the immediate plant site vicinity and the larger area of influence of the plant. The area of influence for the plant would be governed by:

- Extent of air pollutant fate and transport at non-negligible concentrations
- Extent of water effects due to thermal rejection and wastewater effluents
- Extent of fuel procurement and use of transportation modes
- Other similar factors that occur off-site

These planning data allow assessment (and possible avoidance) of direct construction impacts on the site, community infrastructure impacts, environmental justice effects, and effects on

FIGURE T2-34. **Environmental Planning Factors and Information Required for Mitigation Analysis**

Plant Site and Vicinity	Area of Influence
NATURAL RESOURCES	NATURAL RESOURCES
• Hydrogeologic Survey	• Survey of Terrestrial and Aquatic Life
• Meteorology	• Threatened and Endangered Species
• Ambient Air Quality	• Sensitive Habitat/Important Ecosystems
• Water Resources	• Air Quality Data
• Water Quality	• Meteorological Data
• Survey of Terrestrial and Aquatic Life	• Fuel Availability
• Threatened and Endangered Species	
• Sensitive Habitat/Important Ecosystems	
• Prime Farm Land	
• Wetlands	
• Recreation Resources	
• Cultural Resources Survey	
• Aesthetic Resources	
• Ambient Noise	
SOCIOECONOMIC	SOCIOECONOMIC
• Population Demographic	• Population Demographic
- Age, Race, Sex, etc.	- Age, Race, Sex
- Income	- Infrastructure
• Infrastructure	- Transportation
- Transportation	• Economy
- Housing	
- Solid Waste Disposal	
- Wastewater Treatment	
- Other Utilities, Fire, Police, etc.	
• Economy	

the local economy. Proper planning can play an important role in minimizing long-term receptor exposure and the potential cumulative effects of air and water pollutants.

Pollution Prevention

Pollution prevention results from process design. That is, the selection of fuel type, energy conversion technology, and other plant features provides inherent pollution reduction. For example, some fuels such as hydro, wind, and solar have no direct air pollution. The final seven strategies continue the use of regional hydroelectric resources, and one strategy makes significant use of wind energy. Other fuels such as natural gas offer little potential for emission of some pollutants such as metals and sulfur dioxide. Energy conversion cycles that require wet cooling towers to be economical must address concentration and disposal or discharge of water pollutants as cooling tower recirculation water discharge or cooling pond concentration. Other technologies may have no such potential for pollution.

Increased process efficiency reduces fuel requirements and offers inherent reductions in all related waste streams since less fuel is consumed for a given amount of electric energy produced. Energy Vision 2020 evaluated a wide range of efficient thermodynamic cycles including combined cycle, integrated gasification combined cycle, and integrated gasification with cascaded humidified advanced turbine, all of which were resource options in the final seven strategies.

Efficiency through load conservation (demand-side management) also reduces the fuel use and related pollution because of reduced electric production requirements. A number of demand-side management programs are a feature of the final Energy Vision 2020 strategies.

Environmental Controls

Environmental controls have commonly been used on new and existing plants to meet regulatory standards that protect human health and the environment. The most prominent use of controls are for air pollution and waste heat release into surface water. Air pollution controls in particular have been costly to construct and operate and have either reduced plant efficiency or have significant power requirements themselves. Cooling towers prevent thermal release to surface waters but have cost and operational penalties, as well as wastewater effluent. Nevertheless, these controls are effective mitigation measures that can be engineered to meet regulatory requirements.

Adverse Environmental Effects That Cannot Be Mitigated

The mere adoption of a long-term energy strategy has no adverse environmental effects, but the implementation of that strategy would. The nature and potential significance of the environmental effects will depend on the energy resource options eventually implemented under the strategy. However, there are resource options that are common in each strategy, including TVA's portfolio strategy, and these have associated adverse effects that cannot be realistically avoided.

Under every strategy, TVA would continue to operate most of its existing energy resources (its coal-fired units, nuclear units, hydroelectric units, combustion turbines, and hydroelectric pumped storage units). The operation of these units can result in the release of various air and/or water pollutants, depending on the kind of unit. Although the emissions and discharges from electric generating units are relatively well-controlled, certain residual emissions and discharges will continue to be released from TVA's existing units for the duration of Energy Vision 2020. As has been discussed, these residual emissions and discharges can contribute to a variety of environmental impacts such as visibility impairment, acid rain, crop and forest impacts, or low-dissolved oxygen. The operation of coal-fired and nuclear units will continue to expose adjacent populations to small residual quantities of radioactivity and other toxic pollutants.

The implementation of new generating resources would unavoidably result in a change in land use unless new resources are located at existing generating sites. The conversion of land from a non-industrial use to an industrial use will either unavoidably result in the loss of agricultural capabilities or the destruction of wildlife habitat.

The generation and transmission of electric energy unavoidably produces electric and magnetic fields (EMF). Although the health significance of EMF exposures is uncertain, such exposures could have adverse health consequences.

SECTION 9: ENVIRONMENTAL CONSULTATION, REVIEW, AND PERMIT REQUIREMENTS

A number of environmental consultation, review, and permit requirements would apply to the energy resource options that TVA eventually implements. The nature of these requirements vary depending on the kind of option. Fairly substantial requirements would apply to the more environmentally impactive options. This has the effect of substantially reducing the potential significance of impacts and protecting human health and other environmental values. Many of these requirements have associated opportunities for public review and comment. The following identifies and briefly discusses the more important requirements.

National Environmental Policy Act

The National Environmental Policy Act (NEPA), 42 U.S.C. 4321 et seq., requires all federal agencies, including TVA, to consider the potential environmental impacts of proposed actions before deciding whether to proceed with the actions. Under TVA's National Environmental Policy Act procedures and the regulations promulgated by the Council on Environmental Quality, there are three levels of environmental review: (1) categorical exclusions, (2) environmental assessments, and (3) environmental impact statements (EIS). The significance of the potential impacts associated with a proposed action dictate which of these types of review are to be used. Analysis become more detailed and public involvement more extensive as an agency moves from a categorical exclusion review to an environmental impact statement. Energy Vision 2020 has been prepared as both an integrated resource plan and an environmental impact statement. Actual implementation of options identified in the plan would be "tiered" off of Energy Vision 2020 and, as appropriate, would be preceded by more site-specific National Environmental Policy Act reviews.

Air Pollution Reviews

All of the states in which TVA operates require potential major sources of air pollution to obtain construction and operating permits. A major source is generally a source that emits 100 tons or more of pollutant but smaller sources can be major sources if they are located in a nonattainment area (an area that does not comply with a National Ambient Air Quality Standard) or if they emit hazardous air pollutants. Depending on the kind of source, its location, and the pollutants it emits, the source would be required to employ the best available control technology to reduce its potential emissions or even more stringent controls. Other requirements also can apply, such as the need to offset emissions (obtain a better than one-to-one reduction from existing sources) in some areas. The U.S. Environmental Protection Agency (EPA) has the opportunity to review and comment on permits for proposed sources, and there are usually multiple opportunities for public review and comment.

Wastewater Discharge Reviews

All of the states in which TVA operates require potential dischargers of wastewater to obtain a National Pollutant Discharge Elimination System (NPDES) stormwater permit before site preparation and construction activities can commence. A National Pollutant Discharge Elimination System permit must also be obtained for the direct discharge of pollutants to surface waters during facility operation. National Pollutant Discharge Elimination System permit limits are set to protect water quality and water uses. The Environmental Protection Agency has an opportunity to review and comment on proposed permits, as does the general public.

Solid and Hazardous Waste Management

A number of local, state, and federal laws and regulations govern how solid and hazardous wastes are to be managed. Typically, before solid waste can be disposed of on a plant site, state solid waste disposal permits must be obtained. This permitting process controls the design, monitoring, operation, and closure of disposal areas. The requirements for management of hazardous waste are even more stringent. Hazardous waste is regulated from "cradle to grave" (from the point of generation to ultimate treatment or disposal). During the permitting of solid or hazardous waste disposal sites, the public typically has one or more opportunities to comment.

Protection of Wetlands and Floodplains

Because of their biological value, wetlands receive special protection under federal law. Before most wetlands can be disturbed, a permit must be obtained from the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. The Environmental Protection Agency and the public typically have opportunities to review and comment on proposed permits. As part of the permitting process, the pertinent state is asked to determine whether the proposed action would violate state water quality standards. Federal agencies are required to avoid impacting wetlands with new construction to the extent practicable and to otherwise minimize potential wetland impacts under Executive Order No. 11990 (Protection of Wetlands). Federal agencies are also directed to avoid occupying or modifying floodplains to the extent practicable and to otherwise minimize potential impacts to floodplain values under Executive Order No. 11988 (Floodplain Management).

Endangered Species

Under the Endangered Species Act, 16 U.S.C. 1536 et. seq., federal agencies are to ensure that their actions are not likely to jeopardize the continued existence of any endangered or threatened species or adversely modify any critical habitat of such sensitive species. If a proposed action may affect one of these species, the agency must consult with the U.S. Fish and Wildlife Service and obtain that agency's determination of the potential for impacting these species.

Cultural Resources

A number of federal laws protect cultural and archaeological resources, including the National Historic Preservation Act and the Archaeological Resources Protective Act. Before disturbing cultural and archaeological resources that have historical significance, an agency is required to consult with the State Historic Preservation Officer and in some circumstances, the Federal Advisory Council on Historic Preservation.

Farmland Protection

Under the Farmland Protection Policy Act, federal agencies are required to identify and take into account potential adverse effects of a proposed action on farmlands. Typically, analysis and review are undertaken as part of a National Environmental Policy Act review.

Other Review and Permit Processes

A number of other review and permit processes may be important, depending on the nature of the proposed option and its potential environmental effects. These include reviews under or involving:

- Structures in navigable waters (Rivers and Harbors Act of 1898)
- The Safe Drinking Water Act
- The licensing and monitoring of nuclear facilities (Atomic Energy Act)
- The Toxic Substances Control Act
- The Noise Control Act
- The Federal Insecticide, Fungicide, and Rodenticide Act
- The Comprehensive Environmental Response, Compensation, and Liability Act

Although the actual implementation of an energy resource could require the approval and involvement of other federal or state agencies, the selection of an energy resource plan, which is programmatic in nature, does not have review or consultation requirements. The selection of an energy resource plan for TVA is left to the discretion of TVA's Board of Directors.

SECTION 10: RELATED ENVIRONMENTAL DOCUMENTS

The following documents are related to TVA's Energy Vision 2020 planning process. They can be found in TVA's Corporate Library.

Final Environmental Impact Statement, Bellefonte Nuclear Plant Units 1 and 2, Volumes 1 and 2, 1974.

Final Environmental Impact Statement, Browns Ferry Nuclear Plant Units 1, 2, and 3, 1974.

Final Environmental Impact Statement, Policies Relating to Electric Power Rates, 1974.

Final Environmental Impact Statement, Policies Relating to Sources of Coal Used by the Tennessee Valley Authority for Electric Power Generation, 1971.

Final Environmental Impact Statement, TVA Raccoon Mountain Pumped Storage Project, 1976.

Final Environmental Impact Statement, Sequoyah Nuclear Plant Units 1 and 2, 1971.

Final Environmental Impact Statement, Tennessee River and Reservoir System Operation and Planning Review, 1990.

Final Environmental Impact Statement, Watts Bar Nuclear Plant Units 1 and 2, 1972.

Final Supplement 1 to NUREG-0439, Final Environmental Impact Statement related to the operation of Watts Bar Nuclear Plant Units 1 and 2, (Nuclear Regulatory Commission, April 1995) (Adopted by the Tennessee Valley Authority, June 1995).

Supplemental Environmental Review (Final), Operation of Watts Bar Nuclear Plant Units 1 and 2 (Tennessee Valley Authority, June 1995).

Glossary

The development of Energy Vision 2020, using TVA's interactive planning process, requires the careful, consistent use of certain key terms and phrases. Below are definitions of terms used often in Volume 2, Technical Document 2, Environmental Consequences. (Terms in definitions which are themselves defined in the Glossary are printed in *italics*.)

A

Acid Deposition—The wet or dry deposition of acid chemical compounds from the atmosphere.

Aerosol—A gaseous suspension of ultramicroscopic particles of a liquid or a solid.

Aesthetics—The perception or appearance of visual features in relation to the sense of beauty.

Air Toxins—Various man-made and naturally occurring materials that are known or suspected of causing serious public health impacts, but for which no *National Ambient Air Quality Standards* exist.

Ambient—Surrounding.

Ambient Air Quality Standards—National standards set by the U.S. *Environmental Protection Agency* that are permissible concentration levels of certain pollutants (new *ozone, carbon monoxide, particulates (PM 10), sulfur dioxide, nitrogen dioxide,* and *lead*) in the *ambient* air.

Aquatic—Characteristic of and/or pertaining to water.

Archaeological Resources—Material remains of past human activity.

Ash—The noncombustible component of coal or other fuels.

Attainment Areas—Those areas that meet all *National Ambient Air Quality Standards* as determined by monitoring of air pollutant levels.

B

Benthic Invertebrates—An animal lacking a backbone or spinal column and living on lake bottoms.

Benthos—Organisms that live on or in the first few inches of mud, sand, gravel, or other materials that make up the bottom of streams and lakes, e.g. worms, snails, crayfish, mussels, clams.

Biomass—Organic material. Often involves the harvesting of stands of close-growing whole trees, truck transport, tree storage, and drying using air heated by boiler *flue gas* and combustion of whole trees in a special deep-bed burner at the bottom of the furnace.

Biomass Cofiring—The use of *biomass* as a secondary fuel supplement in a coal-fired plant.

BLN—Bellefonte Nuclear Plant

Bottom Ash—Heavier ash (noncombustible component of coal or other fuels) that settles in the bottom of the boiler rather than being carried out with *flue gas*.

C

Carbon Dioxide (CO_2)—A colorless, odorless, nonpoisonous gas that results from fossil fuel combustion and is normally a part of the *ambient* air. Increasing levels of carbon dioxide in the atmosphere are contributing to the *greenhouse effect*.

Carbon Monoxide (CO)—A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

Cascaded Humidified Advanced Turbine (CHAT)—An advanced Ericson cycle that employs intercooling, recuperation, reheat, and humidification of a combustion *turbine* with a cascaded topping *turbine*.

CHAT—*Cascaded Humidified Advanced Turbine.*

Class I Areas—Areas designated by the Prevention of Significant Deterioration section of the *Clean Air Act Amendments of 1977* that includes national parks and wilderness areas, providing special protection for air quality and air quality-related values.

Clean Air Act Amendments of 1970—Enabling legislation which instructs the *Environmental Protection Agency (EPA)* to set air quality standards for pollutants of concern.

Clean Air Act Amendments of 1977—Legislation that provides greater regulatory authority and sets specific provisions to protect national parks and wilderness areas designated as *Class I areas*.

Clean Air Act Amendments of 1990—Legislation that adds additional regulatory authority to enforce compliance in *non attainment areas*. Also sets new requirements for *acid rain, hazardous air pollutants*, and monitors and reports air *emissions*.

Coal Gasification—Process of converting coal into gas.

Coal Plant—A generation plant using coal as its main source of *energy*.

Coalbed Methane—A gas that is present in all coal seams throughout the United States.

Cogeneration—The sequential production of electricity and useful thermal *energy* (generally steam or hot water) from a single fuel source.

Coproduction—A secondary product that is produced usually in an industrial process in addition to the primary product.

Cradle-To-Grave—System including the generation (e.g., mining), transportation, storage, treatment, and disposal of a fuel or wastes.

Criteria—Measuring rods used in integrated resource planning. They are derived from issues or concerns. Examples include concerns over future rates, acceptable levels of environmental impacts, etc.

Cultural Resources—Any prehistoric or historic district, site, building, structure, or object that may yield information regarding past human endeavors.

D

Delta—In load forecasting, the increase or decrease in the forecast sales caused by the high or low levels of any of the assumptions in the forecast.

Demand—The amount of electric *energy* used at a specific point in time, measured in watts (or multiples thereof, such as *KW, MW,* or *GW*). Demand is measured for individual customers, for groups or classes of customers, and for TVA's system as a whole.

Demand-Side Management (DSM)—Activities which influence electricity use on the customer's side of the meter. Examples include home weatherization, use of compact fluorescent lighting, etc.

DSM—*Demand-Side Management.*

E

Ecosystem—Any unit that includes all organisms (i.e., the community) in a given area interacting with the physical environment. The flow of energy leads to a clearly defined trophic structure, biotic diversity, and material cycles (i.e., exchange of materials between living and nonliving parts within the system).

Effects—These include: (a) direct effects caused by an action and occur at the same time and place; (b) indirect effects caused by an action and are later in time or further removed in distance, but still reasonably foreseeable. Effects and impacts as used in this document are synonymous.

Effluent—Wastewater—treated or untreated—that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

EIS—Environmental Impact Statement.

Electric and Magnetic Fields (EMF)—Two types of energy fields which are emitted from any device that generates, transmits, and uses electricity.

EMF—*Electric and Magnetic Fields.*

Emission—Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Endangered Species—Any biotic species formally listed as in danger of extinction throughout all or a significant portion of its range.

Energy—The amount of power consumed over a period of time, measured in watt hours, *kWh, MWh, or GWh*.

Environmental Mitigation—Making environmental pollutants less severe.

Environmental Protection Agency (EPA)—A federal agency established to permit coordinated and effective governmental action for protection of the environment by the systematic abatement and control of pollution through integration of research monitoring, standard setting, and enforcement activities.

F

Flexible Option—An option that can be altered or modified in accordance with TVA needs.

Flexible Strategy—A combination of options that can be easily altered over time to meet TVA's power needs.

Flexibility—The degree to which resource decisions can be changed over time as events unfold and near-term futures become more clearly known.

Flue Gas—Gaseous combustion products from a furnace or boiler.

Fly Ash—The small ash particles that are carried out of a combustor with the existing flue gas. These particles are collected by appropriate equipment prior to discharging the flue gas to the atmosphere.

Fossil Fuel Plant—A plant using coal, oil, natural gas or other fossil fuel as its source of energy.

Fuel Cell—A cell that converts chemical *energy* directly into electrical *energy*, with electric power being produced as a part of a chemical reaction between the electrolyte and a fuel such as kerosene or industrial fuel gas.

G

Gas-fired Combined Cycle—A generating unit consisting of a combustion *turbine* generator and a steam turbine-generator. The primary fuel will be natural gas.

Geographic—Belonging to or characteristic of a particular region.

Gigawatt (GW)—An amount of electric power equal to 1,000 *MW,* or 1 billion watts.

Gigawatt hour—GWh, an amount of *energy* equal to 1,000 MWh, or 1 billion watt-hours.

Greenhouse Effect—The build-up of *carbon dioxide* or other trace gases that allows light from the sun's rays to heat the Earth but prevents a counterbalancing loss of heat.

Greenhouse Gas Emissions—A gas whose presence in the upper atmosphere contributes to the *greenhouse effect* by allowing visible light to pass through the atmosphere while preventing heat radiating back from the Earth from escaping. Greenhouse gases from human produced sources include *carbon dioxide, nitrous oxide,* methane, and *chlorofluoro-carbons* (*CFCs*). There also are even larger quantities of naturally occurring greenhouse gases, notably *ozone* and water vapor, whose concentrations may be affected by interactions with atmospheric pollutants.

Groundwater—Water within the Earth or geologic stratum that supplies wells and springs.

GW—Gigawatt, an amount of electric power equal to 1,000 *MW,* or 1 billion watts.

GWh—Gigawatt hour, an amount of *energy* equal to 1,000 *MWh,* or 1 billion watt-hours.

H

Habitat—The total environmental conditions on a unit of land including food, cover, and water within the home range.

Hazardous Waste—A byproduct of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special *Environmental Protection Agency* lists.

Herbicide—Any substance or mixture of substances intended to prevent the growth of or destroy unwanted plants or vegetation.

Hg—Mercury.

High-Level Waste—Material that is highly radioactive. In a nuclear power plant high-level waste is *spent fuel*.

Historic Site—Cultural sites more than 50 years old.

Hydroelectric Power Generation—The movement of water from a higher to lower elevation. The difference between the two elevations establishes potential *energy* that is used to generate electricity by allowing water to flow through a hydro *turbine*.

I

Independent Power Producer (IPP)—Any person who owns or operates, in whole or in part, one or more new independent power production facilities.

Integrated Gasification Combined Cycle (IGCC)—Integration of a coal gasification plant with a combined cycle plant. A coal gasification plant is a facility that converts coal into a synthetic fuel gas.

Integrated Resource Planning (IRP)—A utility planning process that evaluates *supply-side resources* and *DSM resources* on a level playing field to reliably meet the future *energy* needs of customers.

Integration—As used in this document, integration means combining options to become strategies and uncertainties to become futures. Strategies are combined with futures to create scenarios.

IPP—*Independent Power Producer.*

IRP—*Integrated Resource Planning*.

K

Kilowatt—kW, which is the amount of power equal to 1,000 watts.

Kilowatt-hour—kWh, which is the amount of *energy* equal to 1,000 watt-hours.

KM—Kilometer, unit of length equal to 1,000 meters.

kW—Kilowatt, which is the amount of power equal to 1,000 watts.

kWh—Kilowatt-hour, which is the amount of *energy* equal to 1,000 watt-hours.

L

Lignite—An imperfectly formed coal, usually dark brown and often having woody texture.

Low-Level Waste—Radioactive material that is only slightly or moderately radioactively contaminated. Low-level radioactive waste consists largely of ordinary trash and

other items that have come into contact with radioactive materials.

M

Megawatt—MW, the amount of power equal to 1,000 KW or 1,000,000 watts.

Meteorology—The science dealing with weather and weather conditions.

µg/m³—Micrograms per cubic meter.

Mitigation—Measures taken to reduce adverse impacts on the environment.

Mobile Sources—Transportation air pollution sources, primarily automobiles and trucks.

Monitored Retrievable Storage (MRS)—A temporary (40 years) collection and storage facility for *spent fuel* rods until a permanent waste repository is available.

Multi-Attribute Tradeoff Analysis/ Technique—An approach designed for interactive participation by a group to make dual comparisons among different attributes for many strategies. It provides an open framework for public involvement to investigate different attributes, futures, and strategies.

MW—Megawatt, the amount of power equal to 1,000 KW or 1,000,000 watts.

MWh—Megawatt hour, the amount of power equal to 1,000 kWh or 1,000,000 watt hours.

N

National Ambient Air Quality Standards (NAAQS)—Uniform, national air quality standards established by the *Environmental Protection Agency* that restrict *ambient* levels of certain pollutants to protect public health (primary standards) or public welfare (secondary standards). Standards have been set for *ozone, carbon monoxide, particulates PM (10), sulfur dioxide, nitrogen, nitrogen dioxide,* and *lead*.

Natural Resources—The elements of the natural environment that are evaluated as resources (i.e., water resources, forests).

NEPA—National Environmental Policy Act.

New Construction—Buildings and facilities that are constructed during the current year; it may also include major renovations of existing facilities.

Nitrogen or Nitrous Oxides (NO_X)—A product of combustion by mobile and stationary sources and a major contributor to the formation of *ozone* in the troposphere and *acid deposition*.

Nonattainment Area—A geographic area that does not meet one or more of the *National Ambient Air Quality Standards* for the *criteria* pollutants designated in the Clean Air Act.

O

Off-System Sales—Sales by TVA to utilities outside the TVA service area.

Option—Actions TVA can take to resolve an issue. For example, if TVA forecasts an energy deficit, it has the option to meet it with *DSM* programs or other resources.

Ozone (O_3)—A substance found in the stratosphere and the troposphere. In the stratosphere (the atmospheric layer beginning 7 to 10 miles above the Earth's surface) ozone is a form of oxygen found naturally that provides a protective layer shielding the Earth from ultraviolet radiation. In the troposphere (the layer extending up 7 to 10 miles from the Earth's surface), ozone is a chemical oxidant and a major component of photochemical smog.

Ozone can seriously affect the human respiratory system and is one of the most widespread of all the *criteria* pollutants. Ozone in the troposphere is produced through complex chemical reactions of nitrogen oxides, which are among the primary pollutants emitted by combustion sources; hydrocarbons, released into the atmosphere through the combustion, handling, and processing of hydrocarbon products; and sunlight.

P

Particulate—Minute separate particles.

Peaking Capacity—Capacity that is available for use and used to meet peak load. Such capacity, usually represented by combustion *turbines* and pumped storage, often has low capital costs and high fuel costs, and is designed to operate for relatively short periods of time.

Pesticide—Chemical materials used to control undesirable insects, animals, diseases, vegetation, or other forms of life.

Pulverized Coal—Crushed coal used to fuel a coal plant. Currently the principal electric generation technology in the United States.

R

Reactor Fuel Cycle—The process of extracting fuels, preparing fuel elements and assemblies for use in a reactor, using these elements in reactor operation, recovering radioactive byproducts from *spent fuel*, and reprocessing remaining fissionable material into new fuel elements.

Renewable Resources—Power plants or other generating devices whose fuel source is generally considered to be renewable. These include generators

fueled by biomass, water, photovoltaics, solar, wave, or wind *energy*.

Renewables—Wind, solar, landfill, methane, and biomass (trees and grasses used for fuel).

Repowering—Replacing or adding to the source of power of an existing electric generating station.

S

Scenario—The combining of one *strategy* with one future.

Scrubber—A device that removes *sulfur dioxide* from *flue gas* using lime or limestone.

Seedling.—Live trees of commercial species less than 1.0 inch in diameter 4.5 feet above ground that are expected to survive and develop.

Short Rotation Woody Crops—Plants grown on a relatively short rotation schedule for the explicit purpose of harvesting for use in power production.

Slag—Ash that has been melted during the combustion process and then solidified as it is removed from the boiler.

Soil—A dynamic natural medium composed of mineral and organic materials in which plants grow.

Species—A class of individuals having common attributes and designated by a common name.

Spent Fuel—Nuclear fuel that can no longer economically sustain a chain reaction.

Strategy—A combination of *options* intended to fulfill a particular resource goal. For example, an energy deficiency in 2007 might be met with a combination of *supply-side resources* and *DSM* resources.

Streams—A continually, frequently, or infrequently flowing body of water that follows a defined course. The three classes of streams are:

- **Ephemeral**: A channel that carries water only during and immediately following rainstorms. Also known as a "dry wash."
- **Intermittent**: A watercourse that flows in a well-defined channel during the wet seasons of the year, but not the entire year.
- **Perennial**: A watercourse that flows throughout the year or nearly so (90 percent of the time) in a well-defined channel.

Sulfur Dioxide (SO_2)—A heavy, pungent, colorless, gaseous air pollutant formed primarily by the combustion of fossil-fuel plants.

Supply-Side Resource—Resources that meet customer needs by increased production of electricity (e.g. hydro, fossil, nuclear, combustion *turbines,* etc.).

Surface Water—Streams, rivers, ponds, lakes, and man-made reservoirs.

Surrogate Measure—A substitute measure that varies in the same way as the pollutant and environmental effects it represents.

T

Threatened Species—Any species which is likely to become an *endangered species* within the foreseeable future.

Topography—The physical features of a place or region. Commonly refers to land forms and variation in elevation.

TSP—Total suspended *particulate* matter.

Turbine—A machine for directly converting the kinetic and/or thermal *energy* of a flowing fluid (air, hot gas, steam, or water) into useful rotational *energy*.

U

Uncertainties—Issues or concerns that may impact energy resources in the future.

V

Visibility Impairment or Degradation—Visibility Impairment or degradation is usually defined as *aesthetic* damage where the ability to discern form, color, or texture is reduced and therefore the scenic value is also diminished. Or, as stated in 40 CFR 51.30(x), visibility impairment is ". . .any humanly perceptible change in visibility (visual range, contrast, coloration) from that which would have existed under natural conditions."

Volatile Organic Compounds (VOCs)—Any organic compound that participates in atmospheric photochemical reactions except for those designated by the *Environmental Protection Agency* administrator as having negligible photochemical reactivity.

W

Watershed—The entire area that contributes to a drainage or stream.

Wetland—Area with soils saturated with water during the growing seasons and supporting plants characteristic of wet conditions.

Wind Farm—Groups of wind *turbines*.

Z

Zebra Mussel—A non-native mussel which fouls, among other things, water intake structures.

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Existing Power System

Capabilities and Characteristics

TVA's existing power system of 25,600 megawatts is projected to provide 27,995 megawatts of summer net dependable capacity by 2005. Summer net dependable capacity is the amount of generating capacity available to the system after accounting for internal uses. Summer capacity is used because TVA anticipates summer as the most limited season in the future. This is due to a seasonal loss in generating capacity and the continued higher growth rate of summer demand as compared to other seasons.

TVA's generating capacity comes from a mix of generating resources including hydro, coal-fired, combustion turbines, and nuclear plants. *Figure T3-1* shows the projected generating mix for TVA.

This projected capacity takes into consideration generation sources that will be added or modified through 2005. Specifically, TVA will begin generating power from Watts Bar Nuclear Plant Unit 1 and will restart Browns Ferry Nuclear Unit 3 during 1996, adding 1,170 and 1,065 megawatts, respectively. Ongoing hydro modernization projects will result in an additional 360 megawatts available from existing hydro units. The installation of pollution control equipment at some steam plants may reduce generation capacity by approximately 35 megawatts as TVA implements Phase II compliance with the Clean Air Act Amendments. TVA will also see a loss of 72 megawatts due to the sale of steam from the Johnsonville Fossil Plant to a nearby industry.

For the purposes of Energy Vision 2020, the additions and reductions in generation output described in the paragraph above are considered as part of the existing power system, since they are planned for the immediate future.

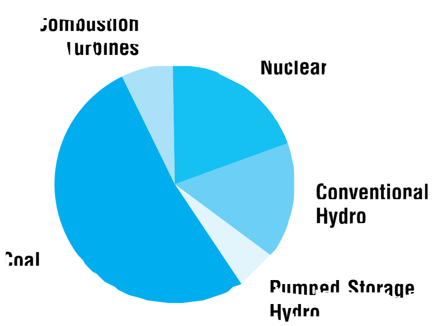
Description of TVA's Generating Resources

TVA'S HYDRO SYSTEM

The TVA hydro system includes 109 conventional hydroelectric generating units and 4 pumped-storage units at Raccoon Mountain. These units are located at 9 main river and 20 tributary plants.

Included with TVA's hydro power capacity is 405 megawatts available from the U.S. Corps of Engineers' facilities through

FIGURE T3-1. **Projected System Capacity in 2005**



	MW	%
Pumped-Storage Hydro	1,532	5
Combustion Turbines	1,952	7
Conventional Hydro	4,404	17
Nuclear	5,517	20
Coal	14,590	51
Total	**27,995**	**100**

This figure shows TVA's generating mix and the percentage supplied by each type of generating resource.

contracts with the Southeastern Power Administration and 321 megawatts available from hydro units owned by Aluminum Company of America and operated by TVA as part of the TVA power system. *Figure T3-2* lists TVA's hydro generating units, including information on location, capacity, years in service, etc.

As noted earlier, TVA's hydro generation capacity will be increased based on ongoing modernization projects. Initial projects will add approximately 360 megawatts of generating capacity and improve efficiency by 3 percent by 2005. Subsequent modernization projects could add 163 megawatts of capacity by 2005

FIGURE T3-2. **Hydro Generating Units**

Hydro Generating Unit	Location	Units	1995 Plant Summer Net Capacity (MW) [1]	Commercial Operation Date	Comments
Appalachia	Polk County, TN	2	76	1943	Tributary
Blue Ridge	Fannin County, GA	1	10	1931	Tributary
Boone	Sullivan & Washington Counties, TN	3	99	1953	Tributary
Chatuge	Clay County, NC	1	10	1954	Tributary
Cherokee	Jefferson County, TN	4	135	1942	Tributary
Chickamauga	Chattanooga, TN	4	130	1940	Main River
Douglas	Sevier County, TN	4	136	1943	Tributary
Fontana	Swain & Graham Counties, NC	3	235	1945	Tributary
Fort Loudoun	Lenoir City, TN	4	140	1943	Main River
Fort Patrick Henry	Sullivan County, TN	2	36	1953	Tributary
Great Falls	Rock Island, TN	2	32	1916	Tributary
Guntersville	Near Guntersville, AL	4	117	1939	Main River
Hiwassee	Cherokee County, NC	2	135	1940	Tributary
Kentucky	Near Paducah, KY	5	183	1944	Main River
Melton Hill	Loudon County, TN	2	75	1964	Tributary
Nickajack	Near Chattanooga, TN	4	96	1967	Main River
Norris	Near Norris, TN	2	100	1936	Tributary
Nottely	Union County, GA	1	17	1956	Tributary
Ocoee #1	Polk County, TN	5	22	1912	Tributary
Ocoee #2	Polk County, TN	2	18	1913	Tributary
Ocoee #3	Polk County, TN	1	27	1943	Tributary
Pickwick	Hardin County, TN	6	240	1938	Main River
South Holston	Near Bristol, TN	1	40	1951	Tributary
Tims Ford	50 miles south of Nashville, TN	1	40	1972	Tributary
Watauga	Near Elizabethton, TN	2	60	1949	Tributary
Watts Bar	Near Spring City, TN	5	179	1942	Main River
Wheeler	Near Town Creek, AL	11	380	1936	Main River
Wilbur	Near Elizabethton, TN	4	11	1912	Tributary
Wilson	Near Muscle Shoals, AL	21	629	1925	Main River
	Total TVA Hydro	**109**	**3,408**		
SEPA	Various		405		
Tapoco			321		
	TOTAL DISPATCHABLE HYDRO		**4,134**		
Raccoon Mountain Pumped-Storage	Near Chattanooga, TN	4	1,532	1978	Pumped-Storage

[1] Based on 1995 SERC IE 411 report.

TVA has 109 conventional hydro generating units located along the Tennessee River and its tributaries.

and have been included as supply-side options for consideration in TVA's integrated resource planning process.

TVA's conventional hydro plants fall into two broad types: main river and tributary. Main river plants are located on the Tennessee River and are generally operated to maintain seasonal lake levels, taking into account recent and predicted rainfall. Tributary plants are located on streams that feed into the Tennessee River and are generally the higher head (vertical change in water elevation) plants located in mountain valleys with deep drawdown possible to provide flood storage capability.

FIGURE T3-3. **TVA's Hydro System**

Hydro System in Fiscal Year	Capacity (MW)	EAF (%)	Total O&M ($/kW)	Total A&I ($/kW)
1994 (Actual)	4,044	97	7.7	13.3 [1]
2005	4,404	97	7.6	6.1

[1] Includes hydro modernization capital expenditures.

Hydro capacity is expected to remain a reliable generating source for TVA, providing 4,404 megawatts with an availability factor of 97 percent.

TVA's hydro facilities are generally operated on five basic considerations:

1. **Flood Control** – In accordance with the TVA Act, the primary responsibility at the dams is flood control.
2. **Environment** – Minimum flow, lake level, and water quality considerations factor into hydro generation.
3. **Power Generation** – In fiscal year 1994, TVA generated or purchased 20.2 billion kilowatt-hours of hydro energy, which represented approximately 15.4 percent of all TVA power generation. In addition to significant power generation, the hydro system is operated to maintain system voltage and provide ready reserve and peaking capability.
4. **Recreation** – System operations are sometimes under constraints to be compatible with white water rafting, fishing, and other recreational activities.
5. **Navigation** – TVA has constructed an extensive system of locks to support river traffic from Paducah, Kentucky to Knoxville, Tennessee. In low rainfall periods, TVA must maintain minimum river levels to support transportation.

Operating reliability is measured by "equivalent availability factor." Equivalent availability factor (EAF) is the ratio of the energy a unit could have generated, if called on, and if sufficient water was available, to the energy the unit would have produced if it had run at full load over the entire period, expressed as a percentage. The hydro system equivalent availability factor for fiscal year 1994 was 97 percent. TVA projects the availability factor for the plants to be 95 percent through 2005 and 97 percent for 2005 through 2020. The drop in availability factor through 2005 is due to the hydro modernization program, which will require that some units be removed from service for refurbishing.

Hydro generation is TVA's lowest cost generation source. Operating and cost features of TVA's hydro generation system, including capacity, equivalent availability factor (EAF), operations and maintenance (O&M) cost, and additions and improvements (A&I) costs, are listed in *Figure T3-3*.

FIGURE T3-4. **Coal-Fired Generating Plants**

Coal-Fired Generating Plants	Location	Units	1995 Plant Summer Net Capacity (MW) [1]	Commercial Operation Date (First Unit) (Last Unit)	Comments
Allen	Memphis, TN	3	744	May 1959 October 1959	Cyclone Furnace
Bull Run	Oak Ridge, TN	1	879	June 1967	Supercritical Pulverized Coal
Colbert	Near Muscle Shoals, AL	5	1,179	January 1955 November 1965	Pulverized Coal
Cumberland	Cumberland City, TN	2	2,448	March 1973 November 1973	Supercritical Pulverized Coal with Scrubbers
Gallatin	Gallatin, TN	4	976	November 1956 August 1959	Pulverized Coal
John Sevier	Rogersville, TN	4	704	July 1955 October 1957	Pulverized Coal
Johnsonville	New Johnsonville, TN	10	1,206	October 1951 August 1959	Pulverized Coal
Kingston	Kingston, TN	9	1,434	February 1954 December 1955	Pulverized Coal
Paradise	Drakesboro, KY	3	2,159	May 1953 February 1970	Supercritical Pulverized Coal Units 1 & 2 Have Scrubbers
Shawnee 1-9	Paducah, KY	9	1,206	April 1953 June 1957	Pulverized Coal
Shawnee 10	Paducah, KY	1	140	December 1989 (AFBC conversion)	Atmospheric Fluidized Bed Combustion
Widows Creek	Bridgeport, AL	8	1,610	July 1952 February 1965	Pulverized Coal; Units 7 & 8 Have Scrubbers
	TOTAL	**59**	**14,685**		
Watts Bar (Idle)	Near Spring City, TN	4	240		Pulverized Coal

[1] Based on 1995 SERC IE 411 Report.

TVA has 59 coal-fired units available for service with a generating capacity of 14,685 megawatts.

TVA'S COAL-FIRED SYSTEM

TVA has 59 active coal-fired units at 11 sites. Four 60-megawatt coal-fired units are now out of service at a twelfth site on the Watts Bar Reservation. The coal-fired units range in size from 107 megawatts each for units 1-4 at the Johnsonville Fossil Plant to 1,224 megawatts for each unit at Cumberland. TVA's oldest active coal-fired unit was placed in service in 1951. The newest unit was placed in service in 1973. One unit at Shawnee was converted to atmospheric fluidized bed combustion (AFBC) in 1989. The average age of TVA's coal-fired generating units is almost 40 years. However, a recent review identified no technical problems that would prevent the continued operation of these plants through the Energy Vision 2020 study period.

Figure T3-4 lists key characteristics and locations of TVA's coal-fired facilities.

TVA's coal-fired units have a 1995 combined net summer capacity of 14,685 megawatts. TVA anticipates reductions in coal system capacity for: (1) loss in Johnsonville capability due to supplying steam to a nearby industry and (2) a possible loss from various units if scrubbers (pollution control equipment) are added. The installation of scrubbers is planned as part of a clean air strategy that is included in the integrated resource plan.

TVA is meeting Phase 1 of the acid rain control program of the 1990 Clean Air Act Amendments (CAAA) by the addition of sulfur dioxide scrubbers at Cumberland Units 1 and 2 and by the purchase of lower sulfur coal. In addition, low nitrogen oxides

FIGURE T3-5. **Coal-Fired Plant Emissions**

	Sulfur Dioxide				Nitrogen Oxides				Carbon Dioxide			
	AVERAGE 1990-1994		ESTIMATED CY95		AVERAGE 1990-1994		ESTIMATED CY95		AVERAGE 1990-1994		ESTIMATED CY95	
Plant/ CAAA Phase	**Tons SO_2**	**LB SO_2/ MMBTU**	**Tons SO_2**	**LB SO_2/ MMBTU**	**Tons NO_X**	**LB NO_X/ MMBTU**	**Tons NO_X**	**LB NO_X/ MMBTU**	**Tons CO_2**	**LB CO_2/ MMBTU**	**Tons CO_2**	**LB CO_2/ MMBTU**
Allen Phase I	66,120	3.34	25,205	1.00	33,729	1.70	42,849	1.70	4,094,359	205	5,167,025	205
Bull Run Phase II	45,087	1.75	77,775	2.50	15,659	0.60	18,666	0.60	5,317,540	205	6,377,550	205
Colbert Phase I	74,605	2.30	97,892	2.89	28,442	0.84	16,918	0.50	6,775,078	205	6,936,175	205
Cumberland Phase I	325,956	4.48	28,334	0.29	97,119	1.36	127,017	1.30	15,257,644	205	20,518,050	210
Gallatin Phase I	129,241	4.24	82,335	3.30	18,345	0.60	11,228	0.45	6,307,466	205	5,114,750	205
Johnsonville Phase I	95,044	2.79	94,908	3.30	26,518	0.83	13,674	0.48	7,064,874	205	5,895,800	205
John Sevier Phase II	57,549	2.35	57,450	2.50	15,308	0.64	13,788	0.60	5,045,858	205	4,710,900	205
Kingston Phase II	87,630	1.86	90,252	2.60	33,013	0.70	90,252	0.70	9,651,209	205	90,252	205
Paradise 1&2 Ph II, 3 Ph I	138,684	2.45	177,349	2.50	120,247	1.74	127,638	1.80	14,543,214	205-210	14,729,700	208
Shawnee 1-9 Ph II, 10 Ph I	55,117	1.62	71,330	1.46	29,803	0.88	40,578	0.83	7,330,461	205-210	10,044,600	206
Widows Creek Phase II	32,685	0.77	54,777	0.95	31,955	0.79	43,316	0.75	8,893,920	205-210	11,938,700	208

This figure shows the historical average for calendar years 1990 - 1994 and 1995 estimate of sulfur dioxide, nitrogen oxides, and carbon dioxide in tons per year and annual average pounds per million Btu by plant. The average is for calendar years 1990 - 1994 with the tons per year being a simple average and the pounds per million Btu being a weighted average.

burners will be added to numerous small units by the end of 1995; also a combination of low nitrogen oxides burners and, possibly, coal reburn at other units will be implemented by 2000.

Phase II sulfur dioxide compliance with the Clean Air Act Amendments will be guided by Energy Vision 2020. Options being considered include sulfur dioxide scrubbers at Paradise Unit 3 and at the Allen Fossil Plant, fuel switching at a number of locations, and natural gas combined cycle repowering of various coal units.

Figure T3-5 lists the coal-fired plants and the average emissions for 1990-1994 and an estimate for 1995 of sulfur dioxide, nitrogen oxides, and carbon dioxide.

Major capital expenditures are anticipated through 2000 (and possibly longer) for compliance with the Clean Air Act Amendments and major overhauls of the large coal-fired units. Capital costs will average between $150-200 million annually for Clean Air Act Amendment compliance and more than $300 million for overhauls to coal-fired plants through 2000.

Figure T3-6 provides cost and performance characteristics for the coal-fired system, including capacity, equivalent availability factor (EAF), heat rate, fuel cost, operations and maintenance (O&M) cost, and additions and improvements (A&I) cost.

FIGURE T3-6. **TVA's Coal-Fired System**

Coal System in Fiscal Year	Summer Net Capacity (MW)	EAF (%)	Heat Rate (Btu/kWh)	Fuel Cost ($/MWh)	Total O&M ($/kW)	Total A&I ($/kW)
1994 (Actual)	14,743	78.9	10,021	13.3	21.9	22.1 [1]
2005	14,590 [2]	85.0	9,884	15.8	26.2	24.0

1 Does not include clean air compliance capital cost.
2 Assumes a reference clean air strategy.

TVA expects some decrease in generating capacity from its coal-fired plants by 2005 due to the installation of additional pollution control equipment and the diversion of steam that will be sold to a local industry. Availability factor is expected to increase by 2005 due to plant improvements that will increase plant efficiency and reliability.

TVA'S COMBUSTION TURBINES

TVA has 48 combustion turbines located at 4 coal-fired plant sites. Twenty-eight of these combustion turbines are capable of burning natural gas or oil; the other 20 combustion turbines have oil capability only. Combustion turbines have a low fixed cost but very high operating cost due to the relatively high cost of gas and oil. These units are normally reserved for use during peak periods only.

The combined summer net dependable capacity of these combustion turbines is 1,952 megawatts. The average age of TVA's combustion turbine units is approximately 23 years. All units are anticipated to be available through the Energy Vision 2020 study period.

Figure T3-7 lists the locations and capacities of the combustion turbines in the TVA system.

TVA recently upgraded the reliability of its combustion turbines. Forced outage factor (FOF) is a measure of combustion turbines' reliability. Forced outage factor is defined as the number of hours a unit is on forced outage divided by the total hours in a period and is expressed as a percentage. A forced outage is defined as those hours when the system needs generation from a unit, but the unit is not able to generate power. Hours when a unit's outage has been planned (for example, scheduled maintenance) do not count as a forced outage.

Figure T3-8 shows significant performance and cost characteristics of TVA's combustion turbines, including capacity, forced outage factor (FOF), heat rate, fuel cost, operations and maintenance (O&M) cost, and additions and improvement (A&I) cost.

FIGURE T3-7. **Combustion Turbine Generating Plants**

Combustion Turbine Generating Plants	Location	Units	1995 Plant Summer Net Capacity (MW)	Commercial Operation Date (First Unit) (Last Unit)	Comments
Allen	Memphis, TN	20	488	June 1971 September 1972	Natural Gas or #2 Fuel Oil
Colbert	Near Muscle Shoals, AL	8	384	September 1972	Natural Gas or #2 Fuel Oil
Johnsonville	New Johnsonville, TN	16	784	June 1972	#2 Fuel Oil
Gallatin	Gallatin,TN	4	296	July 1975	#2 Fuel Oil
TOTAL		**48**	**1,952**		

TVA has 48 combustion turbine plants located at four steam plant sites. Combustion turbines, used primarily for peaking power, have a generating capacity of 1,952 megawatts.

FIGURE T3-8. **TVA's Combustion Turbine System**

Combustion Turbines In Fiscal Year	Summer Net Capacity (MW)	FOF (%)	Heat Rate (Btu/kWh)	Fuel Cost ($/MWh)	Total O&M ($/kW)	Total A&I ($/kW)
1994 (Actual)	1,952	3.5	12,500 [1]	51.1	1.7	4.7
2005	1,952	2.0	12,500	46.9	2.5	0.4

[1] Allen 17-20 heat rate for oil fuel is given as representative of system average.

Combustion turbines are expected to remain a reliable source of power through 2005 with a reduction in forced outage factor due to plant upgrades.

TVA'S NUCLEAR PLANTS

Five nuclear units, located at three sites, are included in existing generating assets—Browns Ferry Nuclear Plant Units 2 and 3, Sequoyah Nuclear Plant Units 1 and 2, and Watts Bar Nuclear Plant Unit 1. *Figure T3-9* gives the locations and capacities of these units.

In 1985 TVA shut down its nuclear operation and construction program to correct significant weaknesses. Operating characteristics since restart from this regulatory outage are anticipated to be more representative of future operations because of the changes in personnel, procedures, and equipment as compared to the pre-1985 period. Since return to service from the regulatory outages, Sequoyah Units 1 and 2 and Browns Ferry Unit 2 have recorded, respectively, a 66 percent, 65.4 percent, and 80.6 percent equivalent availability (explained previously in the section covering TVA's hydro system).

Figure T3-10 gives the significant characteristics for TVA's nuclear system, including capacity, equivalent availability factor (EAF), heat rate, fuel cost, operations and maintenance (O&M) cost, and additions and improvement (A&I) cost.

Although TVA has scaled back its nuclear construction program, nuclear generation is expected to play a vital role in helping TVA meet energy supply demands through the Energy Vision 2020 study period. The nuclear units at Browns Ferry will reach the end of their operating licenses during the study period (2014 for Browns Ferry Unit 2 and 2016 for Browns Ferry Unit 3). It is anticipated that these two units will be excellent candidates for license extension for two reasons. First, boiling water

FIGURE T3-9. **Nuclear Generating Units**

Nuclear Generating Plants	Location	Units	1996 Plant Summer Net Capacity (MW)	Commercial Operation Date (First Unit) (Last Unit)	Comments
Browns Ferry	Near Athens, AL	2 [1]	2,130	1975 1977	General Electric Boiling Water Reactors
Sequoyah	Near Chattanooga, TN	2	2,217	1981 1982	Westinghouse Pressurized Water Reactors
Watts Bar	Near Spring City, TN	1 [2]	1,170	Projected COD in FY 1996	Westinghouse Pressurized Water Reactor
TOTAL		**5**	**5,517**		

[1] Browns Ferry Unit 1 has been idled since 1983. Major modifications are required to bring the plant to current standards. Recovery of this unit is included as a supply-side option within the IRP.
[2] Watts Bar Unit 2 is approximately 68 percent complete. Completion of this unit is included as a supply-side option within the IRP.

Five nuclear units are expected to provide 5,517 megawatts of TVA's generating capacity.

FIGURE T3-10. **TVA's Nuclear System**

Nuclear in Fiscal Year	Summer Net Capacity (MW)	EAF (%)	Heat Rate (Btu/kWh)	Fuel Cost ($/MWh)	Total O&M ($/kW)	Total A&I ($/kW)
1994 (Actual)	3,282	65.6	10,140 [1]	11.0 [2]	90.7	29.8 [3]
2005	5,517	67	10,475	5.4	113.6	19.1

1 Sequoyah 2 heat rate given is typical of all nuclear units.
2 In 1994 TVA took steps to write off sunk interest charges on excess fuel inventory. This will result in future fuel expenses that are significantly lower but are more in line with market costs.
3 Capital expenditures for SQN 1, SQN 2, and BFN 2 plus central office TVAN only.

TVA expects an increase in availability factor for its nuclear system due to plant upgrades. Fuel costs are projected to drop significantly following the write-off of interest charges on excess fuel inventory in 1994.

reactors, such as those at Browns Ferry, are not as susceptible to vessel aging as pressurized water reactors; second, these units have been brought up to current standards. TVA will follow closely the proposed Nuclear Regulatory Commission rule making on license extensions, but TVA anticipates these facilities will be available over the Energy Vision 2020 study period.

TVA has established a nuclear decommissioning fund for all of its operating nuclear reactors. Investments of power funds have been made since 1982 to provide for the accumulation of funds for decommissioning nuclear plants. By September 1993, the lowest interest rate environment in 20 years resulted in a situation where the market value of the decommissioning investments was significantly higher than their book value of $210 million. TVA elected to exercise the flexibility of the internal fund, and sold the investments through a competitive bid for $373 million.

TVA elected to return the proceeds to the decommissioning fund over a three year period beginning in fiscal year 1994. At the end of fiscal year 1994 the fund had $150 million. Plans are to add an additional $100 million by the end of fiscal year 1995 and an additional $123 million by the end of fiscal year 1996.

TVA's policy is to collect funds for decommissioning through rates based on a constant dollar amount adjusted for inflation over the life of the operating license of a nuclear plant. This policy is based on the theory that all ratepayers that benefit from the electric production of a nuclear plant should share equally in the cost of decommissioning. If TVA front-loaded the collection of the nuclear plant decommissioning funds, this would put an undue burden on the ratepayers receiving power generated during the early years of operation of the nuclear plant. On the other hand, if not enough funds were collected throughout the life of the plant, the ratepayers receiving power at the end of the operating license would have an unfair decommissioning burden.

Decommissioning expense has been recovered from ratepayers annually based on the present value of amounts not provided through earnings on the fund. In fiscal year 1990, these

FIGURE T3-11. **Projected Availability of Power Through Interchanges**

	BLOCK 1		BLOCK 2		BLOCK 3	
YEAR	Quantity (MW)	Price $/MWh	Quantity (MW)	Price $/MWh	Quantity (MW)	Price $/MWh
1995	250	23	250	27	1800	40
2000	300	27	300	32	1500	56
2005	0	N/A	300	39	1500	75
2010	0	N/A	0	N/A	1100	106
2015	0	N/A	0	N/A	1000	135
2020	0	N/A	0	N/A	1000	165

This figure shows the amount of power expected to be available through the interchange system through 2000. For each year, power is shown to be available in blocks with varying cost.

collections amounted to $18 million. TVA temporarily suspended decommissioning collections from customers after operating license life extensions were obtained for Browns Ferry and Sequoyah. The temporary suspension was made in an effort not to front-load decommissioning collections. Cashing in the gain on the market value of the fund in 1993 has resulted in a reduction of the annual decommissioning expense collection through rates to $13 million currently based on a projected long-term return of 8 percent. If alternative investments with a higher rate of return could be achieved, the annual collection could be lowered further. Collections for the decommissioning fund will resume in fiscal year 1995.

Interchanges with Neighboring Utilities

TVA has various types of interchange arrangements with neighboring electric systems that allow TVA and these utilities to buy, sell, and exchange power at times when it is mutually beneficial to do so. TVA anticipates that there will be some quantities of non-firm spot market power available, even during peak periods, for the future. Spot market power is power that is available for purchase on the open market, usually surplus power that may be available at any given time from a generating utility. "Non-firm" implies that TVA will not pay capacity charges for the power, and other utilities will not guarantee that it is available.

For planning purposes, TVA has assumed the quantities and price shown in *Figure T3-11*. These blocks are representative of purchase power from neighboring utilities. Depending on the economic loading of the power system, these blocks can be used to offset more expensive internal generating resources.

TVA also anticipates that it will be able to make off-system sales because of differences in timing of system peaks between TVA and neighboring utilities. Over the Energy Vision 2020 study period, these interchange purchases and sales are anticipated to be roughly in balance.

Transmission System

TVA's transmission system serves an area of more than 80,000 square miles, serving a population of approximately 7.7 million. The system includes approximately 16,000 miles of transmission line, including 9,800 miles of 161,000 volt lines and 2,400 miles of 500,000 volt lines.

The system is used to transmit power to 160 distributors of TVA power. These distributors include 50 electric cooperatives, 107 municipal electric systems, and 3 county-operated systems. TVA also directly serves over 60 large industries and Federal installations. In addition, the transmission system is connected directly with 13 neighboring utilities. These interconnections allow TVA to buy power from and sell power to other utilities and to wheel electricity from one utility to another using TVA's power transmission system.

Figure T3-12 lists the electric utilities with which TVA has exchange agreements and the number of interconnections TVA has with each.

TVA is a member of the Southeastern Electric Reliability Council, a voluntary industry oversight organization dedicated to promoting electric system reliability by identifying and enforcing good engineering and operating practices. The Southeastern Electric Reliability Council is a subgroup of the North American Electric Reliability Council, which provides oversight for the entire North American grid. Through these arrangements, TVA has access to emergency backup power.

FIGURE T3-12. **Interchange with Neighboring Utilities**

Neighboring Utilities with Transmission Ties	Interconnections
Associated Electric Cooperative Incorporated	1
Appalachian Power Company	7
Big Rivers Electric Cooperative [1]	7
Carolina Power & Light	1
Central Illinois Public Service	1
East Kentucky Power Cooperative	6
Electric Energy, Inc. (DOE Paducah)	8
Energy Services (Arkansas Power & Light and Mississippi Power & Light Co.)	6
Kentucky Utilities Company	8
Louisville Gas & Electric Company	1
Nantahala Power & Light Company	1
Southern Company (Alabama Power and Georgia Power)	9
Union Electric	1
TOTAL	**57**

[1] Delivery points for power purchased by Big Rivers from the Southeastern Power Administration.

TVA has the capability to exchange power with 13 neighboring utilities which allows power to be bought, sold, or wheeled to meet utility needs.

Energy Vision 2020

4

Volume 2, Technical Document

Evaluation Criteria

Volume 2, Technical Document 4
Evaluation Criteria

Contents

The four major sections of this document named below are working papers that were presented by TVA to support discussions on evaluation criteria during the development of Energy Vision 2020.

Evaluation Criteria

COST/BENEFIT TESTS

1. What are cost-benefit tests?

Cost-benefit tests are a means for any organization to determine if the cost of taking an action is greater than the benefit that is gained from that action. At TVA, cost-benefit tests were used to determine if a given supply-side resource and demand-side management goal can help achieve certain company goals.

2. What cost-benefit tests are used by TVA in the Energy Vision 2020 integrated resource plan?

To determine cost-effectiveness, the standard tests used are:

- Participant Test – Examines the costs and benefits from the perspective of participants in demand-side management programs. Programs that do not pass the participant test have little chance of success.
- Rate Impact Measure (RIM) – Takes the perspective of non-participants and measures the impact of resource options on rates. A program that passes the Rate Impact Measure test will not cause rates to increase and therefore will benefit both program participants and non-participants.
- Total Resource Cost (TRC) – Considers the options of both participants and non-participants and is a measure of economic efficiency for society. Programs that pass the Total Resource Cost test provide energy service at the lowest cost to society as a whole.

Figure T4-1 illustrates the differences among the tests.

3. What assumptions are made to apply the standard tests?

The ability of the standard tests to measure the potential achievement of the desired goals depends on a set of assumptions that are often not acknowledged, namely:

- Customers use the same amount of energy service both before and after the program
- Customers receive the same quality of energy service both before and after the program
- Customers do not change their usage of energy services due to program-induced rate changes

In short, all of the reasons that customers choose not to install a DSM measure (the hidden or market barrier or transactions costs) are assumed to be completely eliminated by the utility program according to the standard tests. These are strong assumptions that often do not hold true even though the standard tests assume they do.

4. How does TVA take into account that the test assumptions named do not always hold true? For example, the purpose of demand-side options is to negate the first assumption—that "customers use the same amount of energy service both before and after the program."

TVA realizes that the assumptions upon which the standard tests are based do not always hold true. For example, a demand-side option may offer an incentive program for purchases of more energy efficient manufacturing equipment. This equipment increases productive efficiency even though it may use more electricity. This makes the first assumption untrue because the amount of energy used would not remain the same. In response, TVA uses the Value Test to measure the value of this increased productivity. Although the Value Test is not one of the standard tests used by regulated utilities, all of the additional measures included in the test are mentioned in the California Standard Practice Manual, *Economic Analysis of Demand-Side Management Programs*.

5. What is the economic basis for the Value Test?

The Value Test is developed rigorously from the principle of economic efficiency. A program that increases economic efficiency is one that increases customer value by either lowering energy service costs or increasing the quality of services. Since the Value Test is a complete measure of economic efficiency, it allows for the relaxation of the four assumptions discussed above associated with the standard tests of cost-effectiveness.

6. Are there any other advantages to the Value Test?

Because the Value Test is a complete test of economic efficiency that acknowledges the fallacy of the assumptions of the standard tests, the Value Test allows all types of Customer Service Options (including DSM) to be evaluated on a level playing field. Customer Service Options include anything that TVA and distributors can do on the end-use customers' side of the meter to increase the value of electricity consumption, making this is a useful test for Energy Vision 2020.

7. Are the components of the Value Test more difficult to measure?

Virtually all costs and benefits associated with customer service and supply-side options are estimated and involve some degree of uncertainty. The techniques that have been developed for the Value Test provide means to develop parameters for the range of uncertainty associated with the estimates of the different costs and benefits.

FIGURE T4-1. **Cost Effectiveness Test—Residential New Homes Program Example**

	PARTICIPANT TEST		RATE IMPACT MEASURE (RIM) (NON-PARTICIPANT IMPACTS)		TOTAL RESOURCE COST (TRC TEST*)	
Benefits:	+Electric Bill Reduction	$226,868	+Avoided Supply Costs	$173,420	+Avoided Supply Costs	$173,420
	+Incentives	$46,664				
Costs:	-Participant Costs	$90,944	-Utility Costs	$13,539	-Participant Costs	$90,944
			-Incentives	$46,664	-Utility Costs	$13,539
			-Revenue Loss	$226,868		
	Net Benefits	$182,588	Net Benefits	- $113,650	Net Benefits	$68,937
	Benefit/Cost Ratio	3.01	Benefit/Cost Ratio	0.60	Benefit/Cost Ratio	1.66

**Note: The TRC is the sum of participant and RIM or non-participant impacts.*

Note: The value test—as shown below—adds components to the participant test and the RIM (non-participant) test that have been omitted as a result of simplifying assumptions.

	PARTICIPANT		NON-PARTICIPANT IMPACTS		TOTAL VALUE	
Benefits:	+Electric Bill Reduction	$226,868	+Avoided Supply Costs	$173,420	+Avoided Supply Costs	$173,420
	+Incentives	$46,664			*+Benefits due to low price of services* [1]	$12,441
	+Benefits due to low price of services [1]	$12,441			*+Reduction in mkt barrier costs* [2]	$6,268
	+Reduction in mkt barrier costs [2]	$6,268				
Costs:	-Participant Costs	$90,944	-Utility Costs	$13,539	-Utility Costs	$13,539
	-Transactions Cost [3]	$38,021	-Incentives	$46,664	-Participant Costs	$90,944
			-Revenue Loss	$226,868	*-Transactions Cost* [3]	$38,021
			-Long-Run Rate Impact [4]	$2,585	*-Long-Run Rate Impact* [4]	$2,585
	Net Benefits	$163,276	Net Benefits	- $116,235	**Net Benefits**	**$47,040**
	Benefit/Cost Ratio	2.27	Benefit/Cost Ratio	0.60	**Benefit/Cost Ratio**	**1.32**

Listings in italic type indicate additions to participant test and non-participant test that differentiate the value test from the TRC test

1,2 Additional benefits to participants that reflect a lower price of services because of efficiency improvements or quality improvements plus reduced market barrier costs achieved by the utility program

3 Transactions costs to participants that reflect market barrier costs not removed by the program

4 Long-run rate impact to non-participants reflects the reaction of non-participants to higher prices caused by the program

TREATMENT OF ENVIRONMENTAL CONCERNS EXPRESSED BY THE PUBLIC

Introduction

Environmental values are a fundamental part of the American value system. No enterprise in today's society can safely proceed in ignorance of the environmental consequences of its activities. TVA Board Chairman Craven Crowell has said:

> *In the years ahead, no major corporation will succeed without a high regard for the environment…We must blend environmental consciousness into everything that we do—from managing our power system to managing our system of lakes and dams, from managing our land use to promoting rural development in ways to support environmental quality.*

There are potentially significant differences in environmental impacts between energy resource strategies. Those differences can result in widely differing economic effects in the form of increased or lessened pollution control costs. Those differences can also result in greater or lesser public acceptance of resource plans.

Environmental Responsibility and Energy Vision 2020

Recognizing the importance of environment values, the TVA Board included environmental responsibility among the four broad strategic goals for TVA. Those goals are:

1. Customer Driven
2. Employee Sensitive
3. Environmentally Responsible
4. Growth Oriented

The ultimate objective of Energy Vision 2020 is to develop a resource plan that will enhance TVA's competitiveness in a manner that meets or exceeds customers' expectations. TVA has defined "competitiveness" broadly to include promoting "sustainable" economic growth.

National Environmental Policy Act

One of the tools to help TVA in this task is the National Environmental Policy Act and its implementing regulations. Since the enactment of the National Environmental Policy Act on January 1, 1970, federal agencies (including TVA) have been required to consider any significant environmental impacts that may result from their proposed actions. The National Environmental Policy Act and its implementing regulations define a process to guide federal agencies in evaluating environmental impacts and involving the public in reviewing this evaluation. The most comprehensive level of review in the process is the environmental impact statement. It provides a structure for involving the public and sets certain minimum analytical requirements, such as the identification of reasonable alternatives to the proposed action.

TVA has prepared an environmental impact statement as part of Energy Vision 2020. This allowed TVA to use the environmental impact statement process to obtain public input, to inform the public about potential environmental impacts, and to ensure that the environmental impacts of alternative strategies are considered.

TVA prepared a "programmatic" level environmental impact statement as opposed to a "project" or site-specific environmental impact statement. This is in keeping with the kind of action under consideration—the formulation of a long-term energy strategy. Because of the programmatic nature of the action, the environmental analyses focuses primarily on regional or broad-scale environmental impacts and those impacts that are normally associated with certain categories of energy options. The environmental impact statement and TVA's integrated resource plan have been merged and collectively consist of Volume 1 and Volume 2.

A particular energy resource strategy may eventually result in individual projects with site-specific impacts. The potential impacts of future resource projects would be addressed through site-specific environmental reviews prior to their development.

FIGURE T4-2. **Environmental Concerns Identified through TVA's Energy Vision 2020 Public Participation Process**

- Acid Rain
- Acid Rain Strategy/Pollution Credits
- Aesthetics
- Air Toxics
- Chlorofluorocarbons (CFC)
- Clean Air/Air Quality/Fossil Pollutants
- Clean Water/Water Quality
- Coal-Mine Reclamation
- Electric and Magnetic Fields (EMF)
- Environmental Regulations
- Externalities
- Global Warming/Greenhouse Gases/Carbon Offsets/CO_2 Constraints
- Human Health
- Lake Levels
- Land Use/Land Impacts
- Nuclear Safety
- Nuclear Waste
- Polychlorinated Biphenyls (PCB)
- Refuse-Derived Fuel (RDF)
- Regional Forests
- Right-of-Way Maintenance
- Smog/Volatile Organic Compounds
- Solid Waste
- Sustainability/Protection of Natural Resources
- Visibility
- Wetlands
- Wildlife
- Zebra Mussels

Treatment of Environmental Concerns and Issues

The analytical process for environmental issues started with the identification of environmental concerns. Through interactions with the public and various stakeholder groups, such as the Energy Vision 2020 Review Group, TVA identified an initial list of environmental concerns. In no particular order of importance, the environmental concerns are identified in *Figure 4-2.* Since the National Environmental Policy Act requires that the environmental impacts of alternatives be considered by the decision-maker, a process was developed to link these concerns to environmental impacts or consequences.

First, these environmental concerns were linked with scientific or regulatory environmental issues based on the associated pollutants or activities.

The public's stated concerns were translated into commonly used scientific or environmental terms that are more concise and amenable to analysis. For example, "smog" from a technical standpoint is associated with ozone, regional ozone, and particulate. TVA's proposed linkage of these concerns with issues/pollutants is identified in *Figure T4-3.*

Second, the environmental impacts or consequences of the environmental issues were identified.

Third, issues that contribute to the same environmental impact or consequences were then grouped together and measures developed to provide capability for quantitative evaluation *(see Figure T4-4).* Constraints were also identified for certain environmental issues, which are discussed later in this section.

Environmental Impacts and Measures

Each of the issues from *Figure T4-4* was associated with an environmental impact measure in order to combine the multi-attribute trade-off analysis approach with the National Environmental Policy Act requirement that the decision-maker consider the environmental consequences or impacts of alternative strategies under consideration. These impacts, typical of those evaluated in other environmental impact statements, are treated as evaluation criteria. The relative magnitude of these impacts have been analyzed among alternative energy strategies.

In many cases, more than one issue will contribute to an impact. For example, human health impact through inhalation pathways is associated with the acid aerosol (sulfate), ozone, indoor air quality, and hazardous air pollutants (e.g., mercury). Both regional ozone and acid deposition issues contribute to crop damage. Other impacts may be linked to only one issue. *Figure T4-4* identifies the proposed environmental impacts and shows the relationship between environmental issues (derived from concerns) and these environmental impacts.

Comparing the relative environmental impacts of strategies requires identification of measures that either directly or indirectly indicate the impact area. Where multiple measures are associated with an impact, the importance of each measure is considered.

Some of these measures are relatively straightforward and can be considered direct measures of the risk of impacts. For example, the possibility of impacts to fish and aquatic life from the discharge of heated condenser cooling water can be measured by the heat (BTUs) discharged to the rivers. Measurements for other issues/pollutants are not so straightforward, but certain pollutants that contribute to or cause an impact can serve as indirect measures of impacts. For example, sulfur dioxide (SO_2) and nitrogen oxides (NO_X) are precursor pollutants that are the primary contributors to acid deposition and associated impacts on forests, crops, fish and other aquatic life and materials. By measuring these pollutants for various strategies, it is possible to obtain some understanding of the potential relative effect of a strategy on environmental impacts.

FIGURE T4-3. **Environmental Concerns and Linkage to Scientific Issues/Pollutants**

Environmental Concern	Issue/Pollutant (Linkage)
Acid Rain	Acid aerosols, acid deposition, acid clouds
Acid Rain Strategy, Pollution Credits	Alternative representative strategies will be evaluated in the IRP
Aesthetics	New construction, windmills
Air Toxics	Hazardous air pollutants, mercury inhalation/deposition
Chlorofluorocarbons (CFC)	Unimportant IRP issue – being phased out by law
Clean Air, Air Quality, Fossil Pollutants	Acid aerosols (sulfate), ozone, particulates, indoor air quality, hazardous air pollutants, regional ozone, acid deposition, acid clouds, combustion byproducts, natural gas leakage, landfill/coal mine, methane, visibility
Clean Water, Water Quality	Point source releases, solid waste, fuel production, air emissions, construction site runoff, general site runoff, acid mine drainage (non-point source pollution), low dissolved oxygen, hydro power releases, releases of nutrients/oxygen demanding substances, discharge of heated condenser cooling water, acid deposition, surface water intakes (including pumped storage), facility construction and operation, mining operations, evaporative water losses and cooling tower drift (consumption), water withdrawal (usage), ground water contamination.
Coal Mine Reclamation	Fuel production, acid mine drainage
Electric and Magnetic Fields	Addressed qualitatively in IRP/EIS
Environmental Regulations	Captured as uncertainties in the analysis
Externalities	Captured by multi-attribute analysis – addressed qualitatively in IRP/EIS
Global Warming, Greenhouse Gases, Carbon Offsets, CO_2 Constraints	Combustion byproducts, natural gas leakage, landfill/coal mine methane
Hazardous Waste	Hazardous waste
Indoor Air Quality	Indoor air quality
Lake Levels	Addressed in TVA's Lake Improvement EIS; IRP assumption
Land Use, Land Impacts	New construction, new plants, new dams, new coal mines, new rights-of-way, energy crops, nuclear and hazardous wastes generated, combustion byproducts and management (ash and pollution control byproducts), generation, transmission, windmills, strip mining
Nuclear Safety	Addressed as a financial uncertainty (nuclear moratorium), addressed qualitatively in IRP/EIS
Nuclear Waste	Low- and high-level nuclear waste
Polychlorinated Biphenyls	Unimportant IRP issue, being phased out on TVA system (PCBs)
Refuse-Derived Fuel (RDF)	RDF is treated as an IRP option
Regional Forests	Regional ozone, acid deposition, acid clouds
Right-of-Way Maintenance	To be addressed qualitatively in Energy Vision 2020
Smog, Volatile Organic Compounds	Ozone, regional ozone, particulates
Solid Waste	Combustion byproduct
Sustainability, Protection of Natural Resources	Addressed qualitatively in IRP/EIS; components of sustainability are captured by criteria (environmental impact, economic impact, energy efficiency)
Visibility	Acid aerosols (sulfate), ozone, particulates
Wildlife	New construction, new plants, new rights-of-way, strip mining, windmills, energy crops
Wetlands	Unimportant IRP issue; site-specific
Zebra Mussels	Point source releases, surface water intakes, water withdrawal

Developing measurements for some impacts is even more difficult; therefore, for a number of impacts, surrogate measures were used. For example, the amount of coal burned provides an indication of the amount of pollutants affecting aquatic life and biodiversity. Finally, for a few impacts, TVA has not been able to identify reasonably, appropriate direct, indirect, or surrogate measures. These potential impacts have been considered qualitatively in Energy Vision 2020. *Figure T4-4* shows the measures proposed for each environmental impact.

ENVIRONMENTAL CONSTRAINTS

A constraint is an absolute limit on a measure. These can be externally imposed in the form of a legal requirement or internally imposed as a policy. A constraint can also result from physical limitations such as the maximum loading that a transmission line can carry or the maximum capacity of a generating unit.

Two environmental constraints have been identified: one affects sulfur dioxide emissions, and the other affects greenhouse gas emissions. In addition, two assumptions have been made

FIGURE T4-4. **Issues, Related Environmental Impacts, and Measures**

Issues/Pollutants	Environmental Impact	Measurements/Treatment
Acid aerosols (sulfate), ozone, particulates, indoor air quality, hazardous air pollutants, mercury inhalation	Human health—inhalation	SO_2, NO_X, TSP, mercury emissions—also Qualitative
Acid aerosols (sulfate), ozone, particulates	Visibility	SO_2, NO_X, VOC—also Qualitative
Regional ozone, acid deposition, acid clouds	Forests, crops	SO_2, NO_X—also Qualitative
Acid deposition, ozone	Materials (structural and cultural)	SO_2, NO_X—also Qualitative
Point source releases, hazardous air pollutants, mercury deposition, groundwater contamination, facility operation	Human health—ingestion	Nuclear power sales, fossil power sales, hydro peaking power sales—also Qualitative
Discharge of heated condenser cooling water, point source releases, mining operations, evaporative water losses and cooling tower drift (consumption), water withdrawal (usage), facility construction and operation, groundwater contamination	Water supply, waste assimilation	Thermal rejection to river, water consumed, hydro peaking power sales—also Qualitative
Point source releases, solid waste, fuel production, air emissions, mercury deposition, construction site runoff, general site runoff, acid mine drainage (nonpoint source pollution), low dissolved oxygen, hydro power releases, releases of nutrients/oxygen demanding substances, discharge of heated condenser cooling water, acid deposition, surface water intakes (including pumped-storage), facility construction and operation	Aquatic life, biodiversity	Thermal rejection to river, water used, coal burned, nuclear power sales, fossil power sales, hydro peaking power sales, new power plants—also Qualitative
New construction, windmills	Aesthetics/visual	Qualitative
New coal mines, new plants and dams, energy crops	Agricultural land loss	Qualitative
New coal mines, new plants, new rights-of-way, energy crops	Biodiversity	Qualitative
Low- and high-level nuclear and hazardous waste generated, new plants, new rights-of-way, new dams, strip mining, combustion by-products and management (ash and pollution control byproducts)	Land consumption, land management	Qualitative
Combustion byproducts, natural gas leakage, landfill/coal mine methane, carbon sequestration	Greenhouse gas emissions	CO_2—also Qualitative
Indoor air quality		Qualitative
Right-of-way maintenance		Qualitative
Electric and magnetic fields		Qualitative
Sustainability, protection of natural resources		Qualitative

for purposes of analyses. These assumptions behave like constraints: one involves those formulated in TVA's *Tennessee River and Reservoir System Operation and Planning Review*, more commonly known as TVA's Lake Improvement Plan. The other environmental constraint involves releases from new fossil plants. These constraints and assumptions are described below.

System Sulfur Dioxide (SO_2) Emissions Constraint

Sulfur dioxide emissions from TVA's fossil-fuel units must meet acid rain control requirements on a system-wide basis.

Greenhouse Gas Emissions Constraint

TVA has committed, along with some 60 other utilities, to participate in the President's Climate Challenge Program, which is a voluntary greenhouse gas reduction or stabilization program. Program participants have substantial flexibility in formulating reduction or stabilization strategies. TVA has agreed to voluntarily reduce equivalent TVA carbon dioxide emissions by the year 2000. These commitments will have to be met by all Energy Vision 2020 strategies.

Lake Improvement Plan Assumption

In 1991, TVA committed to improving water quality and aquatic habitat by increasing minimum flows and aerating releases from a number of TVA dams. TVA is also committed to extending the recreation season on a number of TVA reservoirs by delaying the drawdown of reservoirs for other operating purposes, primarily hydropower generation. These commitments will be met regardless of the strategy.

Minimum Fossil Fuel Plant Releases

Because of the trend toward increasing environmental regulation, it is assumed that all new fossil fuel-fired units will have minimal water discharges as well as lined waste storage areas and will employ best available technology to control air emissions.

CALCULATION OF ENVIRONMENTAL INDICES

TVA's existing energy resources and many of the resource options considered for Energy Vision 2020 can affect the natural environment in different ways. Indices were developed to help characterize how TVA power system operations and alternative energy strategies might affect the environment. All indices were calculated relative to the reference strategy, which was used as a baseline for comparison (See Technical Document 8, Resource Integration). The reference strategy is TVA's "No Action" alternative for purposes of its environmental review.

Each measure was normalized to cancel out the engineering units which may vary among the measures. An illustrative example of computing the air quality index for forest and crop productivity for three strategies is given at the right.

Step 1. Select strategies and determine values for the measures (Tons of SO_2 and NO_X for the Forests and Crops Productivity Index)

	MEASURE/WEIGHTING FACTOR	
Strategy	**Sulfur Dioxide/.25**	**Nitrogen Oxides/.75**
Reference	500,000 Tons	300,000 Tons
Strategy A	600,000 Tons	350,000 Tons
Strategy B	400,000 Tons	250,000 Tons

Step 2. Divide each measure quantity by the maximum measure quantity and multiply by the Weighting Factor for that measure.

	MEASURE/WEIGHTING FACTOR	
Strategy	**Sulfur Dioxide/.25**	**Nitrogen Oxides/.75**
Reference	0.833 x 0.25	0.857 x 0.75
Strategy A	1.0 x 0.25	1.0 x 0.75
Strategy B	0.667 x 0.25	0.714 x 0.75

Step 3. Sum the index components across for each strategy (raw index) and divide by the raw index for the reference strategy to obtain the Forest and Crop Productivity Index for each strategy baselined to the reference strategy.

	MEASURE/WEIGHTING FACTOR	
Strategy	**Sulfur Dioxide/.25**	**Nitrogen Oxides/.75**
Reference	0.208	0.643
Strategy A	0.25	0.75
Strategy B	0.133	0.536

Strategies	**Forest and Crop Productivity Index**
Reference	$\frac{(0.208+0.643)}{(0.208+0.643)} = 1.0$
Strategy A	$\frac{(0.25+0.75)}{(0.208+0.643)} = 1.175$
Strategy B	$\frac{(0.133+0.536)}{(0.208+0.643)} = 0.786$

TVA'S APPROACH TO EVALUATING EXTERNALITIES RESULTING FROM THE PRODUCTION AND CONSUMPTION OF ELECTRICITY

Nature of the Problem

Externalities are activities that result from the production and consumption of goods and services that impose costs or benefits on society that are not reflected in the prices of those goods or services. For example, negative externalities such as pollution and sonic booms can impose costs on a society that are not reflected in the prices of those goods associated with the pollution or sonic boom. Not all externalities impose costs. Positive externalities create benefits to society that are not reflected in those goods and services. For example, positive externalities can result from public parks, flood protection, and the shade resulting from the neighbors' recently planted tree.

Since the costs or benefits of externalities are not reflected in prices or costs of goods and services, the economic allocation of resources is inefficient because consumers and purchasers do not account for external costs and benefits in their resource decisions.

Discussions of externalities in the utility industry have generally dealt with environmental externalities arising from various forms of pollution. Although most of the discussion in this section deals with environmental externalities, it should be noted that the principles would also apply to other negative or positive externalities.

From an economic viewpoint, economic efficiency can be maximized by reducing negative externalities to the point where the marginal benefits from reduced externalities equals the marginal cost of reducing the externalities. The marginal benefits of reduced negative externalities are generally measured by the reduction in the marginal environmental costs imposed on society. The general economic recommendation to reduce environmental externalities is to internalize in prices of products and services the external costs of the externality.

These concepts have led to the policy of social costing in the electric utility industry. Generally, it is stated that economic efficiency can be improved if the external costs of an activity can be included in the private costs for utility decision-making. The external costs of various pollutants are monetized, a value is put on external costs and added to the private costs as indicated in *Figure T4-5*.

In the example in *Figure T4-5*, the private costs (fuel, operation and maintenance, and capital costs) of a combined cycle exceed those for a coal-fired plant. If the external costs associated with sulfur dioxide, nitrous oxide, and carbon dioxide are included, the combined cycle plant has lower costs than the coal-fired plant.

The inclusion of those external costs in utility planning and operation (i.e., system dispatch) has been the subject of debate in the electric utility industry in the last several years.

This section provides a brief summary of industry experience, issues in the application of externalities, and the potential application at TVA.

Environmental Externalities – World, U.S., and Utility Experience

The application of various policy instruments in pollution control or the reduction of external costs is shown in *Figure T4-6* for the United States, Canada, and other countries. Other countries are represented primarily by the European community.

The United States and Canada have experience with command and control policies and market approaches where limits are placed on emissions with trading of offsets or allowances

FIGURE T4-5. **Private and External Costs of Coal and Combined Cycle**

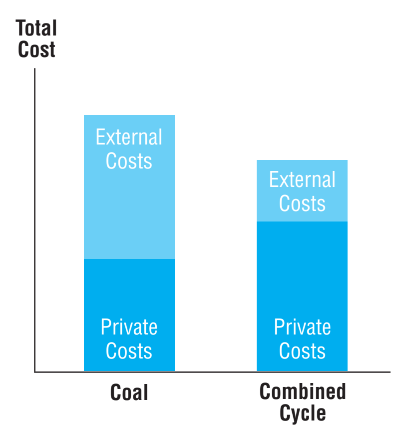


FIGURE T4-6. **Application of Policy Instrument in Pollution Control**

		MARKET					COMMAND AND CONTROL			
Pollutant Area	Country	Trading/ Offsets	Taxes	Fees	Liability	Subsidies	Emissions Standards	Fuel Choice Standards	Technology Standards	Pollution Reduction Target
SO_2	U.S.	●		●			●	●	●	●
	Canada	●					●	●		●
	Others	●	●		●	●	●	●	●	●
NO_X	U.S.	●				●	●	●	●	●
	Canada	●				●	●	●	●	●
	Others		●			●	●	●	●	●
VOC	U.S.	●				●	●	●	●	●
	Canada	●				●	●	●	●	●
	Others					●	●	●		●
CFC	U.S.	●	●							●
	Canada									●
	Others		●							●
CH_4	U.S.									
	Canada									
	Others									
N_2O	U.S.									
	Canada									
	Others									

similar to the policy approach to acid rain. Other countries, particularly European countries, have experience with the same techniques but also have substantial experience with the use of taxes to control or reduce pollution.

Figure T4-7 indicates the methods various state regulatory agencies (public utility commissions) have used to incorporate externalities into utility planning and operations. Currently, eight states monetize externalities as of early 1993. States use a variety of techniques from percentage cost adders for certain technologies to qualitative treatment of external costs. Several states have rejected a monetization of externalities, including Michigan, Alaska, Colorado, Delaware, and Connecticut.

For the states that have included external costs in utility resource decisions, the values used to represent the external costs are shown in *Figure T4-7*. There are two features in *Figure T4-7* that should be noted. First, there is a wide range of value estimates for external costs of any particular pollutant. Second, most of the pollutants involved are air pollutants.

Issues in the Application of Monetizing Externalities

Below is a summary of arguments both for and against for monetizing externalities in the electric utility industry.

PROS

1. Society's resources would be allocated more efficiently.
As previously discussed, internalizing the external costs and benefits of an externality in the production of goods and services would increase the economic welfare or well-being of society.

2. The risk of future environmental control costs would be reduced.
Another argument for internalizing externalities stems from a desire to mitigate the risk of future environmental control costs or other abatement strategies, such as carbon taxes, that could lead to future increases in a utility's costs and to rate increases. One example is the Wisconsin Public Service Commission's decision "to purchase 'insurance' against the risk of future costs" by adopt-

ing adders for greenhouse gases and promoting resources that will reduce emissions of these gases now and at a cheaper price than would occur by waiting for future regulations requiring reductions in emission of such gases.

3. Different resources can be compared consistently.
Proponents also believe that explicit recognition of the environmental effects of different demand and supply options is necessary to make consistent comparisons among resource options with different prices, environmental impacts, and non-price features. The use of adders and other techniques, they argue, will encourage resource developers and/or bidders to develop options that are relatively environmentally clean, since these options will have a relative competitive advantage, when compared to resource options with greater environmental impacts.

CONS

1. Commission action is inefficient and unnecessary.
Many opponents of environmental regulation by state commissions contend that adding externalities to the regulatory agenda is inefficient and unnecessary. They argue that additional action by state commissions is unneeded, given the existence of state and

FIGURE T4-7. **Externality Values Used in Utility Resource Decisions (1992 $/lb.)**

AGENCY/REGION	POLLUTANT SO_2	NO_X	VOC [1]	CO	TSP [2]	CO_2 [3]	CH_4	N_2O	Water Use	Land Use
New York PSC[A]	0.637	3.0405			0.1665	0.0006			0.1/kWh	0.4/kWh
Massachusetts DPU [B]	0.85	3.6	2.95	0.48	2.2	0.012	0.12	2.2		
Nevada PSC [C]	0.822	3.583	0.622	0.485	2.203	0.012	0.116	2.182		
California PUC (SDG&E/SCE)	11.745	15.724	11.231		3.402	0.0042				
California PUC (PGE&E)	2.243	4.56	2.118		1.312	0.0042				
CA PUC (attainment areas) [D]	0.86	3.733	0.6505		2.304	0.0042				
BPA (west side)	0.79	0.466			0.812	0.0032			0.0002/kWh	0.0002/kWh
BPA (east side) [E]	0.79	0.0364			0.088	0.0032				
Wisconsin PSC [F]						0.0075	0.075	1.35		

1 Volatile Organic Compound (VOC) values for California represent ROG (reactive organic gases)—a more inclusive definition, which includes the VOC gases and a few others.
2 Total Suspended Particulates (TSP) values for California represent values for PM10 — a more specific definition, which includes particulate matter most harmful to human health.
3 CO_2 values for BPA were draft cost. No final cost was issued.

*The implicit price deflator for Gross Domestic Product is used to convert the adders to 1992 dollars. The deflators for 1987, 1989, 1990, and 1992 are 101.2, 110.1 115.0 and 121.2, respectively. (*Economic Report of the President*, U.S. Government Printing Office, Washington, DC, Table B-3, January 1993.)*

SOURCES:

A New York State Energy Office, Draft New York State Energy Plan, Vol. 3, July 1991, pp.-18 (issue 8), and pp. 1-51 (issue 9).
B Massachusetts Department of Public Utilities, "Investigation by the Department of Public Utilities on its own motion as to the environmental externality values to be used in resource cost-effectiveness tests by electric companies subject to the Department's jurisdiction," D.P.U. 91-131, November 10, 1992.
C Mitchell, Cynthia, "State Regulatory Experiences in Attempting to Quantify and Incorporate Environmental Externalities: The Nevada Experiences," 1991.
D California Public Utilities Commission, Decision 91-06-022, June 5, 1991.
E Buchanan, Shepard C., "Dancing with the Bear: Lessons Learned in Applying Externality Costs to Real World Resources," paper presented at the National Association of Regulatory Utility Commissioners/U.S. Department of Energy Fourth National Integrated Resource Planning Conference, Burlington, VT, September 15, 1992.
F "Wisconsin PSC Orders that $15/ton CO_2 Value Be Added to Utility Power Project Plans," Utility Environment Report, May 29, 1992, p. 1.

federal environmental regulators and the large expenditures on environmental controls. Further, if the existing regulations are inadequate, they feel state commissions are not well-positioned to make corrections.

2. Further regulations of electric utility industry could reduce economic benefits because of piecemeal problems.
One of the key principles for reducing external costs is that all external costs and benefits that result from a full range of relevant pollutants from all sources should be considered in order to minimize total social cost. Not adhering to this principle can result in a host of so-called "piecemeal" problems. "Piecemeal" problems are costs or benefit changes that potentially increase social costs due to situational, rather than broad-based, development and application of policies designed to address external costs of pollutants. This could occur by singling out one source of pollution out of many sources, one geographic area out of many areas, one economic sector of industry, or one fuel source from many. For example, as indicated in *Figure T4-8*, the utility industry accounts for only 36 percent of carbon dioxide emissions, while industrial and transportation sectors account for approximately 52 percent of total U.S. emissions. If the external costs of carbon dioxide are included only in electric utility planning and operation, there may be undesirable cost changes or actions created in the electric utility sector.

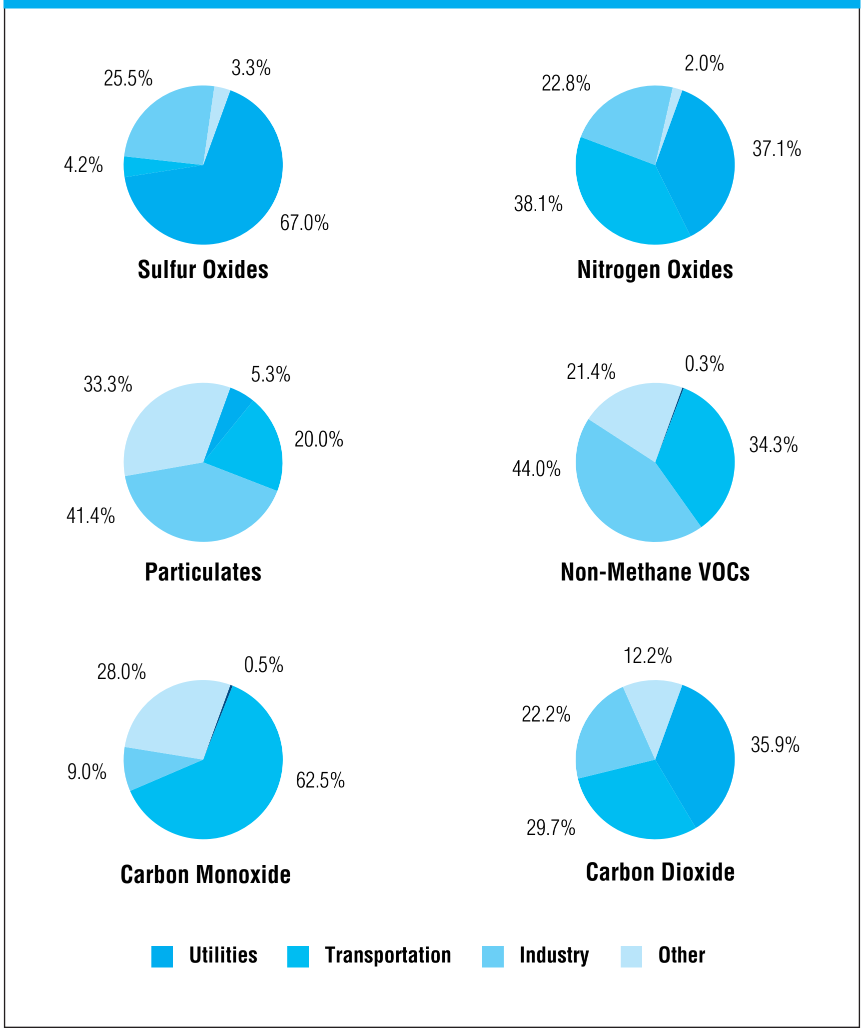
Some of these undesirable changes or distortions in minimizing social costs would include fuel switching from electricity to other fuel and economic dislocation between sectors of the economy (e.g., electricity, transportation). The economic distortion could include the movement of industry from areas that include external costs to areas that exclude external costs, and changes in production and consumption patterns with overproduction (compared to optimum) of products without external costs included in the price to underproduction (compared to optimum) of products with external costs included in the price.

Another example of a "piecemeal" problem is that many regulatory agencies are including external costs only in new resource decisions, which could bias resource efficiency through the increased use of existing resources that may have higher emissions rates.

3. Current valuation methodologies are flawed.
Another common theme in opponents' arguments stems from doubts about the current methodologies used to estimate externality values. In particular, they are critical of the cost-of-control method, which they argue does not reflect a valid benefit-cost analysis because the political process that produced a given level of control reflects more than just the value of the remaining environment impacts.

4. Uncertainty exists in the quality of the damage cost estimates.
A major uncertainty is the quality of the estimates of the external cost of environmental externalities. The preferred method is to estimate the external costs based on the cost of the dam-

FIGURE T4-8. **Emissions by Sector in the United States**



age resulting from the pollutant. From an economic efficiency perspective, social costs are minimized by reducing a pollutant up to the point at which the reduction in marginal damage is equal to the marginal costs of reducing the pollutant. Emissions of sulfur dioxide may cause increased costs of health care or illness. Increased carbon dioxide emissions may result in global warming with its associated costs.

One of the major uncertainties in dealing with the externality problem is the difficulty of estimating the marginal damages from the emissions of an externality. Sulfur dioxide emissions may cause health problems with individuals, it may damage watersheds and forests, and it may affect agriculture production. Estimating the costs of these effects is extremely difficult; therefore, any resulting estimates may be highly uncertain, as previously indicated in *Figure T4-7.*

5. Some air emissions are already regulated.

Existing regulations already or soon will internalize all costs resulting in a zero value for the costs of residual emissions. For example, the Clean Air Act provisions for the regulations of sulfur dioxide permit the trading of allowances for emissions below the regulated limits. The value for allowances is an estimate of the external cost of residual emissions. Thus, further monetization of externalities is not necessary.

TVA's Approach to Environmental Externalities

Given the many difficulties of monetizing externalities and the lack of coherent position within the electric utility industry, TVA does not monetize externalities in the Energy Vision 2020.

Rather, TVA has addressed externalities by using several environmental measures as part of the evaluation criteria used in Energy Vision 2020. Emissions of sulfur dioxide, carbon dioxide, nitrogen oxides, and several other pollutants are measured for resource options. The environmental measures are then used in the multi-attribute trade-off analysis. In addition, externalities have been qualitatively considered through the programmatic environmental review.

In Energy Vision 2020, the potential for future environmental regulations (specifically, carbon dioxide legislation which imposes a dollars per ton tax on carbon dioxide emissions) is explicitly identified. Resource options or strategies that meet environmental future regulations are evaluated based on this evaluation criteria.

Summary of the Rationale by Public Service Commissions for Not Monetizing Externalities

A number of public utility commissions (PUCs) have offered reasons or stated a rationale for not monetizing environmental externalities. Below is a summary of those statements.

Alaska. The Alaska Public Utilities Commission said in its review of the Healy Clean Coal Project that it believes externality requirements to be beyond its current authority. (Docket #U-92-11) (EPRINET, 1994)

Colorado. The Public Utilities Commission rejected monetization of externalities in integrated resource planning. In a 1993 decision, the commissioners stated that: "…the methods for quantification of externalities are highly complex, and, at this time still speculative… Given this state of knowledge, it would be premature to mandate utilities to monetize externalities." (Docket #91R-642E) (EPRINET, 1994)

Connecticut. The Public Utilities Commission ruled in December 1993 that it will not require utilities to use monetized adders to value externalities in least cost planning. Rather, utilities will be directed to use "trade-off analysis" which involves the use of computer models to compare the external cost and benefits of power plan scenarios.[1] The process was developed by researchers at Massachusetts Institute of Technology. (EPRINET, 1994) However, the PUC accepted United Illuminating's voluntary use of a 25 percent credit for demand-side management programs without requiring the credit of other utilities.

Florida. The Department of Environmental Regulation (DER) was directed to review the state's power plant siting process to consider how externalities should be considered. Monetization of externalities was not recommended, but consideration of environmental factors in the selection and evaluation of new resources was suggested. (EPRINET, 1994)

The Public Service Commission stated that it does not believe it should consider environmental externalities when evaluating cost effectiveness in need determinations. The Public Service Commission has stated that it "…has neither the expertise, the

[1] The externalities to be modeled include EMF, economic development, electric system reliability, fuel risk, and impacts on air, land, and water. For air emissions, only NO_x and VOCs were determined not to already be fully internalized by regulatory efforts. The impacts of CO_2 were to be assessed by utilities. Other externalities determined to be fully internalized were SO_2; ash, sludge; hazardous waste disposal; nuclear waste; and noise, visual, and property impacts. (EPRINET, 1994)

personnel, nor a statutory directive to consider such environmental issues. These matters, traditionally and statutorily, have been considered by the DER and not the Public Service Commission. (EPRINET, 1994)

Idaho. The Public Utilities Commission found that the quantification method requires further exploration and environmental externalities be quantified as part of the statewide energy planning process on the basis that insufficient record evidence existed to make an informed decision. The ICC later concluded that the externalities issue requires further study, and that an adversarial approach is appropriate for determining an approach for incorporating externalities into utility planning. (EPRINET, 1994)

Maine. The Public Utilities Commission was directed by legislation to study the extent to which externalities should be included in utility planning. The subsequent Public Utilities Commission report strongly recommended against externality requirements at this time. (EPRINET, 1994)

Michigan. The Public Service Commission seems to concur with its administrative law judge, finding that "implementation of a system to evaluate environmental factors to take into account the differences between combustion and non-combustion resources bids is not appropriate at this time." (Case #U-9586) The administrative law judge also ruled that the Public Service Commission is not authorized to handicap a particular resource. (EPRINET, 1994)

In April 1992, another administrative law judge rejected the consideration of environmental externalities as a requirement on the grounds that the Public Service Commission has no specific legislative mandate to engage in environmental protection activities. The Public Service Commission staff had agreed that the Public Service Commission does have authority to address externalities, and that environmental costs can be estimated. (EPRINET, 1994)

Virginia. Although the Virginia State Corporation Commission indirectly requires utilities to consider environmental externalities, it has stated that the potentially higher rates associated with a resource mix chosen with environmental externalities in mind would be speculative and thus not consistent with its legal authority. The Commission suggests that the environmental externalities are best left to U.S. Congress and the General Assembly of Virginia. (EPRINET, 1994)

Public Service Commission Testimony Regarding Monetization

In an Edison Electric Institute publication (1992), 18 testimonies from Public Service Commissions were summarized with the intent of presenting representative views on the issue of monetizing environmental externalities. Of these testimonies, eight argued against monetization as follows:

A. James Barnes[2] on behalf of Massachusetts Electric Company argued that the monetized values derived by the Tellus Institute and used by the State were based on faulty assumptions. The Tellus Institute used the marginal cost of control as the revealed preference for the cost of environmental externalities (the residual emissions). Barnes argued that existing environmental regulations have resulted in past externalities being internalized; that is, the residual emissions are not of significant value or concern (a value of zero).

Marc Goldsmith[3] on behalf of several Illinois utilities testified that the quality and quantity of available data on environmental impacts are insufficient to justify assignment of monetized values. Another opinion given was that unreliable data or incomplete methods may cause increases in the cost of electricity, but not other energy sources not subject to monetized externalities, which raises competitiveness issues, and increases potential for higher ratepayer costs by biasing supply planning toward higher cost generation.

Alfred Kahn[4] on behalf of Tampa Electric Company testified that there are possible distortions and inefficiencies in imposing additional environmental costs on only selected segments of the energy market that happens to be regulated by the Public Utilities Commission.

Lester Lave[5] on behalf of Western Massachusetts Electric Company testified that the marginal benefit of abatement rather than the marginal cost of control should be used for valuation. According to Lave, the benefits of further abatement are negligible for health for most pollutants in areas where National Ambient Air Quality Standards (NAAQS) are being met (an exception is indirect ozone formation effects). Some small benefits were assigned for visibility and "other." The resulting ranges of externality values are considerably lower (especially the low range value) than most estimates using damage costs or cost of control.

2 Dean, School of Public and Environmental Affairs, Indiana University.

3 President, Energy Research Group, Inc.

4 Special Consultant, National Economic Research Associates.

5 Professor of Economics and Professor of Engineering and Public Policy, Carnegie-Mellon University.

Richard Lester[6] on behalf of the National Independent Energy Producers recommended suspension of Massachusetts' environmental externalities policy until negative environmental, economic, and public policy consequences are addressed. Specifically, he stated that as a policy option, monetized externalities appear to fail in meeting three objectives: (1) efficacy–because emission reductions are not effective since only new resource decisions are affected, (2) cost effectiveness–minimization of mitigation costs are not achieved, and (3) increased costs are passed directly to the consumer. The Massachusetts policy of using externalities only for evaluation of new resources excluded the source of most pollution, the existing power plants. Also, it was asserted that the remaining sulfur dioxide externality was zero and that the cost of control cannot be applied for carbon dioxide since without regulation there was no basis for choosing a control technology. On the topic of fuel switching, it was pointed out that if monetized externalities cause a significant rate increase, the end-use switching to non-electric fuels may result in an increase in pollution. The use of state-imposed regulations to solve regional or global problems may cause competitive disadvantages within the state unless uniform policies are adopted in neighboring states.

Larry Ruff[7] on behalf of Delaware Power and Light Company recommended that the Public Utilities Commission not adopt monetized environmental externalities using a cost of control methodology. He suggested that further study be conducted on society's willingness to pay and that the environmental and regulatory situation in Delaware be reviewed. Ruff argued that a system-wide approach to utilizing existing capacity, not the modification of new resource decisions, is the key to cost-effective emissions reductions. He also contends that an inaccurate estimate of an externality improperly applied can easily be worse than assuming a value of zero. Also, he believes externalities is not a policy that can be applied on a piecemeal basis, if no evaluation of existing capacity or competitive energy resources.

Richard Schmalensee[8] on behalf of Massachusetts Electric Company presented three conclusions regarding the development, application, and role of externality values in IRP: (1) the marginal cost of control used by the Tellus Institute and adopted by the Public Utilities Commission is incorrect in principle; (2) if values are to be calculated, they should be based on non-internalized residual damages and applied only to net incremental emissions after offsets; and (3) in lieu of a piecemeal approach to environmental protection, the Public Utilities Commission should address broader environmental concerns by promoting least-cost control strategies. In regard to conclusion 1, Schmalensee contends that there is no support for the view that Congress or state legislators have "revealed" through their actions that residual damages have the values calculated by Tellus. Concerning the use of residual damages to determine externality values, the values must be applied to all sources, not just electric utilities, to avoid a piecemeal approach to environmental protection. And because residual damages may differ, dependent on the location of emissions, the values from other states or regions should not necessarily be used, should differ with location of each power plant, and should take into account environmental regulations already in place. Schmalensee also argued that an sulfur dioxide externality had no economic meaning in light of the 1990 Clean Air Act and that it would not change the overall level of sulfur dioxide in the U.S. He also said that it made no environmental or economic sense to impose a "large" carbon dioxide emissions value.

Department of Energy comments to the Texas Public Service Commission made the following points: (1) Department of Energy prefers damage-based values since other proxy measures such as the highest marginal cost of control are unlikely to have any relationship to damages. Department of Energy pointed out serious flaws in both the Tellus and Pace University studies and that values from these studies differed by as much as a factor of 16; (2) net system impacts of all alternatives (DSM and generation) should be considered before applying externalities (for example, an alternative with the highest capacity factor will displace more existing generating capacity, and therefore emissions, than an alternative with a lower capacity factor, where the net system impact is the increase in pollution from the new alternative minus the decrease in pollution from existing generation, which will operate less often because of the new alternative); (3) sulfur dioxide will be fully internalized after the year 2000 and should have a value of zero, and it is premature to assign a value to carbon dioxide because of uncertainty in damage costs; and (4) Department of Energy advises against a cost penalty for other criteria pollutants unless it is clear that existing programs have not fully internalized the costs.

6 Professor of Nuclear Engineering and Executive Director of the Commission on Industrial Productivity, Massachusetts Institute of Technology.

7 Director, Putnam, Hayes & Bartlett, Inc.

8 Professor of Economics and Management and Director of the MIT Center for Energy Policy Research, Massachusetts Institute of Technology.

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Energy Vision 2020

5

Volume 2, Technical Document

Load Forecast

Volume 2, Technical Document 5

Load Forecast

Contents

This technical document has two major sections that were originally separate information items. These were the basis for various discussions on load forecast that TVA used to develop Energy Vision 2020.

ENERGY VISION 2020 LOAD FORECAST SUMMARY – 1994

ECONOMIC FORECASTING METHODOLOGY AND VALIDATION

Load Forecast

ENERGY VISION 2020 LOAD FORECAST SUMMARY – 1994

Introduction

Like many utilities, TVA forecasts the long-term energy and peak demand outlook 20 to 25 years into the future. The long-term forecast is developed from individual forecasts of residential, commercial, and industrial sales. These forecasts serve as the basis for planning the TVA power system, budgeting, and financial planning. The Energy Vision 2020 forecast is based on five elements necessary for state-of-the-art forecasting:

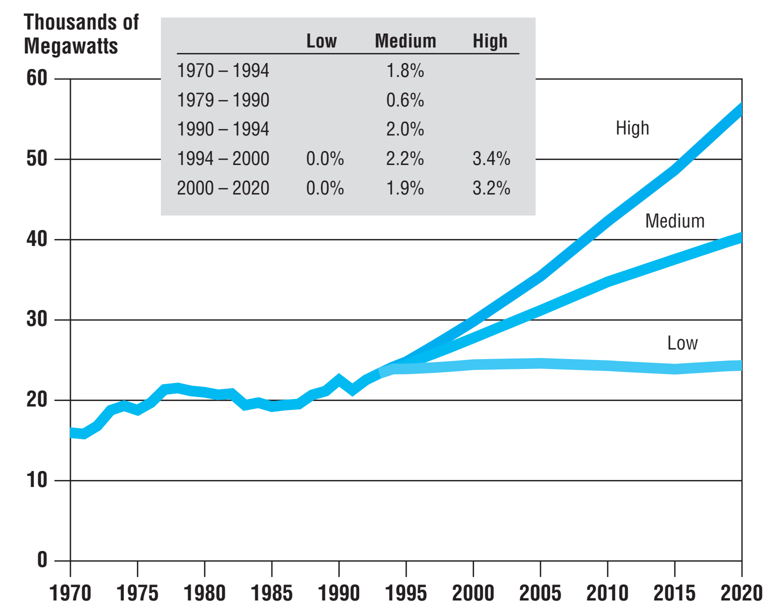
- Accuracy
- Use of best information
- Use of best methods
- Explicit treatment of uncertainty
- Continuous improvement

TVA's system energy forecast is the sum of forecasts by sector. *Figure T5-2* shows the breakdown of the medium forecast into the residential, commercial, and manufacturing sectors. Total energy requirements in 1994 were 35 percent residential, 25 percent commercial, 30 percent manufacturing, and 10 percent other sales and system losses. The commercial and manufacturing sectors are expected to increase faster than residential from 1994 to 2000. From 2000 to 2020, the directly served portion of the manufacturing sector is expected to grow less than the other sectors.

Summary of Results

The range of long-term peak load forecasts developed for Energy Vision 2020 is shown in *Figure T5-1*. For the medium forecast, peak loads are expected to increase 2.2 percent per year from 1994 to 2000 and 1.9 percent per year from 2000 to 2020. Recognizing the uncertainty in forecasting, TVA's high load forecast annual growth is approximately 3.3 percent from 1994 to 2020, and the low forecast is less than 1 percent from 1994 to 2020.

FIGURE T5-1. **System Peak Forecast**



	Low	Medium	High
1970 – 1994		1.8%	
1979 – 1990		0.6%	
1990 – 1994		2.0%	
1994 – 2000	0.0%	2.2%	3.4%
2000 – 2020	0.0%	1.9%	3.2%

Actual and projected growth of system peak needs are shown. High, medium, and low forecasts were developed to address uncertainties in the future. Under the medium forecast, peak demand is projected to be approximately 40,000 megawatts by 2020.

Historical Perspective—Forecast Accuracy

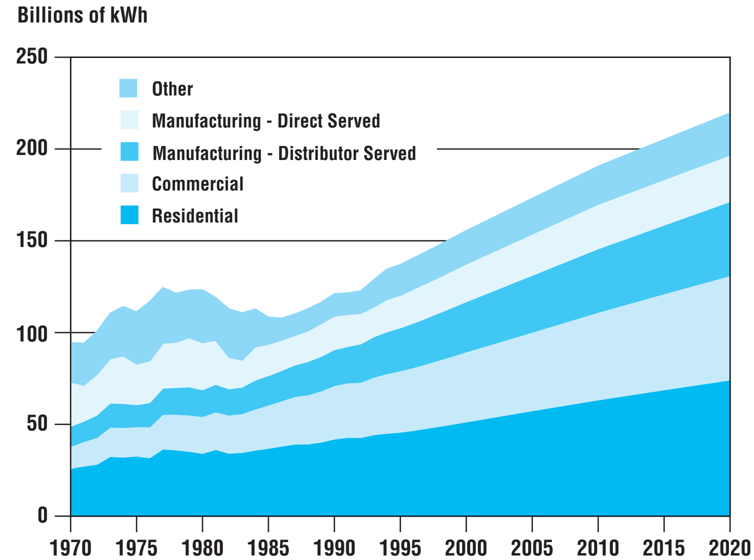
Forecasting is inherently uncertain. However, TVA's load forecast accuracy since 1985 has been within 5 percent (plus or minus) of actual loads, as shown in *Figure T5-3*. This is well within the industry standard of plus or minus 8 percent accuracy. A 1991 review of TVA forecasts by Barakat & Chamberlin, Inc. concluded that: "…on a comparative basis, TVA's forecasting procedures compare very favorably with the best-practice procedures in the United States utility industry."

FORECASTING IN THE 1970S

TVA's load forecasting has changed dramatically over the last 20 years. Until the late 1970s, forecasting at TVA consisted of examining the historical trend of energy sales and projecting future sales based on past growth. These early forecasts were based on a generally stable picture. Underlying factors such as the price of electricity and the economic situation were not considered, causing the forecasts of the 1970s to be very optimistic. TVA's 1970 and 1975 forecasts, shown in *Figure T5-4*, illustrate the error rate for these forecasts.

During and after the oil embargoes of the 1970s, the world economy experienced a long recession and steadily rising energy prices. These changes caused TVA to look to new forecasting techniques that recognized fundamental changes that were taking place in energy costs and patterns of energy use. The old methods were producing large inaccuracies and simply no longer worked.

FIGURE T5-2. **Sales by Customer Class**



ANNUAL INCREASE IN SALES %

	Residential	Commercial	Manufacturing Distributor Served	Manufacturing Direct Served	Other
1970 – 94	2.4%	4.3%	3.2%	-1.5%	-1.7%
1979 – 90	1.6%	3.6%	2.2%	-3.4%	-6.7%
1990 – 94	2.4%	3.0%	4.3%	-2.3%	4.6%
1994 – 00	1.7%	2.5%	2.8%	3.5%	4.0%
2000 – 20	1.9%	2.0%	2.0%	1.1%	1.2%

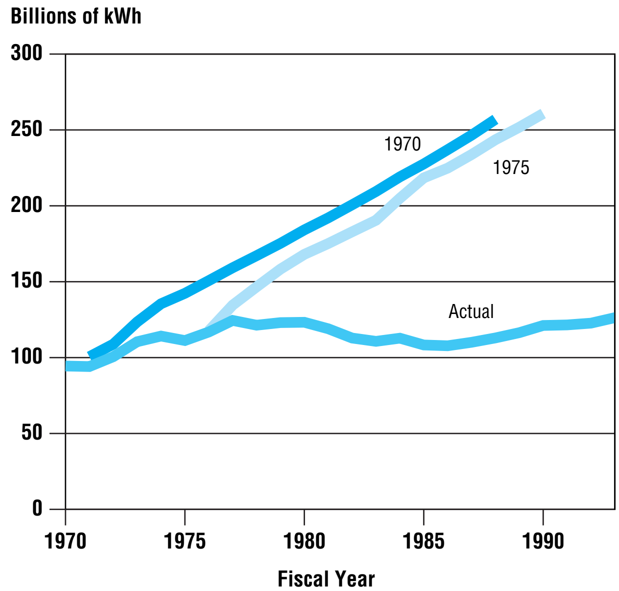
Electricity sales are shown for the customer classes of residential, commercial, and manufacturing. Electricity sales for the manufacturing customer class are divided into sales to industrial customers served by distributors and sales to industries served directly by TVA. The "other" category includes outdoor lighting sales and power sales to other federal agencies.

FIGURE T5-3. **TVA Five-Year Forecast Record**

Year Forecast Prepared	Forecast Target Year	Peak (MW)	Forecast Actual (MW)	Error (Percent)
1983	1988	22,610	20,684	9.3
1984	1989	22,546	21,149	6.6
1985	1990	21,669	21,142	2.5
1986	1991	22,348	21,810	2.5
1987	1992	21,493	22,533	-4.6
1988	1993	23,119	23,354	-1.0
Average Absolute Error				4.4

Since 1985, TVA's load forecast for five years ahead has been within 5 percent (plus or minus) of actual loads.

FIGURE T5-4. **Comparison of Historic Forecasts 1970s – System Energy**



Forecasting techniques used in the 1970s proved to be too optimistic. Earlier forecasts did not explicitly consider uncertainty in prices and economic variables.

FORECASTING IN THE 1980S AND 1990S

New approaches adopted by TVA in the late 1970s included using better quality data in the forecasts, using econometric and end-use models, and making special provisions to deal with uncertainty.

TVA's econometric models link electricity sales to several key factors in the market, such as the price of electricity, the price of natural gas, and growth in economic activity. These models are used to forecast sales growth in the residential and commercial sectors and in each industrial sector.

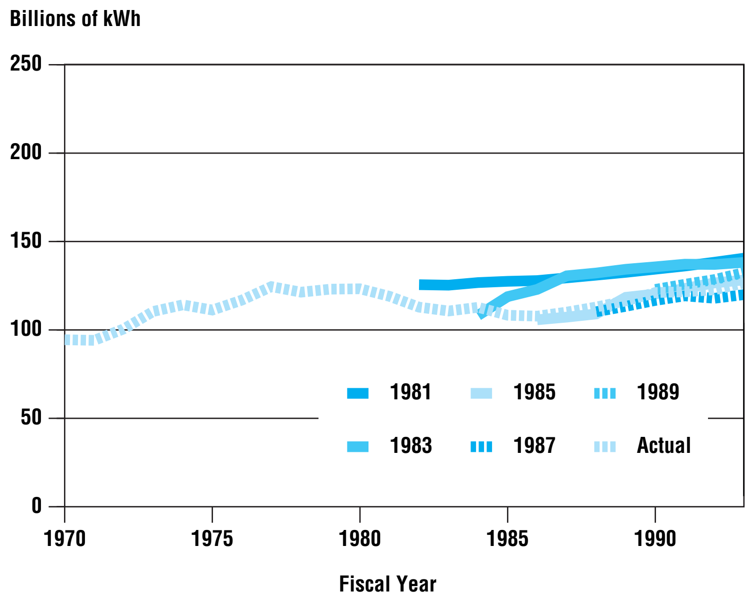
Underlying trends within each sector, such as the use of various types of equipment or processes, also play a major role in forecasting sales. To capture these trends, TVA uses a variety of state-of-the-art end-use forecasting models. For example, in the residential sector, sales are forecast for space heating, air conditioning, water heating, and several other uses. In the commercial sector, a number of end-use categories including lighting, cooling, refrigeration, and space heating are examined.

End-use and econometric models have vastly increased the amount of data used in TVA forecasting. TVA uses a cutting-edge Regional Economic Simulation Model (RESM) to forecast regional economic activity. The regional economic forecasts are based on national economic forecasts provided by DRI/McGraw-Hill.

Forecasts of the price of electricity are provided from TVA's financial modeling. In addition, during the 1980s, TVA began conducting numerous surveys of its residential and business customers. This continuing survey effort provides valuable information on TVA customer market shares, the kinds of electric equipment used, and equipment efficiency. Finally, the inaccurate forecasts of the 1970s demonstrated to utility planners that there is much uncertainty in even the best forecast. In the 1980s, TVA began to deal with this uncertainty by using high and low forecasts to bracket the medium forecast.

Figure T5-5 shows the improved accuracy of TVA forecasts developed in the 1980s. While the 1981 and 1983 forecasts had errors relating to large declines in Department of Energy (DOE) contracts, they are still more accurate than their predecessors. Since 1985—when most of the improvements were fully implemented—every load forecast has been within plus or minus 5 percent accuracy.

FIGURE T5-5. **Comparison of Historic Forecasts 1980s – System Energy**



Forecasting techniques were improved in the 1980s, resulting in a more accurate forecast. Since 1985, TVA's load forecast has been within plus or minus 5 percent accuracy.

Key Variables Affecting the Forecast

Four key variables are used in the load forecasts and in each of the residential, commercial, and industrial sectors.

- Economic activity
- Price of electricity
- TVA's level of competitive success
- Price of substitute fuels

The impact of these variables on the use of electricity is not measured by a single value. Instead, a range of values is developed from which a range of load forecasts is derived. The uncertainties section of this technical document discusses how the range of load forecasts is developed. The key variables are discussed in greater detail below.

ECONOMIC ACTIVITY

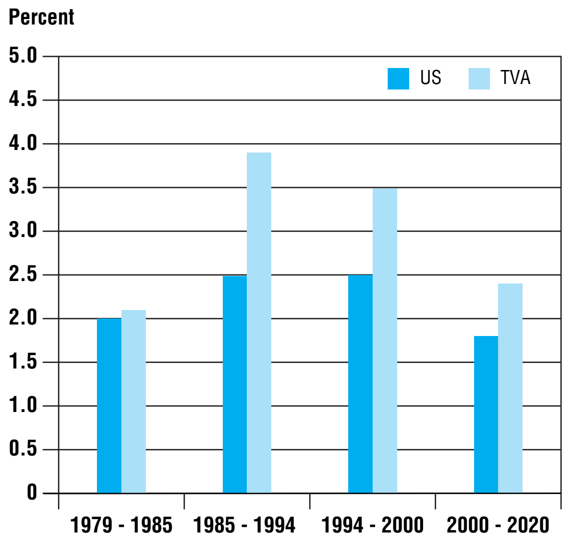
TVA produces its own forecasts of regional economic activity using a Regional Economic Simulation Model (RESM), an econometric model of the TVA region's economy. TVA's forecasts are based on forecasts of the national economy by DRI/McGraw-Hill, an internationally recognized forecasting service. However, RESM does not blindly attribute national trends to the TVA region. Instead, it recognizes differences inherent in the region's economic structure that cause it to perform differently than the United States.

The most likely outlook is for the region to continue to outperform the nation *(Figure T5-6)*. Gross Regional Product (GRP) is forecast to grow 3.5 percent annually from 1994 to 2000 and 2.4 percent from 2000 to 2020, while national Gross Domestic Product (GDP) is expected to grow at 2.5 and 1.8 percent for the respective periods. This compares favorably with the historical performance of GRP and GDP shown in *Figure T5-6*.

The region's economy is expected to grow faster than the rest of the nation's, largely due to the region's advantages in manufacturing. In 1994, about 29 percent of total product in the region was in manufacturing, as opposed to 19 percent for the United States. Manufacturing's predominance in the regional economy is due to several factors:

- A location in the South between the markets of the Northeast, Midwest, Southwest, and Florida
- A good transportation system allowing goods to be shipped to these markets by interstate, rail, and barge
- A good, low wage (for the United States) workforce
- Relatively low-cost, abundant resources including water, electricity, and land

FIGURE T5-6. **Gross Product Comparison – TVA vs. U.S. Average Annual Growth Rates**



This figure shows the most likely outlook is for the Tennessee Valley to continue to outperform the nation. This is largely due to the region's advantages in manufacturing. Manufacturing output in the Tennessee Valley is expected to surpass national average growth rates, continuing the trend since 1985.

Because of these advantages, the regional economic model forecasts manufacturing in the region to outperform manufacturing in the United States, continuing the trend since 1985. Before 1985, manufacturing was adversely affected by exceptionally high oil and energy prices, high interest rates, and the high value of the dollar compared to other currencies. These factors have returned to relatively low levels and are expected to remain relatively low in the future. Given the region's dependence on manufacturing, this sets up favorable conditions for the region's economic growth.

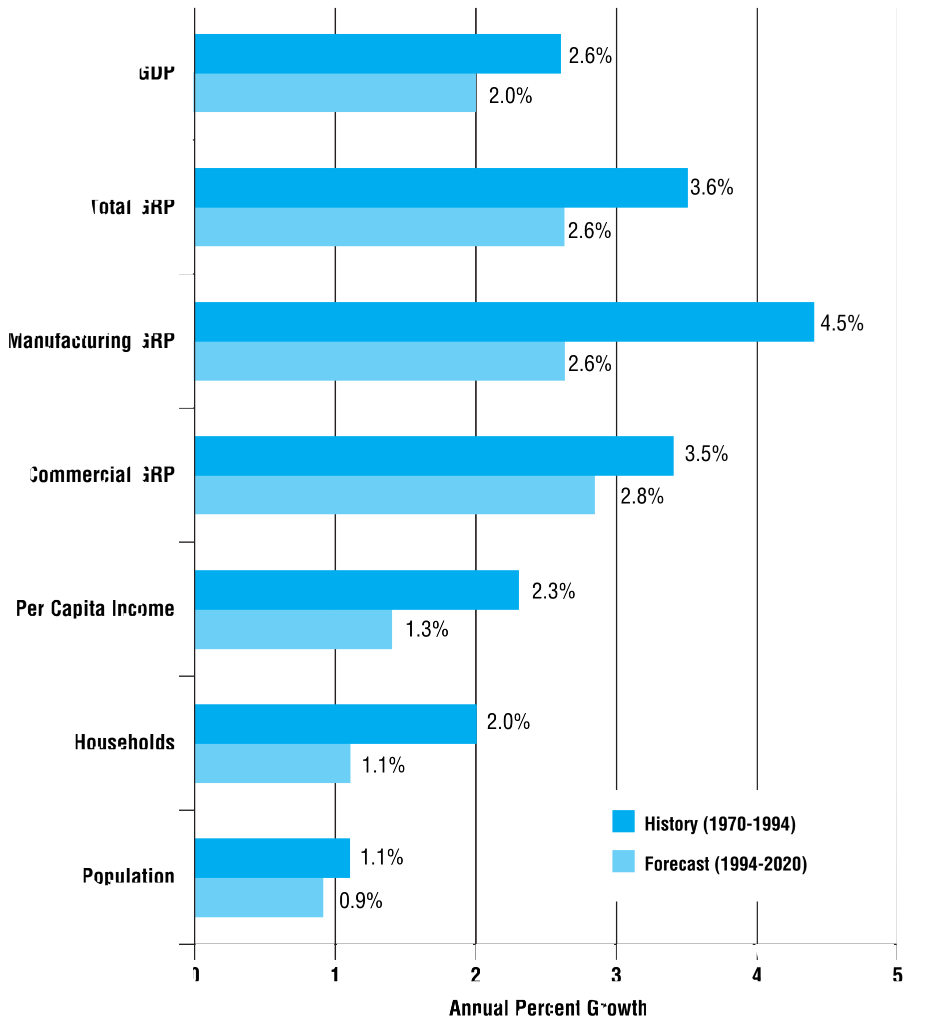
Within the manufacturing sector of the regional economy, several industries are showing favorable growth trends. Durable goods production has expanded while, at the same time, nondurables have held up better than in the rest of the United States. Although there are several examples of newer durable industries growing in the TVA region, such as machinery and furniture, the prime example is motor vehicles. Employment in the motor vehicle industry has grown much faster in the region than the nation, with considerable potential for continuing expansion.

Over the rest of the decade, the region's performance is expected to be similar to that of the 1985-1994 period as newer manufacturing industries continue to expand and national economic conditions remain favorable. Beyond the year 2000, manufacturing is expected to continue to provide enough impetus for the region to expand at a somewhat faster rate than the United States, but the region's growth is expected to be slower than before 2000 as the region's newer manufacturing industries reach maturity. The region does not have particular advantages in the commercial sector as it does for manufacturing. Thus, with the slowing of manufacturing growth, the overall regional economy is expected to grow at a rate closer to the nation's economic growth.

From the economic forecast, several variables are used as drivers to the load forecasts. For the residential sector, population, households, and per capita income drive the load forecast in the Valley. For the commercial and industrial sector, output or Gross Regional Product are key drivers. The historical and predicted growth rates for the medium forecast of the economic variables are shown in *Figure T5-7*.

To account for uncertainty, high and low regional economic forecasts are derived by using corresponding national forecasts and the TVA low and high electricity price forecasts. In addition,

FIGURE T5-7. **Economic Outlook – History and Forecast**



Economic forecasts for the TVA region are developed as part of the load forecast process. Historical and predicted growth rates for economic variables are shown for the medium regional economic forecast. Economic growth is expected to slow from the 1970-1994 rates.

explicit assumptions are made concerning national and international developments. The high scenario assumes that the region will develop a commercial sector that more closely matches that of the nation. On the other hand, the low scenario assumes that the Valley is more affected by foreign competition and that the commercial sector does not develop further.

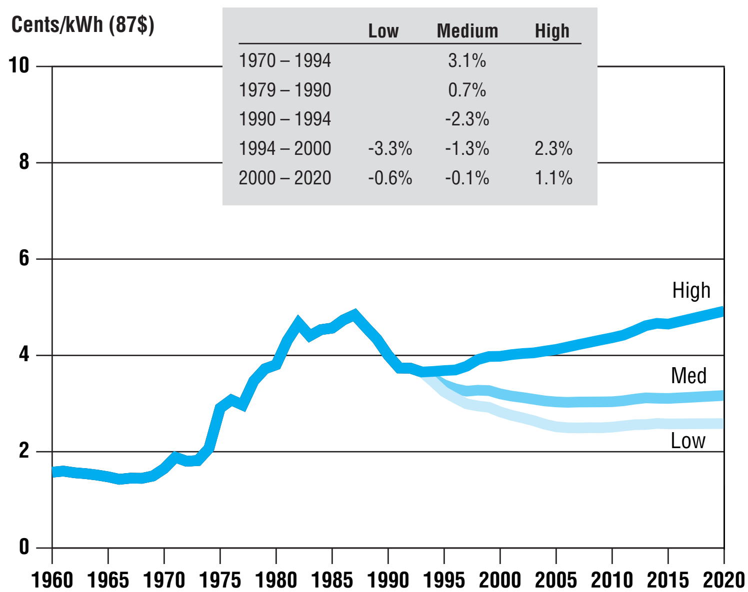
Additional information on the economic forecasts is available from TVA in a report titled "Economic Outlook."

PRICE OF ELECTRICITY

TVA has not increased electricity prices since 1987 and is committed to no rate increases through 1997. This has been achieved through a combination of efforts including controlling costs, refinancing debt, and efficiency improvements. Holding rates constant is expected to continue to have a positive impact on electricity sales.

The real wholesale price of electricity (excluding inflation) is expected to decline 1.3 percent per year from 1994 to 2000 and decline further at 0.1 percent per year from 2000 to 2020 as shown in the medium forecast in *Figure T5-8*. For the low

FIGURE T5-8. **Wholesale Price of Electricity**



	Low	Medium	High
1970 – 1994		3.1%	
1979 – 1990		0.7%	
1990 – 1994		-2.3%	
1994 – 2000	-3.3%	-1.3%	2.3%
2000 – 2020	-0.6%	-0.1%	1.1%

The wholesale price of electricity without inflation is expected to decline through 2020 under the low and medium forecasts.

forecast, the price of electricity will decrease by 3.3 percent per year from 1994 to 2000 and 0.6 percent per year from 2000 to 2020. For the high forecast, the price of electricity will grow at 2.3 percent per year from 1994 to 2000 and 1.1 percent per year from 2000 to 2020.

Forecasts of the price of electricity are based on estimates of the total revenue required to operate and maintain the power system. Forecasts of total revenue requirements are based on estimates of key costs such as fuel, operations and maintenance, depreciation, and interest costs. Therefore, the high and low electric price forecasts are derived from variations in the same factors: fuel, operations and maintenance, depreciation, and interest costs.

TVA'S LEVEL OF COMPETITIVE SUCCESS

In recent years, the electric utility industry has undergone a fundamental change. The world of regulated monopoly is being replaced by a world of competitive pressures. Wholesale open access (the right of wholesale customers to buy power from generating utilities other than the one whose lines serve them) can be mandated by the Federal Energy Regulatory Commission (FERC). Retail firms, such as large industrial customers, are looking for the same privilege, and retail open access is beginning to be mandated by some state regulatory bodies. In a more competitive market, TVA's success as a generating company will be greatly affected by whether TVA is successful in being a low-cost producer.

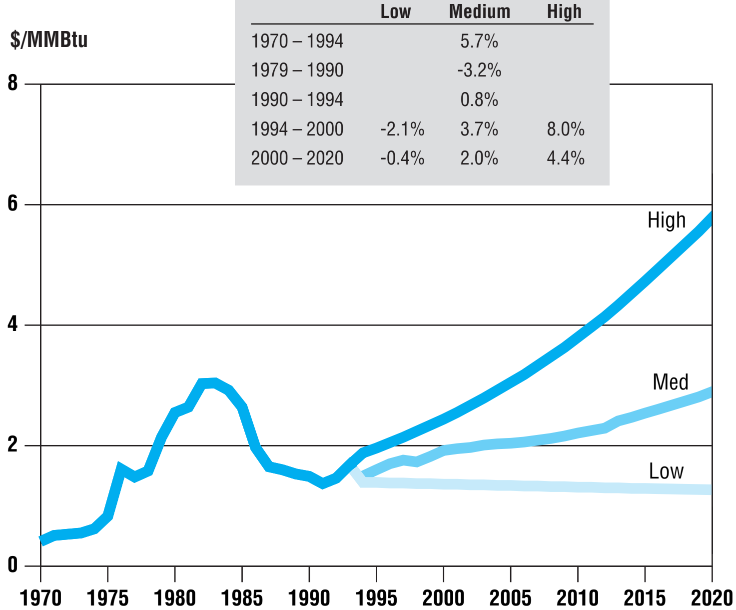
TVA has incorporated different competitive scenarios into its forecasts. In the medium forecast, TVA's price of electricity is expected to remain competitive with other utilities. Market and regulatory changes would have less impact in the medium case than in the high or low cases. As a result, the net impact of competition in the medium forecast is that TVA will retain its current customers.

The prospect of increasingly competitive markets increases the uncertainty in the forecast. If TVA operates at lower costs than the competition and regulations permit, TVA may have opportunities to gain customers. This is termed high competitive success. Likewise, if TVA is a higher cost producer than its competitors, it is likely to lose customers—described as low competitive success. Both cases assume that deregulation of the electric market continues. The high and low forecasts recognize the risks and opportunities of increased competition.

TVA analyzed competitive impacts for all sales. The effort was aimed at looking at the market rather than specific customers. In the low competitive success case, TVA will lose customers to competing electric utilities. In order to estimate the potential for losing sales to competition, TVA's customer survey—complet-

FIGURE T5-9. **Natural Gas Acquisition Price**

	Low	Medium	High
1970 – 1994		5.7%	
1979 – 1990		-3.2%	
1990 – 1994		0.8%	
1994 – 2000	-2.1%	3.7%	8.0%
2000 – 2020	-0.4%	2.0%	4.4%



Natural gas prices without inflation are expected to increase 3.7 percent annually through 2000 and 2 percent per year from 2000 to 2020 under the medium forecast.

ed by many of TVA's distributors and directly served customers—was used to identify the amount of load that appeared to be at high risk.

In the high competitive success case, TVA will gain customers from its competition. To estimate the potential for this gain in the wholesale markets, loads of municipal and cooperative distributors in neighboring regions were used. The chance of gaining any distributor was partly influenced by the wholesale price paid by that distributor. Because a very large percentage of TVA's sales are wholesale compared to neighboring utilities, the potential gain in the wholesale market in the high competitive success case was smaller than the potential loss in the low competitive success case.

For directly served customers, less specific information on nearby opportunities was available. Because TVA is surrounded by states with large industrial loads, a judgment was made that potential gain is higher than potential loss of industrial loads.

Wholesale and retail gains in load were assigned the highest probability for the low electric price forecast, making TVA more competitive. A more complete discussion of all uncertainties in the forecast can be found in the uncertainty section.

PRICE OF SUBSTITUTE FUELS

The potential for substitution between electricity and fossil fuels, primarily oil and natural gas, will depend on relative prices and technological factors. Changes in the TVA price of electricity compared to the price of natural gas and other fuels will influence consumers' choices of appliances—either electric, gas, or other fuels. While other substitutions are possible, natural gas prices are the benchmark for determining substitution impacts in the load forecasts.

In preparing the medium natural gas price forecast, TVA relied on forecasts by Energy Ventures Analysis, Inc., Jofree Corporation, and ICF Resources. The forecast for natural gas prices is higher than for electricity. Natural gas prices in real terms are forecast to increase at 3.7 percent from 1994 to 2000 and at 2.0 percent from 2000 to 2020 as shown in *Figure T5-9*.

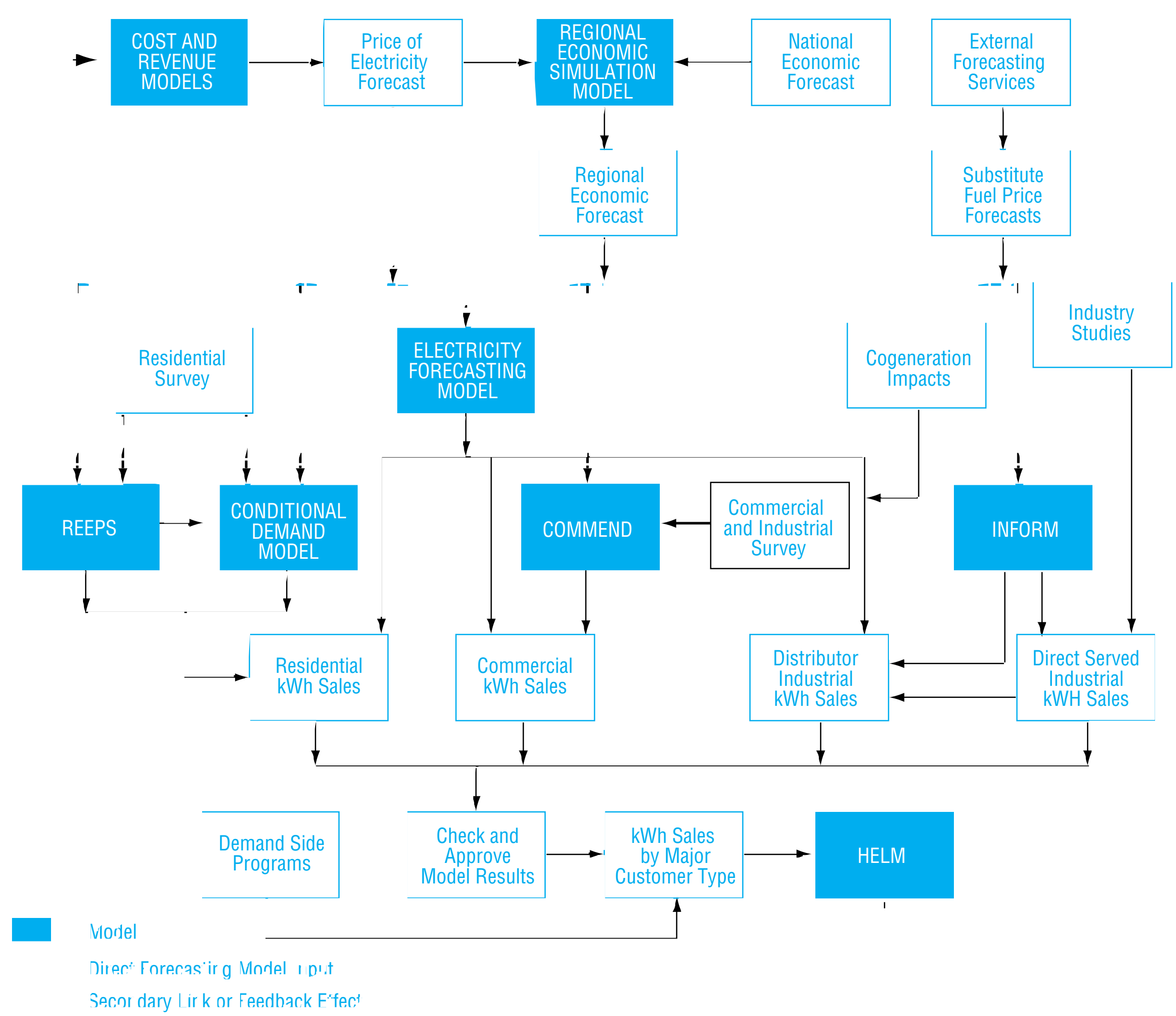
The high and low forecasts for gas prices were derived using several nationally recognized forecasters such as Gas Research Institute, American Gas Association, DRI/McGraw-Hill, and the Energy Information Administration. The high forecast is for growth rates of 8.0 percent per year from 1994 to 2000 and 4.4 percent per year from 2000 to 2020. The low is for -2.1 percent per year and -0.4 percent per year over the same periods.

TVA Uses the Best Methods Available

TVA stays abreast of issues and procedures relating to energy forecasting and continually incorporates new information into its forecasting process. The use of multiple forecasting models makes it possible to avoid blind spots that could result with a single model. At TVA, several advanced forecasting models and techniques have been incorporated to form a complete forecasting system from data collection to evaluation of forecast uncertainties. To deal with uncertainty, the forecast does not rely on a single estimate, but provides decision-makers with a range of forecasts. An overview of the TVA forecasting process is shown in *Figure T5-10*.

The system forecast is built up from its major sectors: residential, commercial, and industrial. The outputs of several models for each sector are systematically compared, and trends

FIGURE T5-10. **Overview of TVA's Load Forecasting Process**



The load forecasting process is illustrated by this flow chart which shows how information is gathered and evaluated to form the basis of the forecast. Multiple models or computer simulations are used to ensure that all possibilities and impacts are considered.

in key parameters, such as saturation rates and unit energy consumption, are examined.

Large customers that have significant electricity requirements are analyzed individually. In addition, each major industry group, such as paper or machinery, is reviewed annually for changes in technology, finances, competitive structure, etc. Ranges of values for key variables are developed in order to measure the varying impacts on TVA sales.

Econometric modeling is used extensively. The strengths of this approach include the explicit estimation of the historical response of electricity consumption to electricity prices, natural gas prices, and income. Each of TVA's primary customer sectors is considered individually in the models to allow for changing shares of energy use.

End-use models are used to measure how much energy consumption will occur from given end uses such as residential air conditioners, office lighting, and industrial motors. These models can reflect how energy use is changing within sectors. While econometric models are tied to historical data, end-use models allow forecasters to incorporate expected future events

such as the introduction of mandated efficiency standards or the arrival of new technologies.

Conditional demand and qualitative choice analysis is a hybrid of econometric and end-use modeling. TVA uses this analysis in the residential sector and is developing a commercial conditional demand model. This analysis is useful in estimating the relationship between electricity consumption and demographic characteristics. These models incorporate the best of econometric and end-use models and allow for a more detailed analysis of each sector.

Best methods available include the following models, which are used in the Energy Vision 2020 forecast:

- Residential Conditional Demand Model (RCDM)
- Residential Energy End-Use Planning System (REEPS)
- Electricity Forecasting Model (EFM)
- Commercial Energy End-Use Model (COMMEND)
- Industrial Energy End-Use Model (INFORM)
- Regional Economic Simulation Model (RESM)
- Financial Model used in price of electricity (FINESSE)
- Hourly Electric Load Model (HELM)

RESIDENTIAL SECTOR FORECASTING MODELS

Residential Conditional Demand Model (RCDM)

This model is based on econometric analysis of data from TVA's residential surveys, which is used to estimate unit energy consumption of major appliances, along with price and income elasticities. This allows individual components of the residential model to be forecast. The estimates of unit energy consumption are used in conjunction with saturation forecasts by appliance types to produce forecasts of total residential sector electricity use. The estimates of unit energy consumption are also used in calibrating Residential Energy End-Use Planning System (REEPS), using TVA service territory data.

Residential Energy End-Use Planning System (REEPS)

REEPS is an end-use econometric model of electricity consumption developed with the Electric Power Research Institute (EPRI). REEPS forecasts residential energy consumption by end-use, fuel type, and market segment in order to forecast market potential and saturation of residential end uses by fuel type and market segment. This model also analyzes the impacts of mandated or utility-sponsored demand-side management programs. REEPS generates aggregate forecasts for the entire residential sector by calculating a weighted sum of all residential market segments. Thus, TVA can evaluate forecast impacts on each market segment, rather than simply assessing behavior of the "average" household.

Electricity Forecasting Model (EFM)

This is an aggregate time series econometric model. For the residential sector, consumption per customer is the major variable. The independent variables are average real price of electricity, average real price of natural gas, and real annual per capita income. By multiplying sales per customer by the projected number of residential customers, a forecast for the total sector is derived.

COMMERCIAL SECTOR FORECASTING MODELS

Commercial Energy End-Use Model (COMMEND)

COMMEND, widely used by utilities and regulatory agencies, was developed by Electric Power Research Institute. It forecasts energy consumption by building types and end uses. COMMEND allows its user to assess the impacts of energy price changes, technology, efficiencies, and economic growth. It also identifies and evaluates demand-side management opportunities. The model allows up to 20 building types to be addressed, each with a variety of end uses.

Electricity Forecasting Model (EFM)

EFM is an econometric forecasting model for the commercial sector. EFM divides the commercial sector into six subsectors—(1) regulated industries, (2) wholesale/retail trade, (3) finance/insurance and real estate, (4) service, (5) government, and (6) unclassified. Electricity demand is derived for each sector based on Gross Regional Product, employment, the real price of electricity, and the real price of natural gas.

INDUSTRIAL SECTOR FORECASTING MODELS

Industrial Energy End-Use Model (INFORM)

INFORM is an industrial end-use model developed by the Electric Power Research Institute. TVA began using this model in 1992. The model categorizes energy sales by subsector and end use.

Electricity Forecasting Model (EFM)

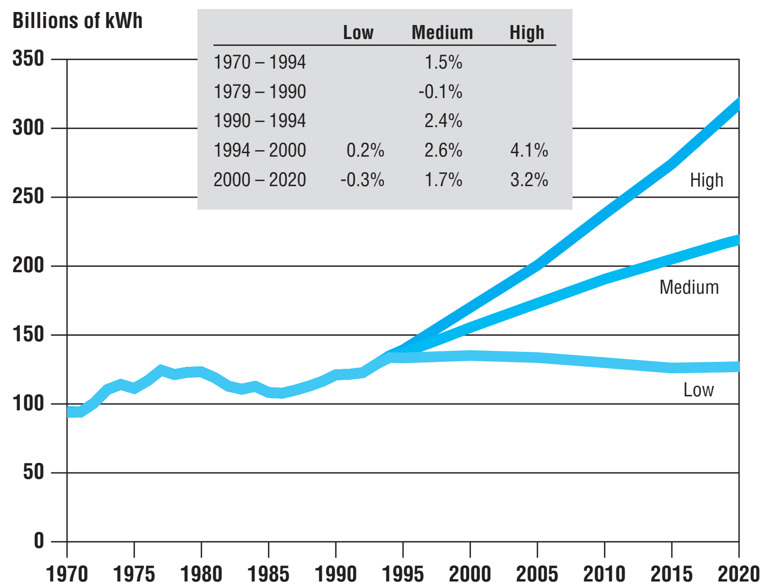
EFM is an econometric forecasting model for the industrial sector. It is divided into subsectors for food, machinery, paper, textiles, chemicals, primary metals, other nondurable goods, and other durable goods. The dependent variable is energy use, and the independent variables are Gross Regional Product, employment, the real price of electricity, and the real price of natural gas.

OTHER FORECASTING MODELS

Regional Economic Simulation Model (RESM)

RESM is an econometric model of the TVA region that maps out the regional economy with its major linkages and feedbacks and its relations to the United States economy. This model uses state-of-the-art methods comparable to those of the major nation-

FIGURE T5-11. **System Energy Requirements**



Actual and projected growth of electricity needs are shown. High, medium, and low forecasts were developed to reflect future uncertainty. Energy requirements are projected to be 219.7 billion kilowatt-hours by 2020 under the medium forecast.

Financial Model (FINESSE)

This model, developed in-house by TVA, estimates TVA's total revenue requirements over time. The forecast of revenue requirements is based on forecasts of the individual cost components. These cost components include the load forecast, capital costs, additions and improvements (A&I) costs, interest rates, fuel costs, and operating and maintenance (O&M) costs.

Hourly Electric Load Model (HELM)

HELM was developed in partnership with TVA, Electric Power Research Institute, and ICF Resources during the early 1980s. It produces an hourly load or peak load forecast based on forecasts of energy consumption. HELM analyzes the load-shape impacts of many changing conditions, including conservation and load management programs, rate design alternatives, market penetrations of new electricity-using technologies, changes in the mix of customers or end uses, and alternative weather conditions.

al forecasters. Several professional papers have been presented on the model including presentations at the Electric Power Research Institute (EPRI) forecasting conference in 1991.

The two major inputs, or key assumptions, to RESM are the national economic forecast from DRI/McGraw-Hill and industrial electricity prices.

RESM is a highly disaggregated model which uses two-digit standard industrial classification (SIC) detail. With regard to the manufacturing sector, there are equations for chemicals, apparel, primary metals, etc. For the commercial sector there are equations for eating and drinking establishments, health services, hotels, etc. This allows for linkages between industries—for instance, wholesale trade is linked to retail trade.

RESM does not simply capture trends, but rather, it captures the differences inherent in the regional economic structure that leads the region to perform differently than the nation as a whole.

Further details on the forecast methodology and accuracy may be found in "Economic Forecasting Methodology and Validation" included in this document.

Load Forecast Results

The medium forecast for total system energy for Energy Vision 2020 is 155.5 billion kilowatt-hours in 2000 and 219.6 billion kilowatt-hours in 2020, as shown in *Figure T5-11*. The medium load forecast is based on the medium forecasts of all the variables discussed in the previous section. The medium forecast assumes the TVA region will experience moderate economic growth of 2.7 percent annually through 2020. It assumes that TVA can maintain its "no rate increase" policy through 1997 and thereafter maintain competitive rates. It is also assumed TVA is able to successfully defend its current market if a less-regulated and more competitive marketplace develops, as expected. Finally, the medium forecast assumes any inroads made by natural gas are not severe, due to TVA's ability to maintain its price versus the price of natural gas.

The Energy Vision 2020 high load forecast is for 170 billion kilowatt-hours in 2000, 238 billion kilowatt-hours in 2010, and 317.5 billion kilowatt-hours in 2020. The primary factor influencing the high load forecast is high economic growth. Competitive success and continued relatively low electric prices also contribute to TVA's success in the high forecast. The

Energy Vision 2020 low load forecast is for 135.1 billion kilowatt-hours in 2000, 129.9 billion kilowatt-hours in 2010, and 126.3 billion kilowatt-hours in 2020, with growth generally less than 1 percent. Low annual economic growth is a major influence in the low load forecast. The low economic scenario can be summarized as follows: the recovery falters and, in the long term, the United States and the TVA region become less competitive globally, interest rates become unstable, and inflation rises. In short, the TVA region has manufacturing output growth of 0.2 percent and commercial output growth of 1.3 percent through 2020.

RESIDENTIAL SECTOR FORECAST

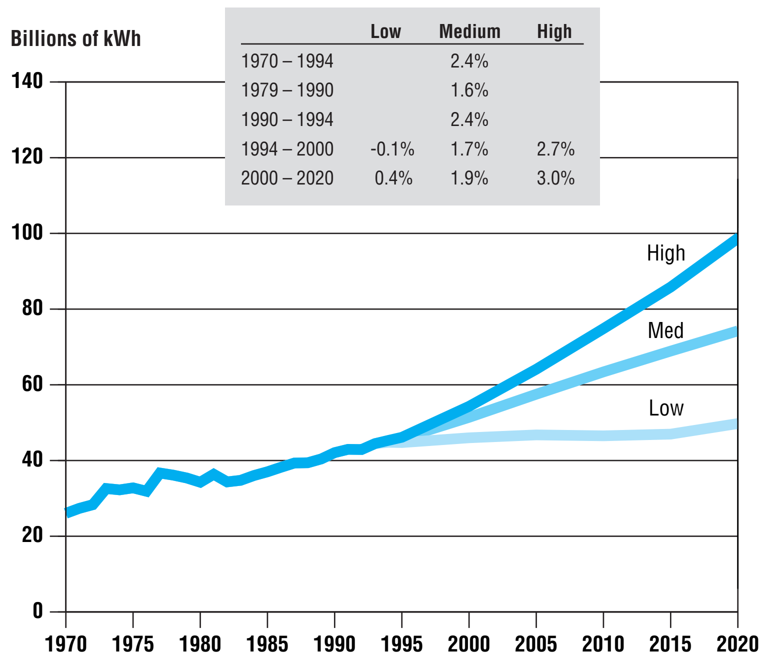
Long-term sales forecasts for the residential customer sector are shown in *Figure T5-12*. In the medium forecast, residential sales are forecast to be 51.4 billion kilowatt-hours in 2000, 63.4 billion kilowatt-hours in 2010, and 74.3 billion kilowatt-hours in 2020. Corresponding growth rates are 1.7 percent per year from 1994 to 2000 and 1.9 percent per year from 2000 to 2020. For the high residential sales forecast, the percent per year growth is 2.7 percent from 1994 to 2000 and 3.0 percent from 2000 to 2020. The low forecast is -0.1 percent from 1994 to 2000 and 0.4 percent from 2000 to 2020.

The residential forecasts are influenced by six factors: per capita income, population, residential electric prices, residential gas prices, household types, and efficiencies, as shown in *Figure T5-13*.

Residential End-Use Energy Forecast

The residential forecast is developed from forecasts of end uses of electricity. Major end uses include space heating, space cooling, water heating, refrigerators, freezers, and cooking. The share of residential electricity sales attributable to each of these end uses and miscellaneous use is shown in *Figure T5-14*. The largest increase in the share of total residential electricity use is for the "other" category, which moves from 31.5 percent to 41.1 percent. The miscellaneous category includes a number of appliances, such as dishwashers,

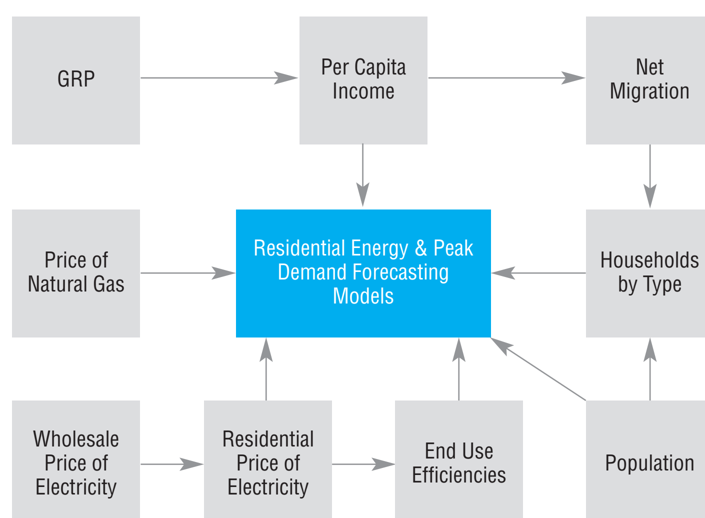
FIGURE T5-12. **Total Residential Sales**



	Low	Medium	High
1970 – 1994		2.4%	
1979 – 1990		1.6%	
1990 – 1994		2.4%	
1994 – 2000	-0.1%	1.7%	2.7%
2000 – 2020	0.4%	1.9%	3.0%

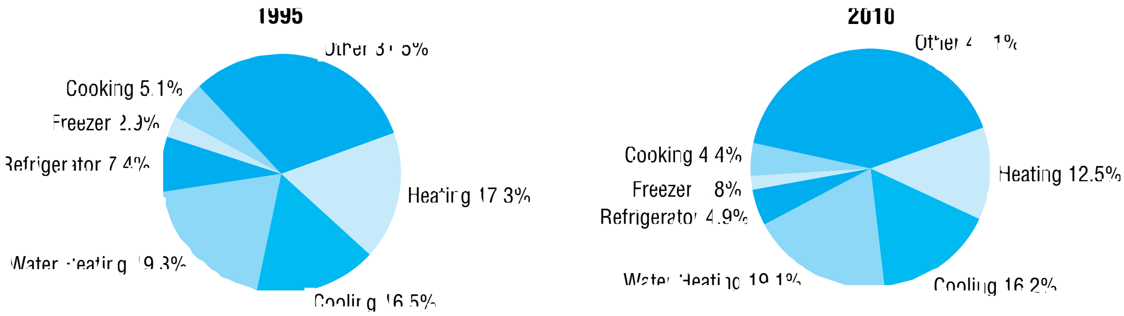
Residential sales are expected to increase to 74.3 billion kilowatt-hours by 2020 under the medium forecast.

FIGURE T5-13. **Residential Sector Influence Diagram**



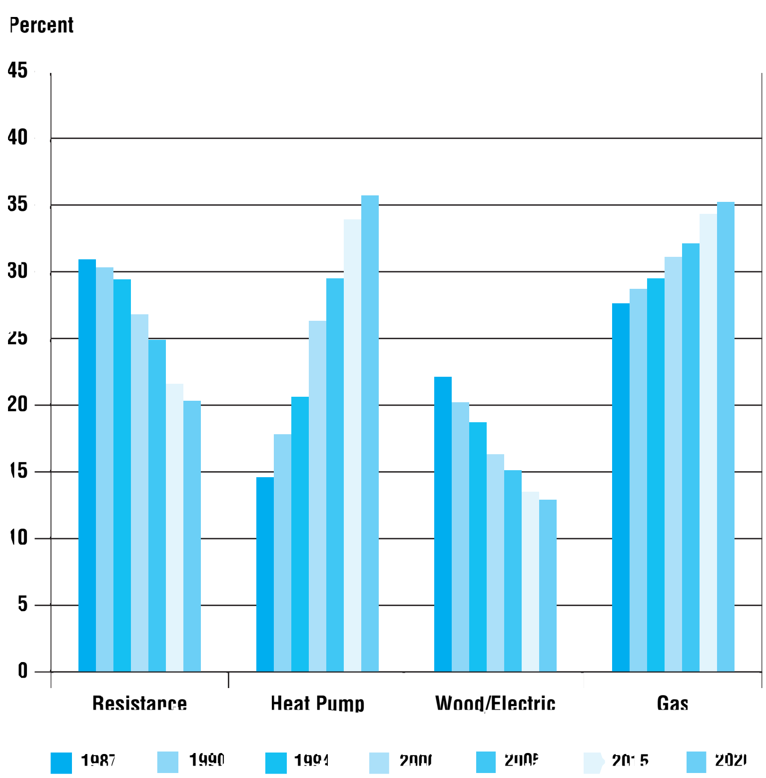
Residential forecasts are influenced by six factors: per capita income, population, residential electric prices, residential gas prices, household types, and efficiencies.

FIGURE T5-14. **Percent of Residential Sales by End Use**



TVA anticipates changes in the way residential consumers use electricity through 2010. The largest increase in the share of total residential electricity use is for the "other" category. The largest decrease in the share of total residential electricity use is for the heating category.

FIGURE T5-15. **Residential Space Heating Saturations**



Electric heat pumps and natural gas heating units are expected to continue to gain favor with consumers at the expense of resistance electric heating and wood-burning stoves.

clothes washers, clothes dryers, and the increasing use of electronic equipment in the home, for which room for growth remains as incomes increase. The heating share drops the most as total heating energy rises only slightly over the forecast period.

Residential Saturations

Major factors in the changing end-use energy forecasts are changes in the saturation of appliances. Saturation is defined as the percentage of total households that have a particular appliance. In the long term, consumers switch to more efficient end-use appliances, as well as those using fuels that are declining relatively in price. Changes in space heating saturations are shown in *Figure T5-15*. Heat pumps are substituted for resistance heat, especially in areas where natural gas is not available. Heat pumps increase in saturation from 21 percent of total households in 1994 to 26 percent in 2000 and 36 percent in 2020. These heat pumps provide both heating and cooling. Electric resistance space heat declines from 29 percent in 1994 to 27 percent in 2000 and 20 percent in 2020. Natural gas used for space heating increases from 30 percent in 1994 to 31 percent in 2000 and 35 percent in 2020. Electric backup for wood heat is expected to decline due to the decline in wood as a primary heating fuel. The gains by

both heat pumps and gas furnaces are at the expense of the dwindling wood heat market and declining resistance heat.

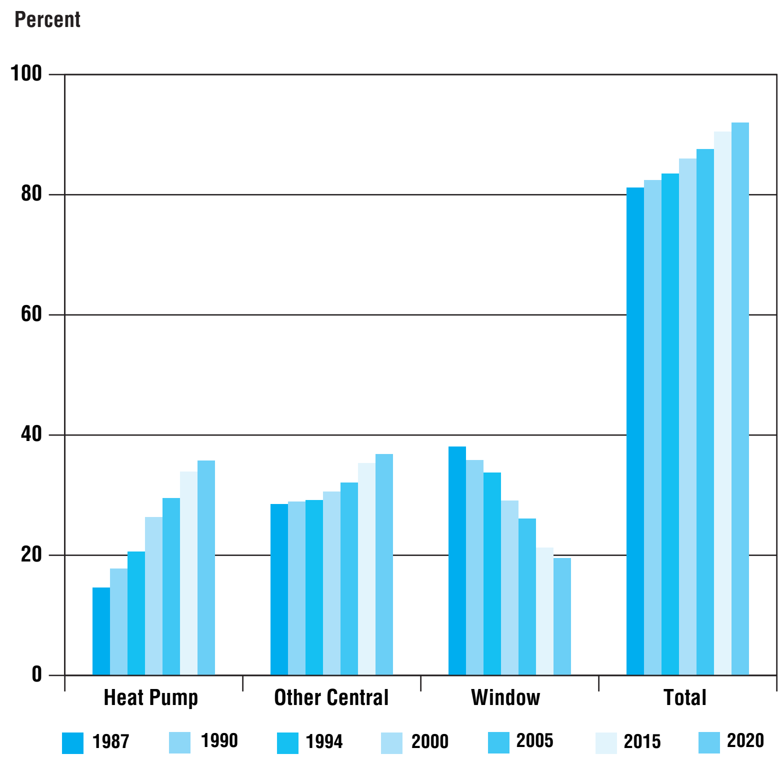
Central air conditioning other than heat pumps increases from 29 percent in 1994 to 31 percent in 2000 and 37 percent in 2020, as shown in *Figure T5-16*. Window air conditioning saturation drops from 33 percent to 20 percent by 2020. Total air conditioning saturation increases from 84 percent in 1994 to 92 percent by 2020.

Residential water heating is dominated by electricity. The saturation of electric resistance water heating decreases slightly from 77 to 75 percent. Natural gas water heating saturation increases moderately from 22 to 25 percent over the same period. Declining electricity prices support the electric water heating market share in spite of increasing competition from natural gas.

Residential Efficiency Improvements

Another major factor in changing end-use energy forecasts is improvement in efficiency of the appliances. These improvements reduce the amount of fuel needed to provide a given level of service. As a result, forecasts of efficiency improvements will reduce the forecast of electricity sales. End-use efficiency improvements for the residential customer class are shown in *Figure T5-17*. The efficiency improvements are in terms of the percentage reduction in energy use by the years 2000 and 2020. For example, heat pump efficiency increases by 12 percent over current levels by 2020, air conditioning efficiency increases by 11.2 percent, and water heating decreases by 7 percent. Efficiency improvements estimates incorporate requirements of the Energy Policy Act of 1992.

FIGURE T5-16. **Residential Space Cooling Saturations**



Air conditioning saturation is projected to increase to 92 percent by 2020.

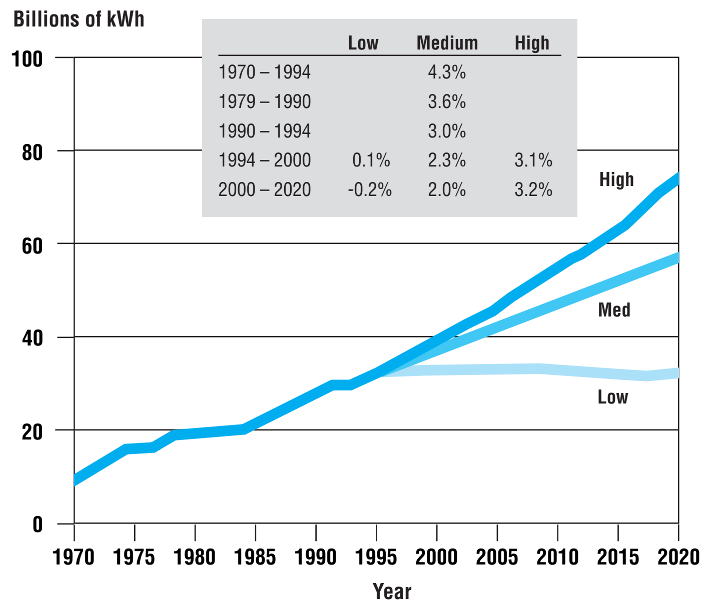
FIGURE T5-17. **Residential Efficiency Improvements 1995–2020**

Water Heating	-7.0%
Resistance Heating	0.0%
Central Air Conditioning	11.2%
Heat Pump Heating	12.0%
Heat Pump Cooling	13.6%
Freezer	20.2%
Refrigeration	59.4%

Total Residential Improvements 7.2%

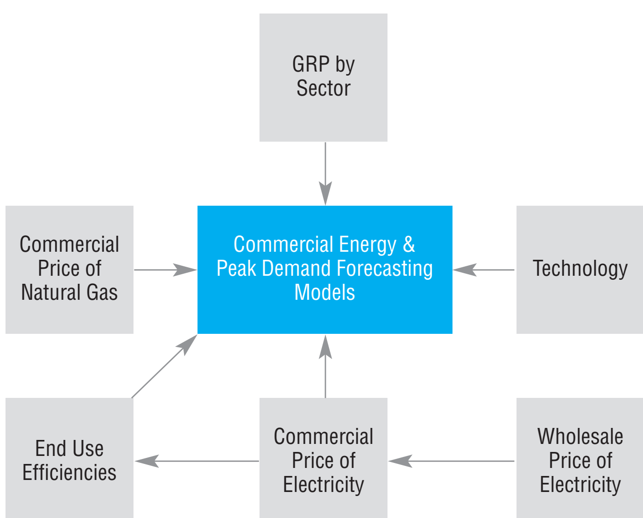
Efficiency improvements in home appliances and heating and cooling equipment will affect future load by reducing the amount of energy needed to provide a given level of service. Because direct electric heating is 100 percent efficient, little opportunity exists for efficiency improvements in water heating and resistance heating. The declining efficiency for water heating is a result of consumers becoming less concerned with the insulation levels of their water heaters as electricity prices fall.

FIGURE T5-18. **Total Commercial Sales**



Commercial sales are expected to be 56.9 billion kilowatt-hours in 2020 for the medium forecast.

FIGURE T5-19. **Commercial Sector Influence Diagram**



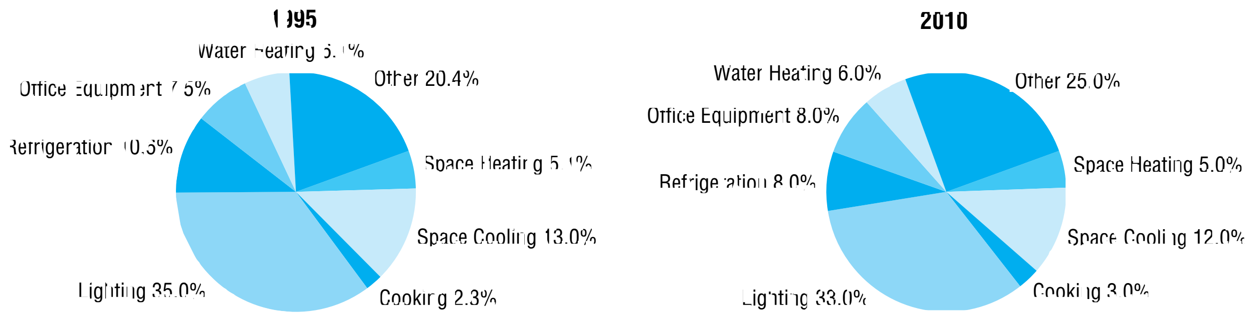
The commercial sector sales forecast is driven by economic activity (in terms of GRP by sector), the price of electricity, the price of competing fuels, efficiency improvements, and technology.

COMMERCIAL SECTOR FORECAST

Long-term sales forecasts for the commercial sector are shown in *Figure T5-18*. In the medium forecast, commercial kilowatt-hours sales are expected to be 38.2 billion kilowatt-hours in 2000 and 56.9 billion kilowatt-hours in 2020. Corresponding growth rates are 2.3 percent per year from 1994 to 2000 and 2.0 percent per year from 2000 to 2020. For the high commercial sales forecast, the growth rates are 3.1 percent from 1994 to 2000 and 3.2 percent from 2000 to 2020. The corresponding sales growth in the low forecast is 0.1 percent from 1994 to 2000 and -0.2 percent from 2000 to 2020.

The commercial sector sales forecast is driven by economic activity, the price of electricity, the price of competing fuels, efficiency improvements, and technology, as indicated in *Figure T5-19*.

FIGURE T5-20. **Percent of Commercial Sales by End Use**



Commercial sales for cooking, office equipment, and miscellaneous uses are expected to increase through the next 15 years.

Commercial End-Use Energy Forecasts

In the commercial sector, the major end uses are space cooling, lighting, space heating, refrigeration, and office equipment. The share of commercial electricity sales attributable to each of these end uses is shown in *Figure T5-20*. Cooking, office equipment, and miscellaneous uses show increasing shares of the total energy consumption between 1994 and 2010.

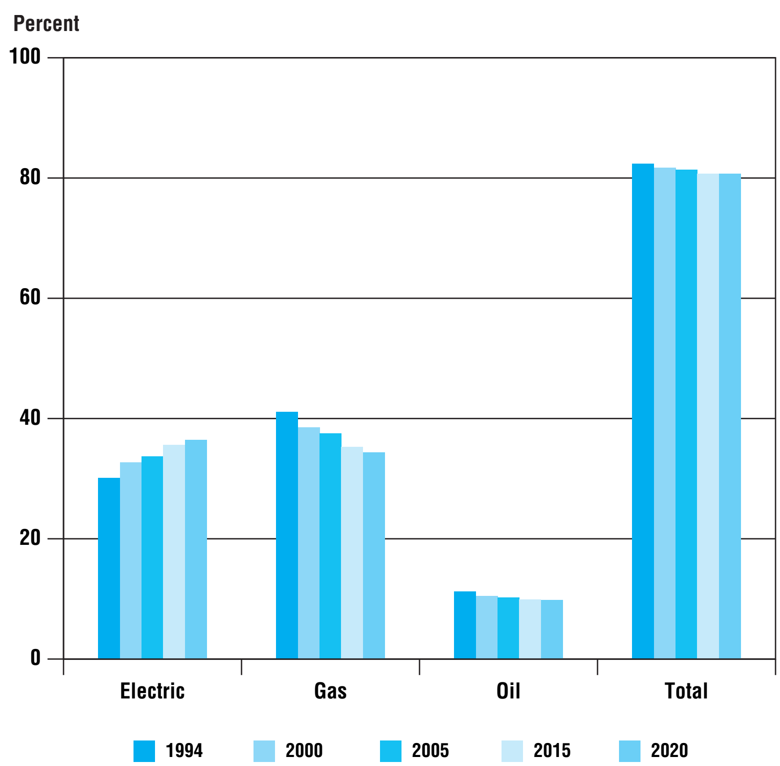
As in the residential sector, end-use energy forecasts are influenced by two major factors, the saturations of each appliance and improvements in efficiency of the appliances.

Commercial Saturations

Space heating saturations by fuel type are shown for the commercial sector in *Figure T5-21*. The saturation of electric space heat increases from 30 percent in 1994 to 36 percent in 2020. Natural gas saturation declines from 41 percent in 1994 to 34 percent in 2020 as gas prices increase. Oil, liquefied petroleum (LP) gas, and other fuels used for space heating decline from 11 to 10 percent.

Other saturations also impact commercial sales. The total saturation of air conditioning increases from 66 percent in 1994 to 71 percent in 2020. The saturation of electric water heating is 43 percent in 1994 and 53 percent in 2020. Over the same period, natural gas water heating saturation declines slightly from 36 to 31 percent, and oil water heating declines from 3 to 1 percent. The saturation of electric lighting is very nearly 100 percent.

FIGURE T5-21. **Commercial Space Heating Saturations**



Electric heating for commercial customers is expected to increase through 2020 at the expense of gas and oil. Rising gas and oil prices will influence this change.

FIGURE T5-22. Commercial Efficiency Improvements 1995–2020

Resistance Heating	0.0%
Space Cooling	6.6%
Refrigeration	4.9%
Lighting	8.4%
Heat Pump Heating	12.8%
Office Equipment	22.3%

Total Commercial Improvements 9.4%

Efficiency improvements in commercial lighting and space cooling will have significant impact on commercial energy usage since lighting and cooling currently consume about half of the energy used in the commercial sector.

Commercial Efficiency Improvements

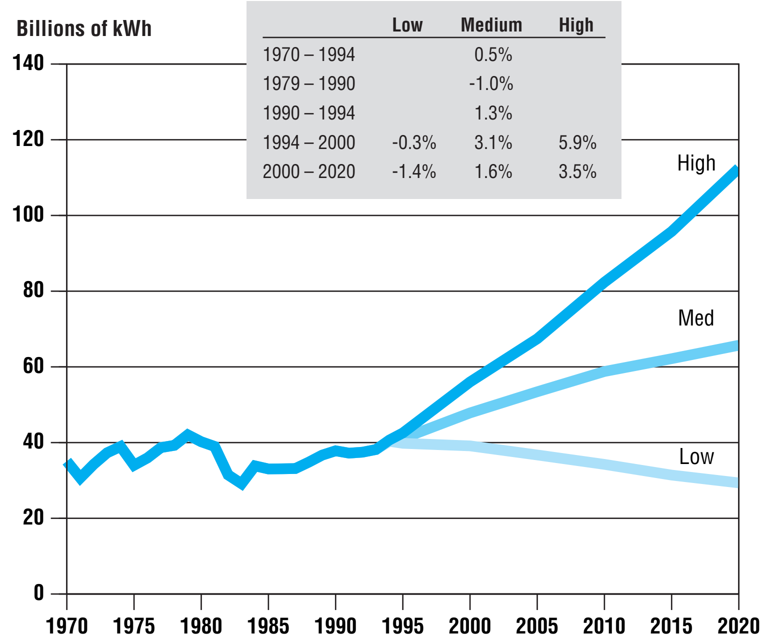
The impact of efficiency improvements and alternative technologies on the commercial long-term sales forecast is shown in *Figure T5-22*. The major impact is in the improvement in efficiency in lighting of 8.4 percent from 1995-2020 and the improvement in space cooling of 6.6 percent over the same period. Efficiency improvements in lighting and cooling have large impacts because lighting and space cooling consumed 48 percent of the energy in the commercial sector in 1994. The impact of efficient office equipment, primarily more efficient computers, is also significant. Efficient office equipment and lighting also generate less heat and reduce cooling requirements. The efficiency improvements comply with the provisions of the Energy Policy Act of 1992.

MANUFACTURING SECTOR FORECAST

The medium manufacturing sales forecast, shown in *Figure T5-23*, has growth rates of 3.1 percent per year from 1994 to 2000 and 1.6 percent per year from 2000 to 2020. The medium forecast of manufacturing kilowatt-hours sales is reasonably bounded by the high and low forecasts, which have 1994 to 2020 growth rates of 5.9 and -0.3 percent per year, respectively.

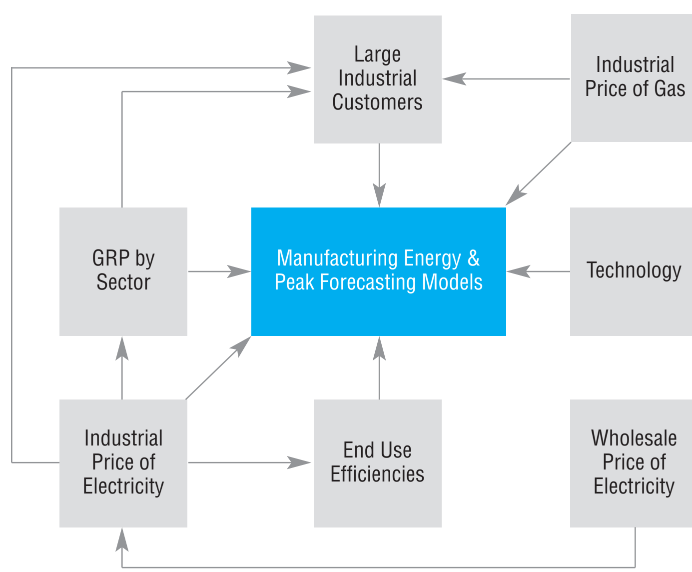
Manufacturing sales are forecast for individual industry groups or standard industrial classification (SIC) codes. In each industry group the sales are influenced by the five major factors shown

FIGURE T5-23. Total Manufacturing Sales



Energy sales to manufacturing customers are expected to increase to over 65 billion kilowatt-hours by 2020.

FIGURE T5-24. Manufacturing Sector Influence Diagram



Factors affecting sales to manufacturing customers include economic activity (in terms of GRP by sector), price of electricity, price of industrial gas, efficiency improvements, and technology.

in *Figure T5-24*: economic activity, price of electricity, price of industrial gas, efficiency improvements, and technology.

These inputs are used in the industrial forecast models to forecast manufacturing sales. In addition, a general survey of business conditions is made for each major industry group. This survey includes major products, technology, and business conditions specific to an industry group. Also, each industry is considered from an international, national, and regional perspective, emphasizing the competitive situation, new products, environmental concerns, and other related issues.

The forecasts of manufacturing by industry groups are shown in *Figure T5-25*.

FIGURE T5-25. **Manufacturing Sales by Industry Group**

	Billions of kWh			Average Annual Growth Rate	
	1979	1994	2020	1979-1994	1994-2020
Food	1.5	2.8	5.7	4.3%	2.8%
Textiles & Apparel	1.9	2.4	3.3	1.6%	1.2%
Paper	2.2	4.8	8.6	5.3%	2.3%
Chemicals	11.7	9.5	11.2	-1.4%	0.6%
Primary Metals	17.1	6.4	9.1	-6.3%	1.4%
Machinery	3.0	4.4	6.9	2.6%	1.8%
Other Durables	2.8	5.6	9.1	4.7%	1.9%
Other Nondurables	1.9	3.9	11.9	4.9%	4.4%
Total Manufacturing	42.1	39.8	65.8	0.4%	2.0%

Electric sales to manufacturing customers are expected to reach 65.8 billion kilowatt-hours by 2020. Other nondurables, food processing, and paper manufacturing are expected to lead in average annual growth rates among Valley industries.

Distributor Served Industries

Manufacturing sales by the 160 power distributors within the TVA service area were 23.1 billion kilowatt-hours in 1994. These sales accounted for 58 percent of the total manufacturing sales in 1994 and are expected to increase to 61 percent in 2020. Distributor served sales have experienced 2.8 percent growth since 1979 in contrast to the -3.0 percent growth in TVA directly served sales. This trend is expected to continue with a 2.2 percent growth in distributor served industry sales through 2020. *Figure T5-26* shows the kilowatt-hours and average annual growth rates for distributor served industry sales.

FIGURE T5-26. **Distributor Served Industrial Sales**

	Billions of kWh			Average Annual Growth Rate	
	1979	1994	2020	1979-1994	1994-2020
Food	1.5	2.8	5.0	4.2%	2.3%
Textiles & Apparel	1.9	2.4	3.3	1.6%	1.2%
Paper	0.8	1.1	1.7	2.1%	1.7%
Chemicals	2.6	2.7	2.9	0.3%	0.3%
Primary Metals	1.5	2.2	2.2	2.6%	0.0%
Machinery	2.5	3.7	5.7	2.6%	1.7%
Other Durables	2.6	4.5	7.8	3.7%	2.1%
Other Nondurables	1.9	3.7	11.7	4.5%	4.5%
	15.3	23.1	40.3	2.8%	2.2%

Distributor manufacturing sales are expected to reach 40.3 billion kilowatt–hours by 2020. The growth leader is expected to be other nondurables at 4.5%.

Other nondurables are expected to be the leader in growth with 4.5 percent annual growth rate through 2020. Nondurables consist primarily of printing and publications, miscellaneous plastics, and petroleum products, among other industries. The food industries are expected to follow with 2.3 percent annual growth rate.

Directly Served Industries

The directly served industrial class consists of relatively large customers served directly by TVA. They account for 42 percent of manufacturing sales and 13 percent of total TVA sales. These sales are spread among 54 companies and are concentrated in 3 industries—primary metals, paper, and chemicals. A close look at each customer is required because these customers have a significant impact on TVA sales.

The forecast for directly served industries is built up on a company-by-company basis. The outlook for the company and the industry is developed from several sources of information. This includes specific company information, industry outlooks, and national economic industry forecasts.

Forecasts for major directly served industries are shown in *Figure T5-27*. Total energy sales for directly served industries are expected to increase from 16.8 billion kilowatt-hours in 1994 to 25.4 billion kilowatt-hours in 2020. Historically, total directly served sales have declined by 3.5 percent per year, largely based on the decline in primary metals and to a lesser degree in chemicals. From 1994 to 2020, directly served industry sales are expected to increase 1.6 percent per year.

FIGURE T5-27. **Directly Served Industrial Sales**

	Billions of kWh			Average Annual Growth Rate	
	1979	1994	2020	1979-1994	1994-2020
Primary Metals	15.6	4.2	6.9	-8.4%	1.9%
Chemicals	9.0	6.9	8.2	-1.8%	0.7%
Chlorine	3.4	4.2	4.7	1.4%	0.4%
Fibers	2.2	2.0	3.0	-0.1%	1.6%
Other Chemicals	3.4	0.7	0.5	-10.0%	-1.3%
Paper	1.4	3.7	6.9	6.7%	2.4%
Other	0.7	2.0	3.4	7.3%	2.1%
Total Direct Served	26.7	16.8	25.4	-3.0%	1.6%

Energy sales to industries served directly by TVA are expected to increase to 25.4 billion kilowatt-hours annually by 2020.

Cogeneration

Cogeneration is the production of electricity by an industry for its own use. Cogeneration by directly served industries is forecast to increase from 2.3 billion kilowatt-hours in 1994 to 3.1 billion kilowatt-hours in 2000 and to 6.1 billion kilowatt-hours by 2020. It is expected that cogeneration will continue to increase as long as it proves beneficial to industries or the environment. Presently, customers most likely to produce their own electricity are those with process steam needs, in particular, operations involving paper, chemicals, and textiles. For example, energy produced during the recovery cycle of the paper manufacturing process is often sufficient to meet the energy needs of the pulp industry. In addition, the lumber industry is becoming increasingly interested in cogeneration because landfills, in many cases, are either charging more for dumping waste sawdust or refusing to accept it.

Load Forecast Uncertainty

A load forecast is inherently uncertain for two reasons. First, there is uncertainty in the future values of the key variables that determine the level of future electricity consumption. For the Energy Vision 2020 forecast these variables are:

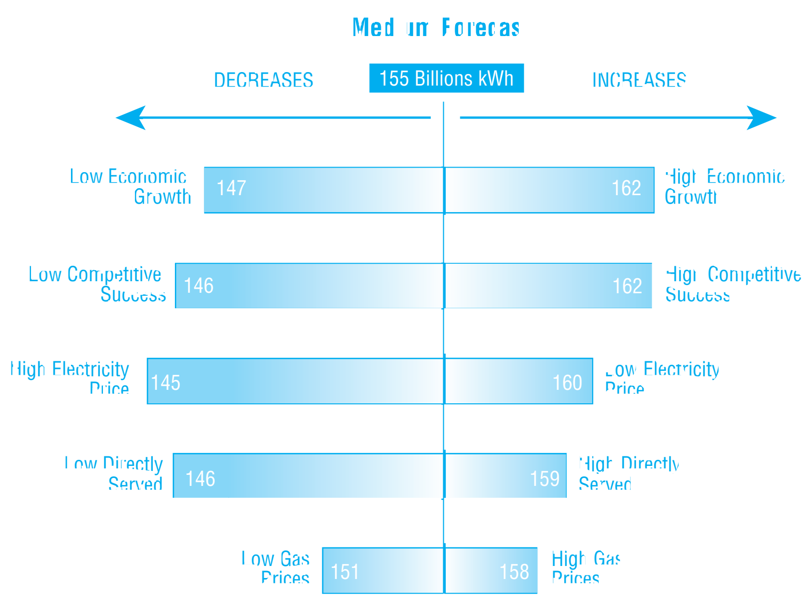
- Economic activity
- Price of electricity
- Competitive success
- Directly served load
- Price of substitute fuels

The second reason for load uncertainty is due to the relationships between the key variables and future electricity consumption. Customer preferences and behaviors will change over time. Therefore, the relationships between them and the consumption of electricity will change.

In the Energy Vision 2020 forecast, TVA has dealt with uncertainty using the following methods.

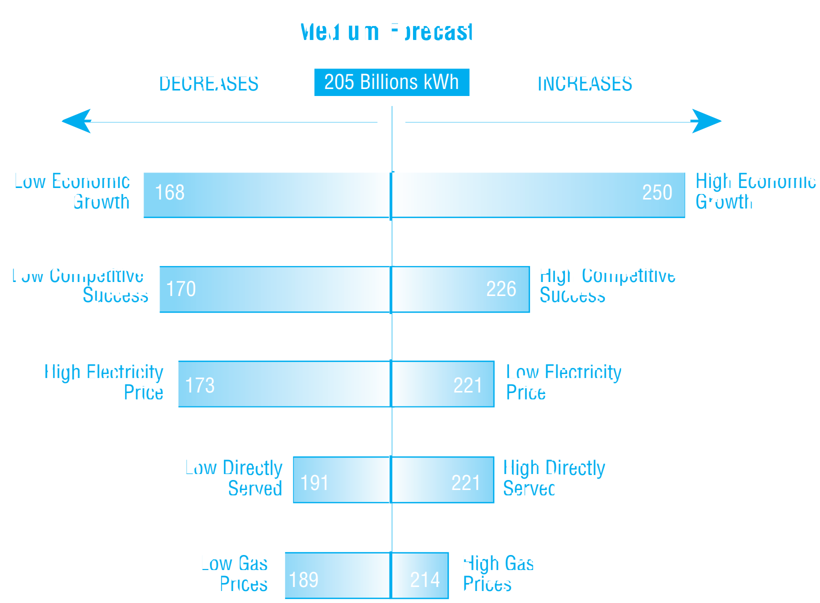
1. Evaluating alternative levels (high, medium, and low) of the key variables for their impacts on future electricity consumption. This process is based on probability and results in a wide range of alternative load forecasts.
2. Use of several quantitative models to evaluate the relationship between the major variables and their impact on future electricity consumption. Both econometric and economic end-use models are used.

FIGURE T5-28. **Variation of the System Energy Forecast Assuming High and Low Conditions for Key Uncertainties in 2000**



Uncertainty about the future requires a broad review of key variables and their impacts on system energy requirements. Load growth is most affected by economic activity, competition, and the price of electricity.

FIGURE T5-29. **Variation of the System Energy Forecast Assuming High and Low Conditions for Key Uncertainties in 2015**



Uncertainty about the future requires a broad review of key variables and their impacts on system energy requirements. Load growth is most affected by economic activity, competition, and the price of electricity.

ALTERNATIVE LEVELS OF KEY VARIABLES

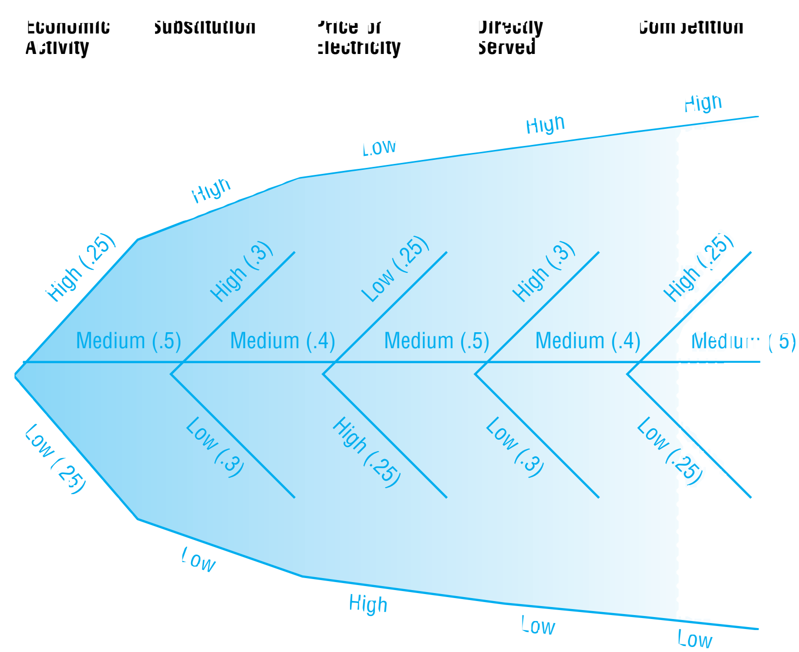
The high, medium, and low load forecasts reflect changes in the key variables which, in turn, impact load growth. The medium load forecast is based on the medium or expected level of each key variable. The high and low levels of each key variable are quantified, and models are used to determine the high and low sales levels.

The incremental impacts above or below the medium sales forecast are shown for each key variable for 2000 and 2015 in *Figures T5-28* and *T5-29*. For example, *Figure T5-28* shows that the impact on system energy requirements in the year 2000 of going from the medium to the high level of economic activity would be to increase system energy requirements by 7 billion kilowatt-hours. In 2015, as shown in *Figure T5-29*, the incremental impact of going from the medium to the high level of economic activity would be to add 45 billion kilowatt-hours—raising the forecast from 205 billion kilowatt-hours to 250 billion kilowatt-hours.

As shown in *Figures T5-28* and *T5-29*, considerable uncertainty exists in the key variables and their impacts on system energy requirements. Economic activity, competition, and the price of electricity have the greatest impact on possible changes in load growth. In 2000 the range of sales due to uncertainty in economic activity is 15 billion kilowatt-hours, increasing to 82 billion kilowatt-hours in 2015. The range on electricity price impacts is 15 billion kilowatt-hours in 2000 and 48 billion kilowatt-hours in 2015. The range on competitive success is 16 billion kilowatt-hours in 2000 and 56 billion kilowatt-hours in 2015.

The range of load growth impacts from the low to the high levels of economic activity, competition, and electricity prices does not include any impacts on the directly served sector since this sector reacts differently to changes in econom-

FIGURE T5-30. **Alternate Load Forecasts**



High and low load forecasts are developed by determining the probabilities assigned to alternative levels of the key variables, what is the likelihood that economic activity, for example, will be high or low for any given forecast period.

ic activity and electricity prices. The range of incremental impacts on net system requirements from the directly served sector is 13 billion kilowatt-hours in 2000 and 30 billion kilowatt-hours in 2020. The incremental impact of substitution of electricity for natural gas based on changes in natural gas prices has a range of 7 billion kilowatt-hours in 2000 and 25 billion in 2020.

PUTTING THE NUMBERS TOGETHER – SELECTING THE HIGH AND LOW FORECASTS

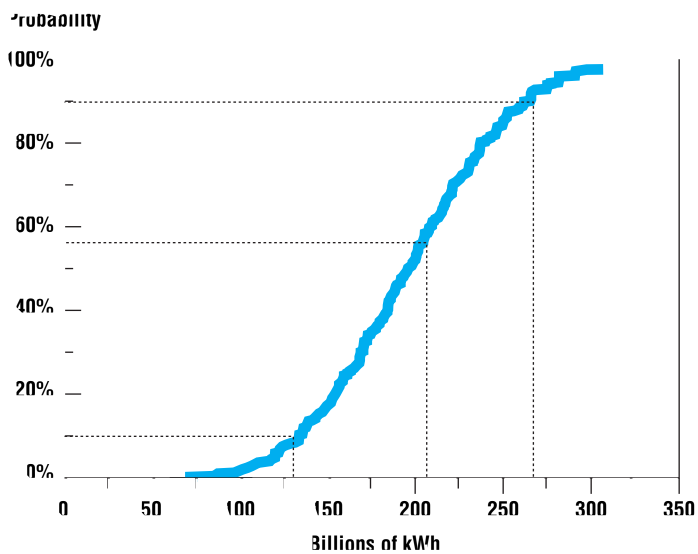
Selecting the high and low forecasts involves organizing the alternative load growth scenarios with a tree diagram *(Figure T5-30)*. There are five alternative branches in the tree—one for each of the five major determinants of load growth: economic activity, substitution (price of natural gas), price of electricity, directly served industry, and competitive success. Combinations of these five major determinants of electricity consumption produce alternative load forecasts. For example, high economic activity, high competitive success, high price of natural gas (high substitution), low price of electricity, and high directly served industry would produce the highest load forecast as represented by the top branch of the tree. Conversely, the alternative levels of the determinants of electricity consumption represented by the bottom branches of the tree would produce the lowest load forecast.

The numbers in parentheses represent the probabilities assigned to the alternative levels of the key variables. For example, high economic growth is assigned a .25 probability, medium economic growth is assigned a .50 probability, and low economic growth is assigned a .25 probability. Some of the variables are not independent. An explanation of the detailed probability assessment will be furnished upon request.

The probabilities associated with the possible forecast outcomes are used as a guideline in selecting those forecasts that will be evaluated explicitly in the decision process. A cumulative probability distribution, shown in *Figure T5-31*, indicates the distribution of probabilities associated with the entire range of possible forecasts. The cumulative probability distribution helps select a set of three forecasts that sufficiently bound the range of uncertainty. The cumulative probability distribution indicates the probability that the actual load will be less than the forecast load. TVA's high load forecast has a 90 percent probability that the actual load will be less than the forecast load. The medium forecast has a 50 percent probability that the actual load will be less than the forecast load, and the low load forecast has a 10 percent probability.

As indicated by the cumulative probability distribution, there are several potential forecasts that will be either greater than the high load forecast (90 percent) or lower than the low forecast (10 percent). Conditions that would result in load growth greater than the high load forecast, for example, are lower electricity prices. One condition that could result in load growth being lower than the low forecast would be lower natural gas prices.

FIGURE T5-31. **Forecast Probability Distribution – 2015**



High, medium, and low load forecasts have assigned probabilities that the actual load will be less than the forecast load. In the high load forecast, for example, there is a 90 percent probability that the actual load will be lower than projected.

Continuous Improvement

TVA recognizes that the world is rapidly changing and its processes and products must continually be assessed to maintain credible load forecasts. TVA therefore contracted with Barakat & Chamberlin, Inc., to evaluate the TVA load forecasting system in 1991. Barakat & Chamberlin, Inc., concluded that, "on a comparative basis, TVA's forecasting procedures compare very favorably with the best-practice procedures in the United States utility industry." Several of Barakat & Chamberlin's recommendations have been incorporated into the TVA load forecast:

- In 1992 TVA began using an industrial end-use model.
- A commercial conditional demand model is being developed.
- TVA is updating residential conditional demand studies.
- The uncertainty analysis has been expanded to include additional factors.
- Industry surveys are made continually to monitor closely the important industrial sectors of the TVA market.

ECONOMIC FORECASTING METHODOLOGY AND VALIDATION

TVA produces its own forecasts of regional economic activity. These forecasts are based on forecasts of the national economy developed by an internationally recognized forecasting service, DRI/McGraw Hill. TVA uses its regional economic forecasts for budget planning, the planning of locks and other navigation facilities, and economic development activities. These forecasts are publicly distributed throughout the Tennessee Valley and are used by four regional universities as the basis for their own publicly released economic forecasts of their local areas. (The regional universities that use the TVA forecasts as the driver in their own local area economic model forecasts are: Eastern Kentucky University, Mississippi State University, the University of Alabama in Huntsville, and Western Carolina University.) The regional economic forecasts are also the major "key assumption" to TVA's load forecasts.

These forecasts are based on five elements necessary for state-of-the-art forecasting: accuracy, use of best information, use of best methods, explicit treatment of uncertainty, and continuous improvement.

Accuracy

Figure T5-32 summarizes the accuracy of TVA's five-year forecast for Gross Regional Product (the sum of the value in dollars of all final goods and services produced) and DRI's forecasts for Gross National Product. (DRI has been used for national forecasts since 1988. Prior to that, the WEFA Group forecasts were used. However, both companies' long-term forecasts of gross national product have been very similar over the years.) These forecasts were made annually during the 1980s. For example, a regional and a national forecast for 1985 (the target year in *Figure T5-32*) were done at the start of 1981, with 1980 as the latest his-

FIGURE T5-32. **TVA Economic Forecast Five–Year Forecast Error**

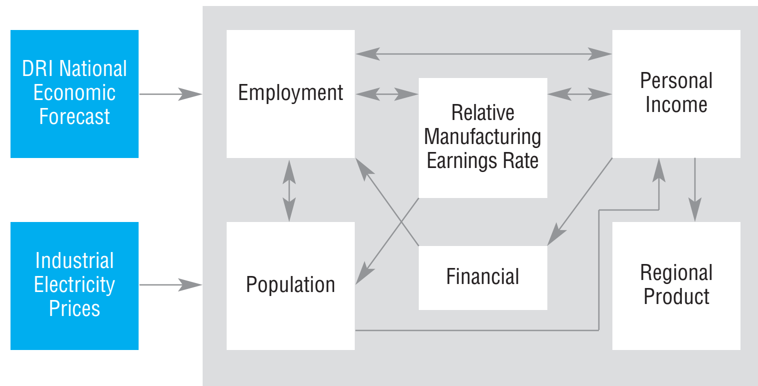
		Gross Product in Billions of Dollars					
		REGIONAL			NATIONAL		
Year of Forecast	Target Year	GRP Forecast	GRP Actual	Forecast Error	GNP Forecast	GNP Actual	Forecast Error
1980	1985	$105.3	$91.5	15.1%	$4,746	$4,054	17.1%
1981	1986	$114.5	$98.1	16.7%	$5,164	$4,278	20.7%
1982	1987	$114.6	$106.6	7.5%	$5,149	$4,545	13.3%
1983	1988	$117.5	$114.9	2.3%	$5,196	$4,908	5.9%
1984	1989	$124.1	$124.1	0.0%	$5,519	$5,267	4.8%
1985	1990	$127.4	$130.7	-2.5%	$5,673	$5,568	1.9%
1986	1991	$143.4	$137.6	4.2%	$6,116	$5,741	6.5%
1987	1992	$145.8	$149.1	-2.3%	$6,171	$6,026	2.4%
1988	1993	$161.7	$159.6	1.3%	$6,862	$6,348	8.1%
1989	1994	$174.7	$172.7	1.1%	$6,863	$6,727	2.0%
Average Absolute Error (1988-1994):				2.0%			4.5%
Average Absolute Error (1985-1994):				5.3%			8.3%

This chart summarizes the accuracy of TVA's five-year economic forecasts for the region and the nation.

torical year (the year of forecast in *Figure T5-32*). Likewise, forecasts for 1994 were done at the beginning of 1990, with 1989 as the latest historical year. *Figure T5-32* shows the percentage of error between the forecasted value and actual data (expressed as a positive—forecast was too high—or negative—forecast was too low—value) for both the regional and national forecasts.

Figure T5-32 indicates that the performance of TVA regional economic forecasts has improved over time and that the performance has been favorable compared to that of the national economic forecasts. For the forecasted years of 1988 through 1994, the average error in the regional forecasts for total gross product was good, within plus or minus 2 percent.

FIGURE T5-33. **Regional Economic Simulation Model Flowchart**



Major inputs into the Regional Economic Simulation Model are the national economic forecast and TVA industrial electricity prices.

The regional economic forecast performance has improved due to the better performance of the national forecasts and to improvements in the TVA economic forecasting process, including the validation procedures. TVA does reviews of long-term forecasting performance (as per the example above), as well as annual reviews of new economic data. Economic forecasts over the historical period are also done annually to test TVA's economic model performance versus actual data.

To improve the process, TVA began a program with universities around the Valley to share economic information in 1985. Currently, there are 11 university partners: The University of Alabama in Huntsville, Eastern Kentucky University, Western Kentucky University, Mississippi State University, Western Carolina University, East Tennessee State University, Middle Tennessee State University, Tennessee State University, The University of Memphis, The University of Tennessee at Martin, and Virginia Polytechnic and State University. TVA's regional economic forecasts are allocated to economic subregions of the Valley. The universities then review both the regional forecast and the forecasts for their subregions on an annual basis. All of this information is incorporated into the economic forecasting process and used to validate the regional economic forecasts.

The TVA regional economic forecast used for the Energy Vision 2020 process has been favorably reviewed by the regional universities. Further, the latest State of Tennessee long-term economic forecast, developed by The University of Tennessee at Knoxville, is consistent with it. The University's independently forecast average annual rate of growth for Tennessee total gross product of 3.8 percent from 1993 through 2002 compares well with the TVA forecast rate for regional total gross product growth of 3.5 percent for the same period. (See Murray, Matthew N., "The Long-Term Outlook for Tennessee: Three Trends Will Determine the State's Economic Future," *Survey of Business*, Center for Business and Economic Research, The University of Tennessee, Knoxville, (Winter 1994), pg. 39, for information on the university forecast.)

Use of Best Information

TVA strives to use the best information available for its economic forecasting. As stated previously, the national economic forecasts are purchased from DRI/McGraw-Hill. DRI forecasts are well recognized and widely used. Among DRI clients are a great number of utilities, federal and state agencies, universities, and Fortune 500 companies. DRI forecasts are quoted by the *Wall Street Journal* and other major business publications and used in Congressional hearings and legal cases.

The source historical economic data for the regional forecasts come from the federal government: the Bureau of Economic Analysis and the Bureau of the Census, U.S. Department of Commerce, and the Bureau of Labor Statistics, U.S. Department of Labor. The federal government has improved these data over the years. Further, TVA has improved its use of these data to get a better and more current picture of the region-

al economy. For example, by using the monthly state employment data from the Bureau of Labor Statistics, TVA can estimate regional employment in a more timely manner than by using estimates from other sources.

TVA has also improved its information by supplementing the data discussed above with information from other sources, including detailed employment and payroll data from state employment agencies, information on industry trends from trade journals and federal government publications, and information from the regional universities (discussed above) about the status of their local economies and industries.

Use of Best Methods

TVA uses its Regional Economic Simulation Model to produce its regional economic forecasts. The model uses state-of-the-art statistical methods comparable to those of the major economic forecasters in the country. TVA has been a leader in the utility industry in the use of econometric forecasting models that have now become the industry standard.

As seen in *Figure T5-33*, the two major inputs to RESM are the DRI national economic forecasts and TVA industrial electricity prices. RESM does not merely allocate national trends, but captures the differences inherent in the regional economic structure that affect regional performance. RESM is updated on an annual basis and has a high degree of industry detail (for example, chemicals, apparel, etc., in manufacturing; food stores, health services, etc., in the commercial sector). This allows for interindustry linkages—for instance, wholesale trade is linked to retail trade. (See Gonzalez, Juan E., “The TVA Regional Economic Simulation Model,” *Proceedings: Eighth Electric Utility Forecasting Symposium*, (EPRI TR-100396), Electric Power Research Institute, Palo Alto, California, April 1992, pp. 39-1 to 39-11, for a more detailed discussion of RESM.)

Explicit Treatment of Uncertainty

Forecasting is inherently uncertain. First, there is uncertainty in the major inputs to the regional forecast. Many events, especially those that are not economic in nature, such as the Gulf War or the breakup of the Soviet Union, may throw the national economy from its expected growth path. Likewise, there is uncertainty related to the TVA electricity price forecasts. In addition, there is uncertainty as to how the regional economic structure will change over time.

To deal with uncertainty, TVA supplements its modeling with industry analyses and studies of specific major issues such as the effects of changes in the value of the dollar or interest rates on the Valley economy. This is an effort to continually improve TVA’s understanding of the Valley economy and its ability to produce accurate economic forecasts.

Further, TVA deals with uncertainty by producing high and low regional economic forecasts that provide a range of possible future economic outcomes. These are derived by using DRI national high and low economic forecasts and TVA low and high electricity price forecasts, respectively. Also, explicit assumptions are made as to possible events that are not considered most likely, but are feasible developments from emerging historical events. Thus, in the current high economic forecast, the assumption is made that the region will develop a commercial sector that more closely matches that of the nation. Likewise in the low forecast, the assumption is made that several of the Valley’s manufacturing industries experience large negative effects due to foreign competition.

Continuous Improvement

TVA is continuously improving its economic forecasting process. Specific efforts have been discussed previously for accuracy, use of best information, use of best methods, and explicit treatment of uncertainty. For example, TVA has made efforts to improve accuracy by working with regional universities. Efforts to improve information include supplementing data from various sources. In using the best methods, the Regional Economic Simulation Model is updated on an annual basis to improve estimates. Finally, to improve the treatment of uncertainty, TVA supplements its modeling with industry analyses and studies of specific major issues.

Energy Vision 2020

6

Volume 2, Technical Document

Supply-Side Options

Volume 2, Technical Document 6

Supply-Side Options

Contents

This technical document has a description and the characteristics for each supply-side option that was identified for consideration in Energy Vision 2020.

Supply-Side Options

Over 100 different supply-side options were identified during the course of Energy Vision 2020. These options represent a broad spectrum of options—both in terms of fuel source and operating characteristics. While the full range of supply-side options is nearly unlimited, this set provides a reasonable representation of the options that are available. In some cases, two or more similar options were defined in order to better evaluate specific differences. In most cases, however, the options represent a "typical" configuration and not necessarily the only design that could be considered. This document provides additional descriptions and characterizations of each of the options that have been identified.

Figure T6-1 shows performance, cost, and environmental characteristics for the conventional TVA supply-side options. *Figure T6-2* shows additional characteristics for the flexible TVA supply-side options.

FIGURE T6-1. **Conventional TVA Supply-Side Options**

Number	Option ID	Option Name	Status	Duty Cycle	Net Full Load Capacity (MW)	Net Full Load Heat Rate (Btu/kWh)	Fuel	Total Schedule (Yr)	Coproducts	Base Capital Cost ($/kW)
			PERFORMANCE CHARACTERISTICS							
1	1.1.1.1	Supercritical Pulverized Coal-Fired Plant (1x300 MW)	Mature Commercial	Base	300	9,522	High Sulfur Coal	7	None	$1,614
2	1.1.1.2	Supercritical Pulverized Coal-Fired Plant (4x300 MW)	Mature Commercial	Base	1,200	9,522	High Sulfur Coal	8	None	$1,345
3	1.1.1.3	Atmospheric Fluidized Bed Combustion Repowering, Generic (1x125 MW)	Initial Commercial	Base	125	10,600	High Sulfur Coal	6	None	$1,119
4	1.1.1.4	Circulating Atmospheric Fluidized Bed Combustion Plant (1x200 MW)	Initial Commercial	Base	200	9,830	High Sulfur Coal	8	None	$1,486
5	1.1.1.5	Subcritical Pulverized Coal-Fired Plant (4x300 MW)	Mature Commercial	Base	1,200	10,000	High Sulfur Coal	8	None	$1,413
6	1.1.2.1	Simple Cycle Combustion Turbine Plant (1x150 MW)	Mature Commercial	Peaking	150	10,500	Natural Gas	5	None	$360
7	1.1.2.2	Natural Gas-Fired Combined Cycle Plant (1x470 MW)	Mature Commercial	Intermediate	470	7,000	Natural Gas	5	None	$655
8	1.1.2.3	Combined Cycle Repowering, Generic (1x425 MW)	Initial Commercial	Intermediate	425	7,900	Natural Gas	4	None	$487
9	1.1.2.4	Small Cogeneration Combined Cycle Plant (3x10 MW)	Mature Commercial	Base	30	12,000	Natural Gas	4	Steam	$1,120
10	1.1.2.5	Small Combined Cycle Plant (1x42 MW)	Mature Commercial	Peaking / Intermediate	42	8,600	Natural Gas	4.5	None	$800
11	1.1.3.1	Refuse-Derived Fuel-Fired Stoker (1x40 MW)	Mature Commercial	Base	40	16,464	Refuse-Derived Fuel	8	None	$5,740
12	1.1.5.1	Lead Acid Battery Energy Storage (1x20 MW)	Mature Commercial	Peaking	20	NA	NA	3	None	$578
13	1.2.1.1	State-of-the-Art Pulverized Coal-Fired Plant (1x400 MW)	Large Scale Demo	Base	400	8,110	High Sulfur Coal	7	None	$1,417
14	1.2.2.1	Compressed Air Energy Storage with Humidification (3x337 MW)	Initial Commercial	Peaking	1,011	5,874	Natural Gas	7	None	$315
15	1.2.2.2	Compressed Air Energy Storage with Recuperation (3x337 MW)	Initial Commercial	Peaking	1,011	4,509	Natural Gas	7	None	$338
16	1.2.3.1	Biomass Whole Tree Energy Boiler Power Plant (1x100 MW)	Large Scale Demo	Base	100	10,654	Biomass	8	None	$1,512
17	1.3.1.1	First Generation Pressurized Fluidized Bed Combustion Repowering, Generic (1x156 MW)	Large Scale Demo	Base	156	8,830	High Sulfur Coal	6	None	$1,167
18	1.3.1.2	First Generation Pressurized Fluidized Bed Combustion (1x340 MW)	Large Scale Demo	Base	340	8,200	High Sulfur Coal	8	None	$1,281
19	1.3.1.3	Integrated Gasification Compressed Air Storage with Humidification (1x410 MW)	Large Scale Demo	Intermediate	410	10,020	High Sulfur Coal	8	Sulfur	$1,492
20	1.3.1.4	Integrated Gasification Combined Cycle with Fertilizer Coproduction (3x227 MW)	Initial Commercial	Base	682	9,860	High Sulfur Coal	8	Urea	$2,241
21	1.3.1.5	Integrated Gasification Combined Cycle (3x245 MW)	Initial Commercial	Base	740	7,230	High Sulfur Coal	8	Sulfur	$1,524
22	1.3.1.6	Compressed Air Storage with Humidification with Integrated Gasification & Natural Gas Peaking (1x850 MW)	Large Scale Demo	Intermediate/ Peaking	850	4,700	Natural Gas and Coal	8	Sulfur	$872

COST CHARACTERISTICS					ENVIRONMENTAL AND OTHER CHARACTERISTICS					
Fuel Cost ($/MMBtu)	Base Fixed Operating & Maintenance ($/kW-Yr)	Base Variable Operating & Maintenance (Mills/kWh)	Base Fixed Additions & Improvements ($/kW-Yr)	Base Decommissioning Cost ($ Million)	Sulfur Dioxide (lb/MMBtu)	Nitrogen Oxides (lb/MMBtu)	Carbon Dioxide (lb/MMBtu)	Thermal Discharge (MMBtu/MWh)	Solid Waste (lb/MMBtu)	Economic Development [1] (Annual Average Employment)
$1.00	$21.80	1.3	$13.60	$0	0.3	0.1	210	0	24.02	NA
$1.00	$20.00	1.3	$13.60	$0	0.3	0.1	210	0	24.02	918
$1.00	$21.20	1.4	$14.70	$0	0.25	0.1	210	6.02	31.74	NA
$1.00	$21.00	1.4	$14.70	$0	0.25	0.1	210	0	31.74	NA
$1.00	$20.00	1.3	$13.60	$0	0.3	0.15	210	0	24.02	NA
$2.48	$2.00	2.6	$0.00	$0	0	0.08	115	0	0	20
$2.48	$4.70	1.3	$4.50	$0	0	0.08	115	0	0	128
$2.48	$4.60	1.3	$4.50	$0	0	0.08	115	0.82	0	96
$2.48	$18.30	3.2	$0.00	$0	0	0.16	115	0	0	NA
$2.48	$13.10	4.3	$0.00	$0	0	0.16	115	0	0	NA
($1.54)	$84.00	1.8	$58.00	$0	0.07	0.06	0	0	21.43	128
NA	$2.50	7.7	$7.10	$0	0	0	0	0	0	4
$1.00	$19.90	1.6	$16.00	$0	0.1	0.06	210	0	24.02	NA
$2.48	$2.20	2.5	$0.00	$0	0	0.03	115	0	0	130
$2.48	$2.20	2.6	$0.00	$0	0	0.03	115	0	0	NA
$1.87	$33.50	7	$12.50	$0	0.002	0.1	-267	0	0.57	190
$1.00	$18.70	4	$16.90	$0	0.25	0.1	210	3.33	30.14	NA
$1.00	$29.00	1.3	$27.80	$0	0.25	0.1	210	0	30.14	NA
$1.00	$20.50	0.4	$15.00	$0	0.05	0.03	210	0	9.48	NA
$1.00	$22.50	1.2	$13.20	$0	0.035	0.029	159	0	9.48	NA
$1.00	$20.80	1.2	$12.00	$0	0.05	0.035	205	0	9.48	610
$2.48 & $1.00	$20.50	0.4	$15.00	$0	0.025	0.03	180	0	7.22	NA

[1] Calculated for selected options only

FIGURE T6-1. **Conventional TVA Supply-Side Options** *CONTINUED*

Number	Option ID	Option Name	Status	Duty Cycle	Net Full Load Capacity (MW)	Net Full Load Heat Rate (Btu/KWh)	Fuel	Total Schedule (Yr)	Coproducts	Base Capital Cost ($/kW)
			PERFORMANCE CHARACTERISTICS							
23	1.3.1.7	Advanced Pressurized Fluidized Bed Combustor with Development Cost (1x300 MW)	Initial Commercial	Base	300	7,400	High Sulfur Coal	8	0	$1,518
24	1.3.1.8	Advanced Pressurized Fluidized Bed Combustor with No Development Cost (1x300 MW)	Initial Commercial	Base	300	7,400	High Sulfur Coal	8	0	$1,246
25	1.3.1.9	Partnered IGCC with Coproduction, Greenfield Site (1x530 MW)	CC-Mature Commercial	Base	530	7,200	Syngas	8	None	$581
26	1.3.1.10	IGCC with Coproduction, Greenfield Site (1x498 MW)	Initial Commercial	Base	498	11,140	High Sulfur Coal	8	Methanol	$2,325
27	1.3.1.11	Integrated Gasification Cascaded Humidified Advanced Turbine (IGCHAT) with Coproduction, Greenfield Site (1x598 MW)	Initial Commercial	Base	598	10,515	High Sulfur Coal	8	Methanol	$1,930
28	1.3.1.12	Coal Refinery/IGCC, Greenfield Site (1x530 MW)	Initial Commercial	Base	530	17,000	High Sulfur Coal	8	Naphtha, Benzene	$2,590
29	1.3.1.13	Coal Refinery/IGCHAT, Greenfield Site (1x530 MW)	Initial Commercial	Base	530	17,000	High Sulfur Coal	8	Naphtha, Benzene	$2,325
30	1.3.1.14	Coal Refinery/IGCHAT with Coproduction, Greenfield Site (1x180 MW)	Initial Commercial	Base	180	43,250	High Sulfur Coal	8	Methanol	$7,100
31	1.3.2.1	Fuel Cell - Molten Carbonate or Solid Oxide (1x2 MW)	Large Scale Demo	Base	2	6,450	Natural Gas	4	Waste Heat, Steam	$1,034
32	1.3.2.2	Intercooled Aeroderivative Combustion Turbine (1x125 MW)	Large Scale Demo	Intermediate/ Peaking	125	8,100	Natural Gas	5	None	$467
33	1.3.2.3	Cascaded Humidified Advanced Turbine (F Series CT) (1x288 MW)	Large Scale Demo	Intermediate	288	7,315	Natural Gas	6	None	$503
34	1.3.2.4	Integrated Gasification Cascaded Humidified Advanced Turbine with Coproduction (F Series CT) (2x303 MW)	Large Scale Demo	Base	606	12,485	High Sulfur Coal	8	Urea, MTBE, Methanol	$1,739
35	1.3.2.5	Integrated Gasification Cascaded Humidified Advanced Turbine (F Series CT) (2x303 MW)	Large Scale Demo	Base	606	8,750	High Sulfur Coal	8	None	$1,243
36	1.3.2.6	Cascaded Humidified Advanced Turbine (G Series CT) (1x400 MW)	Large Scale Demo	Intermediate	400	6,920	Natural Gas	6	None	$477
37	1.3.2.7	Integrated Gasification Cascaded Humidified Advanced Turbine with Coproduction (G Series CT) (2x420 MW)	Large Scale Demo	Base	840	10,660	High Sulfur Coal	8	Urea, MTBE, Methanol	$1,622
38	1.3.2.8	Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	Large Scale Demo	Base	840	8,200	High Sulfur Coal	8	None	$1,126
39	1.3.2.9	Integrated Fuel Cell/Combustion Turbine (1x2.5 MW)	Large Scale Demo	Base	2.5	5,250	Natural Gas	4	None	$1,240
40	1.3.3.1	Large Solar-Photovoltaic - Fixed Flat Plate (1x50 MW)	Pilot Scale	Intermediate	50	NA	Solar	7	None	$3,032
41	1.3.3.2	Landfill Methane (1x2 MW)	Pilot Scale	Intermediate	2	6,450	Landfill Gas (Methane)	3	Waste Heat, Steam	$1,034
42	1.3.3.3	Coalbed Methane (1x2 MW)	Pilot Scale	Intermediate	2	6,450	Coalbed Methane	3	Waste Heat, Steam	$1,034
43	1.3.3.4	Biorefinery - Coproduction of Electricity and Chemicals (1x100 MW)	Demo	Base	100	18,000	Biomass	5	Multiproducts	$4,000

COST CHARACTERISTICS					ENVIRONMENTAL AND OTHER CHARACTERISTICS					
Fuel Cost ($/MMBtu)	Base Fixed Operating & Maintenance ($/kW-Yr)	Base Variable Operating & Maintenance (Mills/kWh)	Base Fixed Additions & Improvements ($/kW-Yr)	Base Decommissioning Cost ($ Million)	Sulfur Dioxide (lb/MMBtu)	Nitrogen Oxides (lb/MMBtu)	Carbon Dioxide (lb/MMBtu)	Thermal Discharge (MMBtu/MWh)	Solid Waste (lb/MMBtu)	Economic Development 1 (Annual Average Employment)
$1.00	$36.00	1.3	$6.50	$0	0.4	0.1	210	0	30.14	NA
$1.00	$36.00	1.3	$6.50	$0	0.4	0.1	210	0	30.14	NA
$1.00	$4.20	1.2	$4.00	$0	0.03	0.08	131	0	0	NA
$1.00	$57.00	2.5	$0.00	$0	0.03	0.08	173	0	0	NA
$1.00	$54.00	2.5	$0.00	$0	0.03	0.08	173	0	0	NA
$1.00	$55.00	2.6	$0.00	$0	0.03	0.08	173	0	0	NA
$1.00	$50.00	2.6	$0.00	$0	0.03	0.08	173	0	0	NA
$1.00	$275.00	20	$5.00	$0	0.03	0.08	173	0	0	NA
$2.48	$10.00	1.7	$105.00	$0	0	0.16	115	0	0	1
$2.48	$3.50	3.7	$0.00	$0	0	0.08	115	0	0	NA
$2.48	$4.50	1.3	$3.50	$0	0	0.005	115	0	0	65
$1.00	$20.80	1.7	$13.20	$0	0.035	0.01	205	0	9.48	NA
$1.00	$18.60	0.9	$13.20	$0	0.05	0.01	205	0	9.48	NA
$2.48	$4.50	1.3	$3.50	$0	0	0.005	110	0	0	NA
$1.00	$20.80	1.7	$13.20	$0	0.035	0.01	205	0	9.48	NA
$1.00	$18.60	0.9	$13.20	$0	0.05	0.01	205	0	9.48	569
$2.48	$0.60	12	$70.00	$0	0	0.005	110	0	0	NA
NA	$5.00	0	$1.30	$0	0	0	0	0	0	44
$1.29	$9.80	1.7	$40.00	$0	0	0.16	-798	0	0	1
$1.80	$9.80	1.7	$40.00	$0	0	0.16	115	0	0	1
$3.00	$200.00	40.0	$0.00	$0	0.05	0.1	0	0	1.0	NA

[1] Calculated for selected options only

FIGURE T6-1. **Conventional TVA Supply-Side Options** *CONTINUED*

			PERFORMANCE CHARACTERISTICS							
Number	Option ID	Option Name	Status	Duty Cycle	Net Full Load Capacity (MW)	Net Full Load Heat Rate (Btu/kWh)	Fuel	Total Schedule (Yr)	Coproducts	Base Capital Cost ($/kW)
44	1.3.5.1	Advanced Battery Energy Storage (1x20 MW)	Pilot Scale	Peaking	20	NA	NA	3	None	$491
45	1.3.5.2	Superconducting Magnetic Energy Storage (1x500 MW)	Pilot Scale	Peaking	500	NA	NA	8	None	$1,235
46	2.1.3.1	Additional Hydro Generation at Existing Nonpower Projects (1x10 MW)	Mature Commercial	Peaking	10	NA	NA	5	None	$2,460
47	2.1.3.2	Additional Hydro Generation at Existing Projects (1x24 MW)	Mature Commercial	Peaking	24	NA	NA	6	None	$4,288
48	2.1.3.3	Additional Hydro Generation-New Conventional Projects (1x65 MW)	Mature Commercial	Peaking	65	NA	NA	9	None	$8,753
49	2.1.3.4	Hydro Modernization at Existing Projects	Mature Commercial	Peaking	3,864	NA	NA	11	None	$52
50	3.3.1.1	Generic Pressurized Fluidized Bed Combustion Cogeneration (1x70 MW)	Large Scale Demo	Base	70	7,700	High Sulfur Coal	6	Steam	$0
51	4.1.1.1	Lignite-Fired Circulating Fluidized Bed Combustion Plant (1x200 MW)	Initial Commercial	Base	200	10,777	Lignite	7	None	$1,600
52	5.1.1.1	NUG - Generic IPP Lignite Circulating Fluidized Combustion Plant (1x300 MW)	Mature Commercial	Base	300	10,500	Lignite	5	None	$0
53	6.3.2.7	Gas Turbine - Modular Helium Reactor (3x289 MW)	Pilot Scale	Base	867	7,070	Nuclear	13	None	$2,273
54	6.3.4.1	Advanced Light Water Reactor (1x1300 MW)	Large Scale Demo	Base	1,300	10,200	Nuclear	10	None	$1,904
55	7.1.1.1	Bellefonte Repowering with Integrated Gasification Combined Cycle (9x250 MW)	Initial Commercial	Base	2,250	8,488	High Sulfur Coal	9	None	$1,484
56	7.1.1.2	Bellefonte Repowering with Pulverized Coal (4x616 MW)	Mature Commercial	Base	2,464	9,611	Medium Sulfur Coal	11	None	$1,263
57	7.1.1.3	Bellefonte Repowering - Phased Combined Cycle/IGCC - Phase A -Combined Cycle (9x222 MW)	Mature Commercial	Intermediate	1,997	7,367	Natural Gas	8	None	$551
58	7.1.1.4	Bellefonte Repowering - Phased Combined Cycle/IGCC - Phase B - IGCC (9x250 MW)	Initial Commercial	Base	2,250	8,463	High Sulfur Coal	7	None	$1,555
59	7.1.1.5	Bellefonte Repowering - IGCC with Coproduction (11x229 MW)	Initial Commercial	Base	2,520	12,560	High Sulfur Coal	11	Multi-products	$1,857
60	7.1.1.6	Bellefonte Repowering - IGCC with Coproduction with Partners (2x242 MW)	Initial Commercial	Base	484	7,200	Syngas	8	Multi-products	$465
61	7.1.1.7	Bellefonte Repowering - IGCC Demo with Partners (1x400 MW)	Initial Commercial	Base	400	7,200	Syngas	5	Multi-products	$600
62	7.1.2.1	Bellefonte Repowering - Natural Gas Combined Cycle (10x222 MW)	Mature Commercial	Intermediate	2,220	7,367	Natural Gas	8	None	$475
63	7.1.4.1	Completion of Bellefonte Unit 1 as Nuclear (1x1212 MW)	Mature Commercial	Base	1,212	10,204	Nuclear	5	None	$2,163
64	7.1.4.2	Completion of Bellefonte Unit 2 as Nuclear (1x1212 MW)	Mature Commercial	Base	1,212	10,204	Nuclear	6	None	$1,505

COST CHARACTERISTICS					ENVIRONMENTAL AND OTHER CHARACTERISTICS					
Fuel Cost ($/MMBtu)	Base Fixed Operating & Maintenance ($/kW-Yr)	Base Variable Operating & Maintenance (Mills/kWh)	Base Fixed Additions & Improvements ($/kW-Yr)	Base Decommissioning Cost ($ Million)	Sulfur Dioxide (lb/MMBtu)	Nitrogen Oxides (lb/MMBtu)	Carbon Dioxide (lb/MMBtu)	Thermal Discharge (MMBtu/MWh)	Solid Waste (lb/MMBtu)	Economic Development 1 (Annual Average Employment)
NA	$2.50	6.9	$1.10	$0	0	0	0	0	0	NA
NA	$4.00	4.2	$1.20	$0	0	0	0	0	0	NA
NA	$7.50	0	$11.40	$0	0	0	0	0	0	NA
NA	$7.50	0	$11.40	$0	0	0	0	0	0	NA
NA	$7.40	0	$11.40	$0	0	0	0	0	0	NA
NA	$6.90	0	$10.80	$0	0	0	0	0	0	619
NA	$150.00	40	$0.00	$0	0.25	0.1	210	0	30.14	NA
$1.40	$21.00	1.4	$18.50	$0	0.4	0.1	210	0	38.02	NA
NA	$240.80	12.9	$0.00	$0	0.6	0.27	210	0	38.02	280
$1.31	$39.60	0.3	$16.20	$300	0	0	0	0	0	NA
$0.41	$45.30	0.1	$16.20	$350	0	0	0	0	0	NA
$1.00	$20.40	1.2	$12.00	$0	0.05	0.03	205	0	9.48	NA
$1.38	$20.00	1.3	$13.60	$0	0.3	0.15	210	0	24.02	NA
$2.48	$5.00	2.8	$0.00	$0	0	0.03	115	0	0	NA
$1.00	$20.40	1.2	$12.00	$0	0.05	0.03	205	0	9.48	NA
$1.00	$27.80	2.6	$15.50	$0	0.035	0.03	173	0	9.48	NA
$3.59	$4.70	1.3	$4.50	$0	0.03	0.08	131	0	9.48	108
$3.59	$4.70	1.3	$4.50	$0	0.03	0.08	131	0	9.48	NA
$2.48	$4.70	1.3	$4.50	$0	0	0.03	115	0	0	NA
$0.41	$92.00	0	$12.40	$300	0	0	0	0	0	NA
$0.41	$46.00	0	$12.40	$300	0	0	0	0	0	NA

1 Calculated for selected options only

FIGURE T6-1. **Conventional TVA Supply-Side Options** *CONTINUED*

Number	Option ID	Option Name	Status	Duty Cycle	Net Full Load Capacity (MW)	Net Full Load Heat Rate (Btu/kWh)	Fuel	Total Schedule (Yr)	Coproducts	Base Capital Cost ($/kW)
			PERFORMANCE CHARACTERISTICS							
65	7.1.4.3	Bellefonte Units 1&2 Cancellation	NA	NA	NA	NA	NA	NA	NA	NA
66	7.1.4.4	Bellefonte- Partnership for Completion and Operation	Mature Commercial	Base	600	NA	Nuclear	4.5	None	NA
67	8.1.4.1	Recover Browns Ferry Unit 1 (1x1065 MW)	Mature Commercial	Base	1,065	10,418	Nuclear	5	None	$2,229
68	8.1.4.2	Browns Ferry Unit 1 Cancellation	NA	NA	NA	NA	NA	NA	NA	NA
69	8.1.4.3	Browns Ferry Unit 1 Recovery with Fixed Cost to Complete (1x1065 MW)	Mature Commercial	Base	1,065	10,418	Nuclear	5	None	$1,502
70	9.1.4.1	Completion of Watts Bar Unit 2 (1x1170 MW)	Mature Commercial	Base	1,170	10,000	Nuclear	5	None	$1,875
71	9.1.4.2	Watts Bar Unit 2 Cancellation	NA	NA	NA	NA	NA	NA	NA	NA
72	10.1.2.1	Inlet Air Precooling with Storage (16x61 MW)	Mature Commercial	Summer Peaking	982	8,847	Natural Gas	3	None	$51
73	10.1.2.2	New Combustion Turbine at Johnsonville to Supply Steam to DuPont (1x174 MW)	Mature Commercial	Base	174	9,834	Natural Gas	4	None	$1,113
74	10.1.2.3	Repowering One of JOF 7-10 with Natural Gas/Combined Cycle (1x465 MW)	Initial Commercial	Intermediate	465	7,100	Natural Gas	4	None	$481
75	10.1.2.4	Water Spray Cooling of Combustion Turbine Inlet Air	Initial Commercial	Summer Peaking	97	13,230	Natural Gas	2	None	$17
76	10.3.1.1	Repowering One of JOF Units 1-6 with IGCC (1x242 MW)	Initial Commercial	Base	242	8,700	High Sulfur Coal	7	None	$1,470
77	10.3.1.2	Repowering One of JOF Units 7-10 with IGCC (1x250 MW)	Initial Commercial	Base	250	8,400	High Sulfur Coal	7	None	$1,440
78	11.1.5.1	Laurel Branch Pumped-Hydro Storage (4x386 MW)	Mature Commercial	Peaking	1,544	NA	NA	10	None	$1,120
79	12.1.2.1	Generic Combined Cycle Cogeneration (2x210 MW)	Mature Commercial	Base	420	9,045	Natural Gas	4	Steam	$0
80	13.1.2.1	NUG - Generic IPP Combined Cycle (2x260 MW)	Mature Commercial	Intermediate	520	7,200	Natural Gas	4	None	$0
81	13.1.2.2	NUG - Generic IPP Combined Cycle (1x150 MW)	Mature Commercial	Intermediate	150	7,500	Natural Gas	5	None	$0
82	14.1.3.1	Wind - 33 Meter Variable Speed Advanced Wind Turbine (285x0.35 MW)	Initial Commercial	Intermediate	100	NA	Wind	6	None	$1,056
83	14.3.3.1	Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	Pilot Scale	Intermediate	200	NA	Wind	6	None	$958
84	15.1.5.1	Reynolds Creek Pumped-Hydro Storage (3x366 MW)	Mature Commercial	Peaking	1,098	NA	NA	10	None	$1,498
85	16.1.5.1	Raccoon Mountain Pumped-Hydro Energy Storage Addition (3x255 MW)	Mature Commercial	Peaking	765	NA	NA	10	None	$1,038
86	16.1.5.2	Raccoon Mountain Pumped-Storage Modernization	Mature Commercial	Peaking	1,608	NA	NA	6	None	$20
87	17.1.5.1	Rorex Creek Pumped-Hydro Storage (3x292 MW)	Mature Commercial	Peaking	876	NA	NA	10	None	$1,075
88	18.1.1.1	Shawnee Unit 11 (1x168 MW)	Mature Commercial	Base / Intermediate	168	10,241	Low Sulfur Coal	5	None	$561

COST CHARACTERISTICS					ENVIRONMENTAL AND OTHER CHARACTERISTICS					
Fuel Cost ($/MMBtu)	Base Fixed Operating & Maintenance ($/kW-Yr)	Base Variable Operating & Maintenance (Mills/kWh)	Base Fixed Additions & Improvements ($/kW-Yr)	Base Decommissioning Cost ($ Million)	Sulfur Dioxide (lb/MMBtu)	Nitrogen Oxides (lb/MMBtu)	Carbon Dioxide (lb/MMBtu)	Thermal Discharge (MMBtu/MWh)	Solid Waste (lb/MMBtu)	Economic Development 1 (Annual Average Employment)
NA	NA	NA	NA	$0	NA	NA	NA	NA	NA	NA
NA	$180.00	9.3	NA	NA	0	0	0	0	0	2,818
$0.41	$46.00	0	$14.10	$350	0	0	0	8.17	0	NA
NA	NA	NA	NA	$0	0	0	0	0	0	NA
$0.41	$46.00	0	$14.10	$350	0	0	0	0	0	NA
$0.41	$46.00	0	$12.80	$300	0	0	0	0	0	NA
NA	NA	NA	NA	$0	NA	NA	0	0	0	NA
$2.48	$2.50	2.6	$0.00	$0	0	0.16	115	0	0	NA
$2.48	$4.70	2.8	$0.00	$0	0	0.08	115	0	0	NA
$2.48	$5.30	0.9	$3.80	$0	0	0.08	115	0.39	0	110
$2.48	$4.70	2.8	$0.00	$0	0	0.08	115	3.68	0	NA
$1.00	$16.00	1.6	$18.80	$0	0.05	0.03	205	4.33	9.48	NA
$1.00	$26.30	1.6	$19.00	$0	0.05	0.03	205	4.06	9.48	NA
NA	$1.60	0	$2.50	$0	0	0	0	0	0	NA
NA	$120.00	15	$0.00	$0	0.0004	0.048	115	0	0	59
NA	$175.00	15	$0.00	$0	0.00063	0.048	115	0	0	27
NA	$86.70	17.2	$0.00	$0	0	0.08	115	0	0	15
$0.00	$25.00	0	$0.00	$0	0	0	0	0	0	76
$0.00	$15.00	0	$0.00	$0	0	0	0	0	0	108
NA	$1.80	0	$2.50	$0	0	0	0	0	0	NA
NA	$1.30	0	$2.50	$0	0	0	0	0	0	NA
NA	$1.40	0	$2.50	$0	0	0	0	0	0	NA
NA	$2.20	0	$2.50	$0	0	0	0	0	0	NA
$1.38	$19.60	0.6	$13.60	$0	1.2	0.8	205	0	0	92

1 Calculated for selected options only

FIGURE T6-1. **Conventional TVA Supply-Side Options** *CONTINUED*

Number	Option ID	Option Name	Status	Duty Cycle	Net Full Load Capacity (MW)	Net Full Load Heat Rate (Btu/kWh)	Fuel	Total Schedule (yr)	Coproducts	Base Capital Cost ($/kW)
			PERFORMANCE CHARACTERISTICS							
89	19.3.1.1	NUG - Generic Integrated Gasification Combined Cycle (1x110 MW)	Large Scale Demo	Base	110	8,200	High Sulfur Coal	5	None	$0
90	20.1.1.1	Restart One Unit of Watts Bar Fossil Plant (1x56 MW)	Mature Base/ Commercial	Intermediate	56	12,519	Low Sulfur Coal	4	None	$575
91	20.1.3.1	RDF - Fluidized Bed Combustion Repowering of One Unit of Watts Bar Fossil Plant (1x56 MW)	Mature Commercial	Base	56	14,000	Refuse-Derived Fuel	6	RDF Credit	$2,551
92	20.1.3.2	RDF Companion Boiler at Watts Bar Fossil (1x60 MW)	Mature Commercial	Base	60	14,000	Refuse-Derived Fuel	6	RDF Credit	$2,333
93	20.3.1.1	Repowering Two Units of Watts Bar Fossil Plant with IGCC (1x242 MW)	Initial Commercial	Base	242	8,900	High Sulfur Coal	7	0	$1,541
94	21.1.3.1	RDF Companion Boiler at Kingston Fossil Plant (1x60 MW)	Mature Commercial	Base	60	14,000	Refuse-Derived Fuel	6	RDF Credit	$2,333
95	22.1.1.1	NUG - Generic IPP Pulverized Coal with Cogeneration (2x170 MW)	Mature Commercial	Base	340	9,900	Low Sulfur Coal	4	Steam	$0
96	23.1.2.1	Power Purchase - Base Load (1x300 MW)	Mature Commercial	Base	300	NA	NA	0	0	$0
97	23.1.2.2	Power Purchase - Peaking (1x300 MW)	Mature Commercial	Peaking	300	NA	NA	0	None	$0
98	23.1.3.1	NUG - Generic IPP Run of River Hydro (4x20 MW)	Mature Commercial	Base	80	N/A	NA	4	None	$0
99	24.1.1.1	Unit Power Purchase 15 Year	Mature Commercial	Base	400	NA	NA	0	None	$0
100	24.1.1.2	Partially Complete Pulverized Coal Plant (1x710 MW)	Mature Commercial	Base	710	9,600	High Sulfur Coal	5	None	$888
101	25.1.2.1	Repowering Allen Fossil Plant with Natural Gas/ Combined Cycle (1x705 MW)	Initial Commercial	Intermediate	705	7,200	Natural Gas	4	None	$449
102	25.3.1.1	Repowering Allen Fossil Plant with IGCC (1x500 MW)	Initial Commercial	Base	500	8,200	High Sulfur Coal	7	0	$1,318
103	26.1.3.1	Biomass Cofiring - Customer Service	Initial Commercial	Base	See Note 1	Same as Existing Unit	See Note 1	1	None	$0.36
104	26.2.3.1	Biomass Cofiring - Low Level	Initial Commercial	Base	See Note 2	Same as Existing Unit	See Note 2	1	None	$2.70
105	26.3.3.1	Biomass Cofiring - Emissions Reduction (<$5/Ton CO_2)	Initial Commercial	Base	See Note 3	Same as Existing Unit	See Note 3	1	None	$3.10
106	28.2.3.2	Biomass Cofiring - Moderate Level at Colbert Fossil Plant Unit 5	Initial Commercial	Base	See Note 4	Same as Existing Unit	See Note 4	2	None	$20.10
107	29.1.5.1	NUG - Generic IPP Pumped-Hydro Storage	Initial Commercial	Peaking	1,000	NA	NA	0	None	$0

Note 1: This option applies to JSF,CUF,BRF,ALF,SHF1-9. There are no capacity changes from the current units. The capital cost is to add the cofiring capability. Adjustments should be made as follows: Fuel Cost =(Current Unit Coal Cost)*(1-.0031)+$0.60*.0031. Fixed O&M Costs=Current Unit+$0.09/kW. SO_2 Emissions=Current Unit Coal Emissions*(1-.0031). CO_2 Emissions=Current Unit Emissions*(1-.0031)-322*.0031. These adjustments reflect a 0.31% biomass energy input. All other cost and performance are same as current units.

Note 2: This option applies to COF1-4,GAF,JOF,KIF,PAF. There are no capacity changes from the current units. The capital cost is to add the cofiring capability. Adjustments should be made as follows: Fuel Cost =(Current Unit Coal Cost)*(1-.012)+$0.77*.012. Fixed O&M Costs=Current Unit+$0.09/kW. SO_2 Emissions=Current Unit Coal Emissions*(1-.012). CO_2 Emissions=Current Unit Emissions*(1-.012)-322*.012. These adjustments reflect a 1.2% biomass energy input. All other cost and performance are same as current units.

COST CHARACTERISTICS					ENVIRONMENTAL AND OTHER CHARACTERISTICS					
Fuel Cost ($/MMBtu)	Base Fixed Operating & Maintenance ($/kW-Yr)	Base Variable Operating & Maintenance (Mills/kWh)	Base Fixed Additions & Improvements ($/kW-Yr)	Base Decommissioning Cost ($ Million)	Sulfur Dioxide (lb/MMBtu)	Nitrogen Oxides (lb/MMBtu)	Carbon Dioxide (lb/MMBtu)	Thermal Discharge (MMBtu/MWh)	Solid Waste (lb/MMBtu)	Economic Development 1 (Annual Average Employment)
NA	$225.00	17	$0.00	$0	0.056	0.03	205	0	9.48	NA
$1.38	$29.50	0.3	$11.20	$0	1.2	0.8	205	7.73	9.48	NA
($1.54)	$83.00	1.8	$58.00	$0	0.07	0.1	0	9.05	21.43	132
($1.54)	$90.00	5.8	$0.00	$0	0.07	0.1	0	9.05	21.43	NA
$1.00	$10.90	1.5	$19.90	$0	0.05	0.03	205	4.51	9.48	NA
($1.54)	$90.00	5.8	$0.00	$0	0.07	0.1	0	9.05	21.43	NA
NA	$200.00	12	$0.00	$0	0.24	0.1	210	0	0	NA
NA	$114.50	22	$0.00	$0	0	0.1	115	0	0	0
NA	$33.60	31.8	$0.00	$0	0	0.1	115	0	0	0
NA	$50.00	17	$0.00	$0	0	0	0	0	0	160
NA	$42.60	19.7	$0.00	$0	0.6	0.7	205	0	0	NA
$1.00	$24.00	0.6	$16.20	$0	0.3	0.15	210	0	24.02	513
$2.48	$4.00	1.3	$5.40	$0	0	0.08	115	0.45	0	144
$1.00	$15.30	0.9	$19.00	$0	0.05	0.03	205	3.89	9.48	NA
See Note 1	See Note 1	Same as Existing Unit	Same as Existing Unit	$0	See Note 1	Same as Existing Unit	See Note 1	Same as Existing Unit	Same as Existing Unit	NA
See Note 2	See Note 2	Same as Existing Unit	See Note 2	$0	See Note 2	Same as Existing Unit	See Note 2	Same as Existing Unit	Same as Existing Unit	NA
See Note 3	See Note 3	Same as Existing Unit	See Note 3	$0	See Note 3	Same as Existing Unit	See Note 3	Same as Existing Unit	Same as Existing Unit	NA
See Note 4	See Note 4	Same as Existing Unit	See Note 4	$0	See Note 4	Same as Existing Unit	See Note 4	Same as Existing Unit	Same as Existing Unit	NA
NA	$151.20	33.8	$0.00	$0	0	0	0	0	0	NA

Note 3: This option applies to all plants. There are no capacity changes from the current units. The capital cost is to add the cofiring capability. Adjustments should be made as follows: Fuel Cost =(Current Unit Coal Cost)*(1-.0125)+$0.764*.0125. Fixed O&M Costs=Current Unit+$0.09/kW. SO_2 Emissions=Current Unit Coal Emissions*(1-.0125). CO_2 Emissions=Current Unit Emissions*(1-.0125)-322*.0125. These adjustments reflect a 1.25% biomass energy input. All other cost and performance are same as current units.

Note 4: This option applies to all COF5 only. There are no capacity changes from the current units. The capital cost is to add the cofiring capability. Adjustments should be made as follows: Fuel Cost =(COF5 Coal Cost)*(1-.10)+$0.73*.10. Fixed O&M Costs=COF5 Cost+$0.13/kW. SO_2 Emissions=COF5 Emissions*(1-.10). CO_2 Emissions=COF5 Emissions*(1-.10)-322*.10. These adjustments reflect a 10% biomass energy input. All other cost and performance are same as COF5.

[1] Calculated for selected options only

FIGURE T6-2. **Flexible TVA Supply-Side Options**

Number	ID Number	Option	Original Schedule (Yrs)	Accelerated Schedule (Yrs)	Cost to Obtain Accelerated Schedule ($/kW)	Cost Remaining ($/kW)
1	1.1.1.1.F	Supercritical Pulverized Coal-Fired Plant (1X300 MW)	8	3	$35	$1,579
2	1.1.1.2.F	Supercritical Pulverized Coal-Fired Plant (4X300 MW)	8	3	$10	$1,335
3	1.1.1.3.F	Atmospheric Fluidized Bed Combustion Repowering, Generic (1X125 MW)	6	3	$73	$1,046
4	1.1.1.4.F	Circulating Atmospheric Fluidized Bed Combustion Plant (1x200 MW)	8	3	$60	$1,426
5	1.1.1.5.F	Subcritical Pulverized Coal-Fired Plant (4x300 MW)	8	3	$8	$1,405
6	1.1.2.1.F	Simple Cycle Combustion Turbine Plant (1x150 MW)	5	1.5	$22	$338
7	1.1.2.2.F	Natural Gas-Fired Combined Cycle Plant (1x470 MW)	5	2	$14	$641
8	1.1.2.3.F	Combined Cycle Repowering, Generic (1x425 MW)	4	2	$14	$473
9	1.1.2.4.F	Small Cogeneration Combined Cycle Plant (3x10 MW)	4	1.5	$76	$1,044
10	1.1.2.5.F	Small Combined Cycle Plant (1X42 MW)	4.5	1.5	$59	$741
11	1.1.3.1.F	Refuse-Derived Fuel-Fired Stoker (1x40 MW)	8	3	$152	$5,588
12	1.1.5.1.F	Lead Acid Battery Energy Storage (1x20 MW)	3	1.5	$72	$506
13	1.2.1.1.F	State-of-the-Art Pulverized Coal-Fired Plant (1x400 MW)	8	4	$33	$1,384
14	1.2.2.1.F	Compressed Air Energy Storage with Humidification (3x337 MW)	7	3	$12	$303
15	1.2.2.2.F	Compressed Air Energy Storage with Recuperation (3x337 MW)	7	3	$11	$327
16	1.2.3.1.F	Biomass Whole Tree Energy Boiler Power Plant (1x100 MW)	8	3	$95	$1,417
17	1.3.1.1.F	First Generation Pressurized Fluidized Bed Combustion Repowering, Generic (1x156 MW)	6	3	$67	$1,100
18	1.3.1.2.F	First Generation Pressurized Fluidized Bed Combustion (1x340 MW)	8	3	$38	$1,243
19	1.3.1.3.F	Integrated Gasification Compressed Air Storage with Humidification (1x410 MW)	8	4	$36	$1,456
20	1.3.1.4.F	Integrated Gasification Combined Cycle with Fertilizer Coproduction (3x227 MW)	8	3.5	$23	$2,218
21	1.3.1.5.F	Integrated Gasification Combined Cycle (3x245 MW)	8	3.5	$18	$1,506
22	1.3.1.6.F	Compressed Air Storage with Humidification with Integrated Gasification & Natural Gas Peaking (1x850 MW)	8	4	$14	$858
23	1.3.1.7.F	Advanced Pressurized Fluidized Bed Combustor with Development Cost (1x300 MW)	8	3	$46	$1,472
24	1.3.1.8.F	Advanced Pressurized Fluidized Bed Combustor with No Development Cost (1x300 MW)	8	3	$42	$1,204
25	1.3.2.1.F	Fuel Cell - Molten Carbonate or Solid Oxide (1x2 MW)	4	1.5	$262	$772

FIGURE T6-2. **Flexible TVA Supply-Side Options** CONTINUED

Number	ID Number	Option	Original Schedule (Yrs)	Accelerated Schedule (Yrs)	Cost to Obtain Accelerated Schedule ($/kW)	Cost Remaining ($/kW)
26	1.3.2.2.F	Intercooled Aeroderivative Combustion Turbine (1x125 MW)	5	1.5	$36	$431
27	1.3.2.3.F	Cascaded Humidified Advanced Turbine (F Series CT) (1x288 MW)	6	2.5	$26	$477
28	1.3.2.4.F	Integrated Gasification Cascaded Humidified Advanced Turbine with Coproduction (F Series CT) (2x303 MW)	8	3.5	$21	$1,718
29	1.3.2.5.F	Integrated Gasification Cascaded Humidified Advanced Turbine (F Series CT) (2x303 MW)	8	3.5	$21	$1,222
30	1.3.2.6.F	Cascaded Humidified Advanced Turbine (G Series CT) (1x400 MW)	6	2.5	$20	$457
31	1.3.2.7.F	Integrated Gasification Cascaded Humidified Advanced Turbine with Coproduction (G Series CT) (2x420 MW)	8	3.5	$15	$1,607
32	1.3.2.8.F	Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	8	3.5	$15	$1,111
33	1.3.2.9.F	Integrated Fuel Cell/Combustion Turbine (1x2.5 MW)	4	1.5	$183	$1,057
34	1.3.3.1.F	Large Solar-Photovoltaic - Fixed Flat Plate (1x50 MW)	7	3	$111	$2,921
35	1.3.3.2.F	Landfill Methane (1x2 MW)	3	1.5	$205	$829
36	1.3.3.3.F	Coalbed Methane (1x2 MW)	3	1.5	$182	$852
37	1.3.5.1.F	Advanced Battery Energy Storage (1x20 MW)	3	1.5	$68	$423
38	1.3.5.2.F	Superconducting Magnetic Energy Storage (1x500 MW)	8	4	$26	$751
39	2.1.3.1.F	Additional Hydro Generation at Existing Nonpower Projects (1x10 MW)	5	3	$266	$2,194
40	2.1.3.2.F	Additional Hydro Generation at Existing Projects (1x24 MW)	6	3	$132	$4,156
41	2.1.3.3.F	Additional Hydro Generation - New Conventional Projects (1x65 MW)	9	5	$224	$8,529
42	4.1.1.1.F	Lignite-Fired Circulating Fluidized Bed Combustion Plant (1x200 MW)	7	3	$59	$1,541
43	6.3.2.7.F	Gas Turbine - Modular Helium Reactor (3x289 MW)	13	6	$28	$2,094
44	6.3.4.1.F	Advanced Light Water Reactor (1x1300 MW)	10	6	$18	$1,822
45	7.1.1.1.F	Bellefonte Repowering with Integrated Gasification Combined Cycle (9x250 MW)	9	3.5	$6	$1,478
46	7.1.1.2.F	Bellefonte Repowering with Pulverized Coal (4x616 MW)	11	4	$5	$1,258
47	7.1.1.3.F	Bellefonte Repowering - Phased Combined Cycle/IGCC - Phase A - Combined Cycle (9x222 MW)	8	2.5	$4	$547
48	7.1.1.4.F	Bellefonte Repowering - Phased Combined Cycle/IGCC - Phase B - IGCC (9x250 MW)	7	3	$4	$1,551
49	7.1.1.5.F	Bellefonte Repowering - IGCC with Coproduction (11x229 MW)	11	3.5	$6	$1,851
50	7.1.1.6.F	Bellefonte Repowering - IGCC with Coproduction with Partners (2x242 MW)	8	3.5	$20	$445
51	7.1.2.1.F	Bellefonte Repowering - Natural Gas Combined Cycle (10x222 MW)	8	2.5	$3	$472

FIGURE T6-2. **Flexible TVA Supply-Side Options** *CONTINUED*

Number	ID Number	Option	Original Schedule (Yrs)	Accelerated Schedule (Yrs)	Cost to Obtain Accelerated Schedule ($/kW)	Cost Remaining ($/kW)
52	10.1.2.1.F	Inlet Air Precooling with Storage (16x61 MW)	3	1	$2	$49
53	10.1.2.2.F	New Combustion Turbine at Johnsonville to Supply Steam to DuPont (1x174 MW)	4	2	$34	$1,079
54	10.1.2.3.F	Repowering One of Johnsonville Fossil (JOF) Units 7-10 with Natural Gas/Combined Cycle (1x465 MW)	4	2	$13	$468
55	10.3.1.1.F	Repowering One of JOF Units 1-6 with IGCC (1X242 MW)	7	3.5	$50	$1,420
56	10.3.1.2.F	Repowering One of JOF Units 7-10 with IGCC (1x250 MW)	7	3.5	$48	$1,392
57	11.1.5.1.F	Laurel Branch Pumped-Hydro Storage (4x386 MW)	10	7	$9	$1,111
58	14.1.3.1.F	Wind - 33 Meter Variable Speed Advanced Wind Turbine (285x0.35 MW)	6	2	$45	$1,011
59	14.3.3.1.F	Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	6	2	$24	$934
60	15.1.5.1.F	Reynolds Creek Pumped-Hydro Storage (3x366 MW)	10	7	$13	$1,485
61	16.1.5.1.F	Raccoon Mountain - Pumped-Hydro Energy Storage Addition (3x255 MW)	10	7	$13	$1,025
62	16.1.5.2.F	Raccoon Mountain Pumped-Storage Modernization	6	2	$1	$19
63	17.1.5.1.F	Rorex Creek Pumped-Hydro Storage (3x292 MW)	10	7	$15	$1,060
64	18.1.1.1.F	Shawnee Unit 11 (1x168 MW)	5	2.5	$30	$531
65	20.1.1.1.F	Restart One Unit of Watts Bar Fossil Plant (1x56 MW)	6	2.5	$86	$489
66	20.1.3.1.F	RDF - Fluidized Bed Combustion Repowering of One Unit of Watts Bar Fossil Plant (1x56 MW)	6	3	$136	$2,415
67	20.3.1.1.F	Repowering Two Units of Watts Bar Fossil Plant with IGCC (1x242 MW)	7	3.5	$48	$1,492
68	25.1.2.1.F	Repowering Allen Fossil Plant with Natural Gas/Combined Cycle (1x705 MW)	4	2	$9	$440
69	25.3.1.1.F	Repowering Allen Fossil Plant with IGCC (1x500 MW)	7	3.5	$24	$1,294

Option 1.1.1.1
SUPERCRITICAL PULVERIZED COAL-FIRED PLANT (1X300 MEGAWATTS)

This option is technically similar to the subcritical pulverized coal (PC)-fired plant, option 1.1.1.5, with the exception that the supercritical boiler operates at supercritical pressures of greater than 3,200 pounds per square inch. The properties of water at supercritical pressures are such that there is no discrete phase change from liquid water to steam as the fluid temperature is raised. Therefore, there is no need for a boiler drum for steam separation to occur as there is in a subcritical boiler. The supercritical PC boiler is a once-through design. The higher pressure steam cycle provides greater efficiency. The final main steam and reheat steam temperatures are 1,000°F.

The relatively high capital cost, low fuel cost, and high efficiency of the modern supercritical PC power plant make it a promising candidate for base-load capacity additions.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 1.1.1.2
SUPERCRITICAL PULVERIZED COAL-FIRED PLANT (4X300 MEGAWATTS)

This option is similar to the 1 X 300-megawatt supercritical pulverized coal-fired plant, option 1.1.1.1, except for the plant capacity. The 4 X 300-megawatt plant will have capital cost savings, on a dollar-per-kilowatt basis, relative to the single unit plant due to common facilities shared by each unit.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide. The Technical Assessment Guide procedures were used to determine cost adjustments for a multiple-unit plant.

Option 1.1.1.3
ATMOSPHERIC FLUIDIZED BED COMBUSTION REPOWERING, GENERIC (1X125 MEGAWATTS)

Option 1.1.1.4, which follows, describes the atmospheric fluidized bed combustion (AFBC) boiler and other systems. One or more existing coal-fired boilers could be retired and replaced with an AFBC boiler. For each retired boiler, one AFBC boiler would be installed. Steam generated in the AFBC boiler would power the existing steam turbine. The efficiency and capacity of the repowered unit would be approximately the same as the original unit.

The steam cycle systems, plant infrastructure, transmission facilities, fuel-handling facilities, and a permitted site would be reused. Therefore, the capital cost of repowering would be less than that for a greenfield AFBC unit of similar capacity. Repowering costs are very site-specific. The cost advantage of a repowering installation over a greenfield installation will depend on site characteristics.

Sulfur capture in the AFBC boiler would allow a range of fuels to be burned. High sulfur coal would be the design fuel.

Cost and performance data are based on an AFBC repowering proposal presented to TVA, with adjustments to reflect results from Electric Power Research Institute repowering studies.

Option 1.1.1.4
CIRCULATING ATMOSPHERIC FLUIDIZED BED COMBUSTION PLANT (1X200 MEGAWATTS)

Fluidized bed combustion (FBC) has attracted interest in the electric utility industry in the last decade due to its ability to meet sulfur dioxide (SO_2) and nitrogen oxides (NO_X) emissions standards without the need for add-on control equipment. Atmospheric FBC is now considered a commercial technology for utility applications in unit sizes up to about 200 megawatts. The AFBC option is based on the subcritical circulating FBC concept.

Crushed coal and limestone are injected at the bottom of the FBC furnace. SO_2 released from the coal combustion reacts with the calcium in the limestone to form a solid byproduct. The amount of sulfur captured in the process depends on the amount of limestone added. The furnace temperature is maintained in the optimum range for this reaction, 1500-1600°F. This relatively low temperature, compared to a pulverized coal furnace, reduces the formation of NO_X.

Fluidizing air from the forced draft fans and air heater is introduced from below the furnace to provide combustion air and maintain the fuel/limestone mixture in a well-mixed state throughout the height of the furnace. Solids that are carried out of the furnace are captured in a cyclone separator and recycled to the furnace to maximize carbon burnout and sulfur capture. The partially cleaned flue gas exits the cyclone into a convection pass, where additional heat transfer surfaces for steam superheating and reheating are located. An economizer surface is located near the exit of the convection pass. The flue gas passes through an air heater before final particulate collection in a fabric filter. Cleaned flue gas is exhausted to the atmosphere.

Heated feedwater is pumped from the steam turbine condenser to the boiler economizer. The feedwater then enters the boiler drum from which it is distributed to the waterwall furnace enclosure in which steam generation occurs. The steam/water mixture from the waterwalls re-enters the drum, where steam separation takes place. The steam is superheated in the boiler before exiting to the turbine. The final main steam pressure and

temperature are 2,400 pounds per square inch and 1,000°F, respectively. To increase efficiency, the steam is reheated after partial expansion in the steam turbine to 1,000°F.

Energy in the steam is converted to electrical energy by the turbine-generator. The turbine exhaust steam is condensed and pumped back to the boiler through a series of feedwater heaters. Heat is rejected from the condenser cooling water to the atmosphere in a mechanical draft cooling tower.

Ash, consisting of coal ash and limestone products (including the captured sulfur), is removed from the fabric filter and the furnace bottom and disposed of on-site.

Sulfur capture in the AFBC boiler would allow a range of fuels to be burned. High sulfur coal is the design fuel for the AFBC option.

The relatively high capital cost, low fuel cost, and relatively high efficiency of the AFBC plant make it a candidate for base-load capacity additions.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 1.1.1.5

SUBCRITICAL PULVERIZED COAL-FIRED PLANT (4X300 MEGAWATTS)

The pulverized coal (PC)-fired boiler with steam turbine power generation is currently the principal electricity generation technology in the United States.

Coal is delivered from on-site storage or receiving facilities to day bunkers in the powerhouse. From the day bunkers, coal is metered to the pulverizers, where it is ground to a very small particle size. The pulverized coal is air-conveyed to burners penetrating the walls of the furnace. This conveying air, as well as the remainder of the combustion air, is provided by the forced draft fans through an air heater. The air heater recovers heat from the flue gas exiting the boiler prior to the gas being exhausted to the atmosphere.

Heated feedwater is pumped from the turbine condenser to the boiler economizer in which energy is recovered from the flue gas prior to the gas exiting the boiler. The feedwater then enters the boiler drum from which it is distributed to the waterwall furnace enclosure in which steam generation occurs. The steam/water mixture from the waterwalls re-enters the drum, where steam separation takes place. The steam is superheated in the boiler before exiting to the turbine. Energy in the steam is converted to electrical energy by the turbine-generator. To increase efficiency, the steam is reheated after partial expansion in the steam turbine and readmitted to the turbine. The turbine exhaust steam is condensed and pumped back to the boiler as feedwater through a series of feedwater heaters. Heat is rejected from the condenser cooling water to the atmosphere in a mechanical draft cooling tower. For the subcritical PC option, the final main steam pressure, main steam temperature, and reheat temperature are 2,400 pounds per square inch, 1,000°F, and 1,000°F, respectively.

Selective catalytic reduction (SCR), located in the region of the boiler where flue gas temperature is optimal for nitrogen oxides (NO_X) reduction, is used to control NO_X emissions. A fabric filter located downstream of the air heater controls particulate emissions. Sulfur dioxide (SO_2) emissions are controlled with a limestone flue gas desulfurization (FGD) system, or scrubber. The cleaned flue gas is exhausted to the atmosphere. Ash collected in the fabric filter and gypsum from the FGD system are disposed of on-site.

This option is based on a total 1,200-megawatt capacity, four-unit plant. Each unit has a 300-megawatt capacity. Multiple-unit plants offer capital cost savings on a dollar-per-kilowatt basis compared to single-unit plants due to common facilities, such as fuel handling, transmission facilities, and others that are shared by each unit.

High sulfur coal is the design fuel for the subcritical PC option.

The relatively high capital cost, low fuel cost, and relatively high efficiency of the modern subcritical PC power plant make it a candidate for base-load capacity additions.

Cost and performance data are based on TVA estimates and historical performance.

Option 1.1.2.1

SIMPLE CYCLE COMBUSTION TURBINE PLANT (1X150 MEGAWATTS)

A simple cycle combustion turbine (CT) generator consists of an air compressor, combustor, and expansion turbine. Gaseous or liquid fuels are burned under pressure in the combustor. The hot, high pressure combustion products expand through the turbine. The turbine drives the air compressor, as well as an electric generator. The electric generator converts the mechanical energy produced by the turbine into electrical energy. Gases from the expansion turbine are exhausted to the atmosphere.

The primary fuel will be natural gas with fuel oil as the back-up fuel.

The major emissions from combustion turbines fired with natural gas are nitrogen oxides (NO_X). To reduce NO_X emissions, dry, low NO_X burners would be used. As natural gas contains negligible amounts of sulfur, sulfur dioxide (SO_2) emissions are essentially zero. Because of the higher hydrogen content of the natural gas fuel relative to coal, carbon dioxide (CO_2) emissions on an energy input basis will be lower than the emissions for coal-based technologies.

Combustion turbine efficiency is strongly affected by CT firing temperature. This option reflects the current generation of advanced CTs operating at a firing temperature of 2,350°F.

Several features of simple cycle CTs, including their relatively low capital cost, short construction times, low emissions, rapid start-up times, relatively high fuel costs (compared with coal), and relatively low efficiency (compared to combined cycle CTs and most modern coal-based technologies), make this technology attractive for peaking capacity additions.

The cost and performance data are based on information provided by a combustion turbine supplier.

Option 1.1.2.2

NATURAL GAS-FIRED COMBINED CYCLE PLANT (1X470 MEGAWATTS)

The combined cycle power plant consists of a combustion turbine (CT) generator, option 1.1.2.1, and a steam turbine-generator. The hot exhaust gases from the CT pass through a heat recovery steam generator (HRSG). The HRSG reduces the CT exhaust from about 1,100°F to about 300°F before it is exhausted to the atmosphere. Steam raised in the HRSG powers the steam turbine-generator. Steam turbine exhaust is condensed and pumped back to the HRSG as feedwater. Heat is rejected from the condenser cooling water to the atmosphere in a mechanical draft cooling tower. The CT provides about two-thirds of the generated power and the steam turbine about one-third. The heat recovery from the CT exhaust provides an efficiency improvement over the simple cycle CT.

The primary fuel will be natural gas with fuel oil as the back-up fuel.

Nitrogen oxides (NO_X) emissions from the combined cycle CT will be controlled by selective catalytic reduction (SCR). Optimal performance of the SCR requires a relatively narrow gas temperature range. The SCR will be installed in the region of the HRSG, where the gas temperature is optimum for SCR performance. Sulfur dioxide emissions from the natural gas fuel would be essentially zero. The high efficiency and natural gas fuel combine to produce relatively low carbon dioxide (CO_2) emissions.

Features of the combined cycle CT option, including its high efficiency, moderate capital cost, relatively high fuel cost, low emissions, and short construction time make this technology a candidate for intermediate capacity additions.

The cost and performance data are based on information provided by a combined cycle CT supplier.

Option 1.1.2.3

COMBINED CYCLE REPOWERING, GENERIC (1X425 MEGAWATTS)

Repowering coal-fired generating units may in some cases provide operating cost savings, emissions reductions, capacity addition, and life extension of existing power-generating facilities. TVA has several low efficiency, relatively low capacity (less than 125 megawatts), aging coal-fired generating units for which repowering may be advantageous.

For each retired coal-fired boiler, two natural gas-fired combustion turbines (CT) and heat recovery steam generators (HRSG) would be installed at the plant site. The steam raised in the HRSGs would power the existing steam turbine that was previously powered by the coal-fired boiler. The HRSGs would be designed to provide steam that matches the conditions of the steam turbine. The turbine exhaust is condensed and pumped back to the HRSG as feedwater. If the capacity of the steam turbine is maintained, the additional capacity of the CTs provides a total repowered unit capacity approximately three times that of the unit prior to repowering.

Steam cycle systems, plant infrastructure, transmission facilities, and a permitted site would be reused. Therefore, capital costs for repowering would be less than for a greenfield plant of similar capacity. Repowering costs are very site-specific. The cost advantage of a repowering installation over a greenfield installation depends on site characteristics. Combined cycle repowering would provide efficiency improvement relative to the unit prior to repowering. Efficiency would not likely be as high as for a greenfield combined cycle CT plant.

Nitrogen oxides (NO_X) emission control by selective catalytic reduction (SCR) and negligible sulfur dioxide (SO_2) emissions associated with the natural gas fuel would result in lower emissions of these gases relative to the unit prior to repowering. The fuel switch to natural gas and the higher efficiency relative to the unit prior to repowering would result in lower carbon dioxide emissions.

The cost and performance data are based on information provided by a combined cycle combustion turbine supplier. Costs were based on CT selection and HRSG design that would fully repower a specific steam turbine. Other applications of this option are considered to be similar.

Option 1.1.2.4

SMALL COGENERATION COMBINED CYCLE PLANT (3X10 MEGAWATTS)

The small cogeneration combined cycle plant consists of three small combustion turbines (approximately 10 megawatts each), with each combustion turbine exhausting flue gas into separate heat recovery steam generators. The steam conditions

from the steam generators are driven by the pressure and temperature requirements of the steam host. Either a condensing steam turbine or a backpressure steam turbine may be added to the configuration to provide low pressure steam at various pressure levels if required by the steam host. The combustion turbines can be fired by either natural gas or #2 fuel oil.

Each combustion turbine/heat recovery steam generator pair can produce 37,000 pounds of steam per hour without duct firing. Thus, the small cogeneration combined cycle plant can produce in excess of 100,000 pounds of steam per hour. The addition of duct firing can raise the amount of steam produced significantly, but at the expense of the higher steam production cost due to fuel used by the duct burners.

The cost and performance information provided are based upon data from Black & Veatch on their "Instant Power Station" joint venture with Solar Turbines. The primary advantage of this type of plant is its very short lead time.

Option 1.1.2.5

SMALL COMBINED CYCLE PLANT (1X42 MEGAWATTS)

The small combined cycle plant consists of three small combustion turbines (CT), approximately 10 megawatts each, with each combustion turbine exhausting flue gas into separate heat recovery steam generators. The steam from the three steam generators is passed to a single condensing steam turbine (ST) bottoming cycle. The steam cycle heat rejection is through cooling towers. The combustion turbines can be fired by either natural gas or #2 fuel oil.

The small combined cycle plant can produce approximately 42 megawatts of electricity at ISO (International Standards Organization) conditions. The addition of duct firing can raise the amount of steam produced significantly, thus increasing power output, but at a higher steam production cost due to fuel used by the duct burners.

The cost and performance information provided is based upon data from Black & Veatch on their "Instant Power Station" joint venture with Solar Turbines. The primary advantage of this type of plant is its very short lead time.

Option 1.1.3.1

REFUSE-DERIVED FUEL-FIRED STOKER (1X40 MEGAWATTS)

Option 20.1.3.2

REFUSE-DERIVED FUEL COMPANION BOILER AT WATTS BAR FOSSIL PLANT (1X60 MEGAWATTS)

Option 21.1.3.1

REFUSE-DERIVED FUEL COMPANION BOILER AT KINGSTON FOSSIL PLANT (1X60 MEGAWATTS)

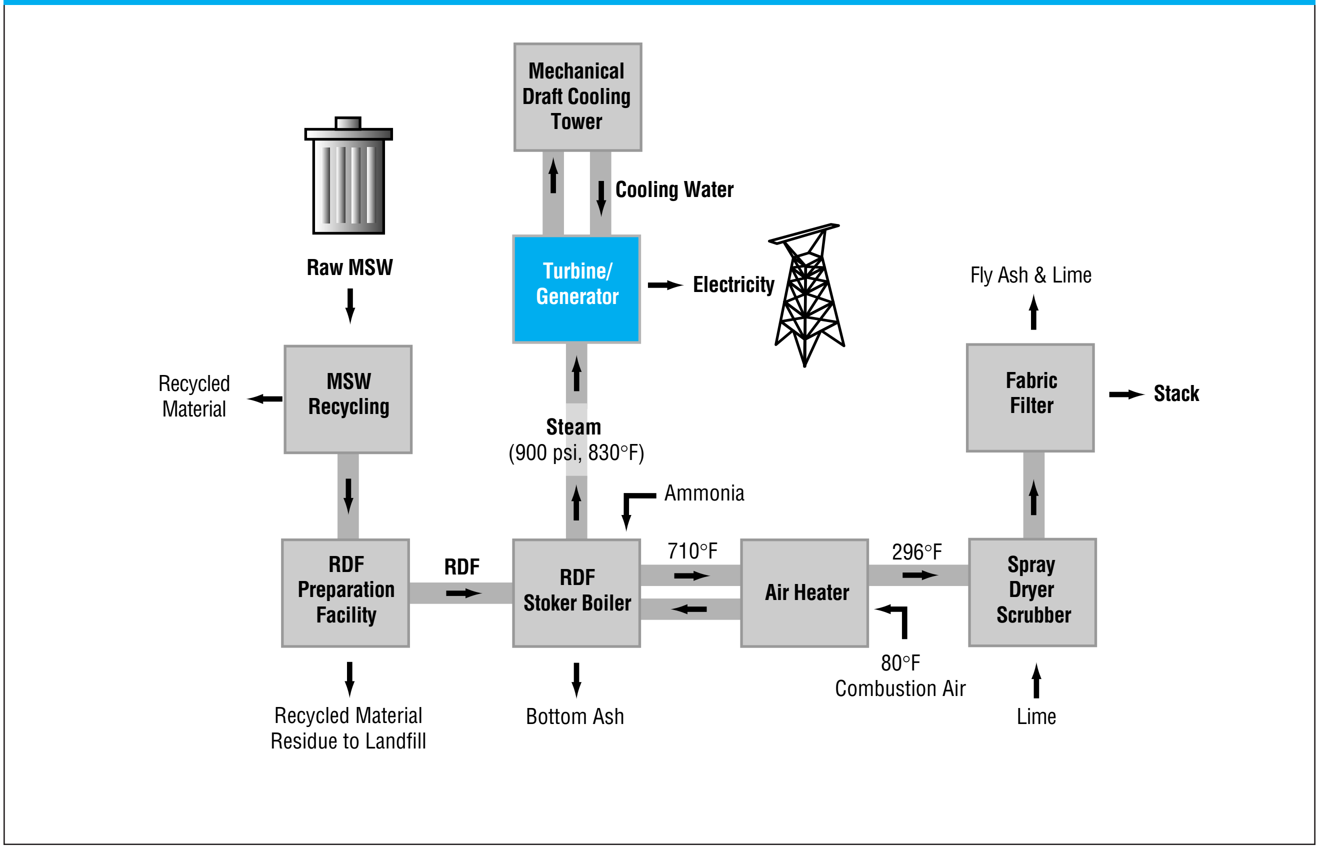
The refuse-derived fuel-fired power plant consists of both the refuse-derived fuel (RDF) preparation facility and the RDF-fired stoker boiler power plant.

After the removal and recycling of about 20 percent of the material from the raw municipal solid waste (MSW), the remaining MSW is delivered by truck to the tipping floor of the on-site RDF preparation facility. The production facility consists of three parallel trains, each sized to process about 100 tons of MSW per hour over five days per week. The waste passes through a sequence of process steps, including flail milling, trommel screening, magnetic separation, and size reduction to produce RDF containing about 12 percent ash and 5,900 Btu per pound higher heating value (HHV). The RDF is stored in a live-bottom hopper and transported by conveyor as needed to the power plant, where it is injected by spreaderstoker and burns both in suspension and on the grate. The steam conditions are 900 pounds per square inch and 830°F. The remainder of the plant includes waterwall and convective heat transfer surfaces, a steam turbine generator, a mechanical draft cooling tower, an ammonia thermal de-NO_X (nitrogen oxides) system, a lime spray dryer scrubber, a baghouse, fans, and ash disposal.

The 40-megawatt RDF preparation and stoker power plant consumes 1,736 tons of MSW per day, delivered to the plant after recycling off-site about 400 tons per day of paper, glass, metals, and other materials from 2,166 tons of raw MSW per day. The RDF preparation plant produces 1,396 tons of RDF per day, with a moisture content of 28.2 percent and 5,663 Btu per pound (HHV as received), which is consumed by the stoker boiler. The gross capacity is 46.2 megawatts, auxiliary power consumption is 6.2 megawatts, and the net plant heat rate at full load is 16,464 Btu per kilowatt-hour, based on the RDF fuel (20.7 percent thermal efficiency). *Figure T6-3* shows a diagram of an RDF preparation and stoker boiler power plant.

The companion boiler options produce steam for use in existing steam turbines. At Watts Bar, the companion boiler would displace an existing boiler to supply an existing steam turbine. At Kingston, the steam from the companion boiler would

FIGURE T6-3. **RDF Preparation and Stoker Boiler Power Plant**



increase the steam flow to existing turbines to make use of excess turbine capacity. Since these options are rated at 60 megawatts, the quantities of RDF would be proportionally higher than for the 40-megawatt stoker option. Otherwise, the companion boiler options are similar to the RDF stoker option.

The cost and performance data are based on Electric Power Research Institute's Technical Assessment Guide.

Option 1.1.5.1
LEAD ACID BATTERY ENERGY STORAGE (1X20 MEGAWATTS)

Low cost, off-peak electricity would be used to charge the lead acid battery plant. The plant has a 20-megawatt capacity and a 2-hour discharge time. The battery plant would be used for heavy duty applications such as load leveling and frequency regulation with deep discharge.

Battery plants have a very rapid response time of less than one-tenth of a second to reach full load. Another advantage of battery plants is their siting flexibility. They could be located virtually anywhere, including in urban areas.

There would be no emissions associated with the battery plant itself; however, there would be emissions from the generation sources used to charge the plant.

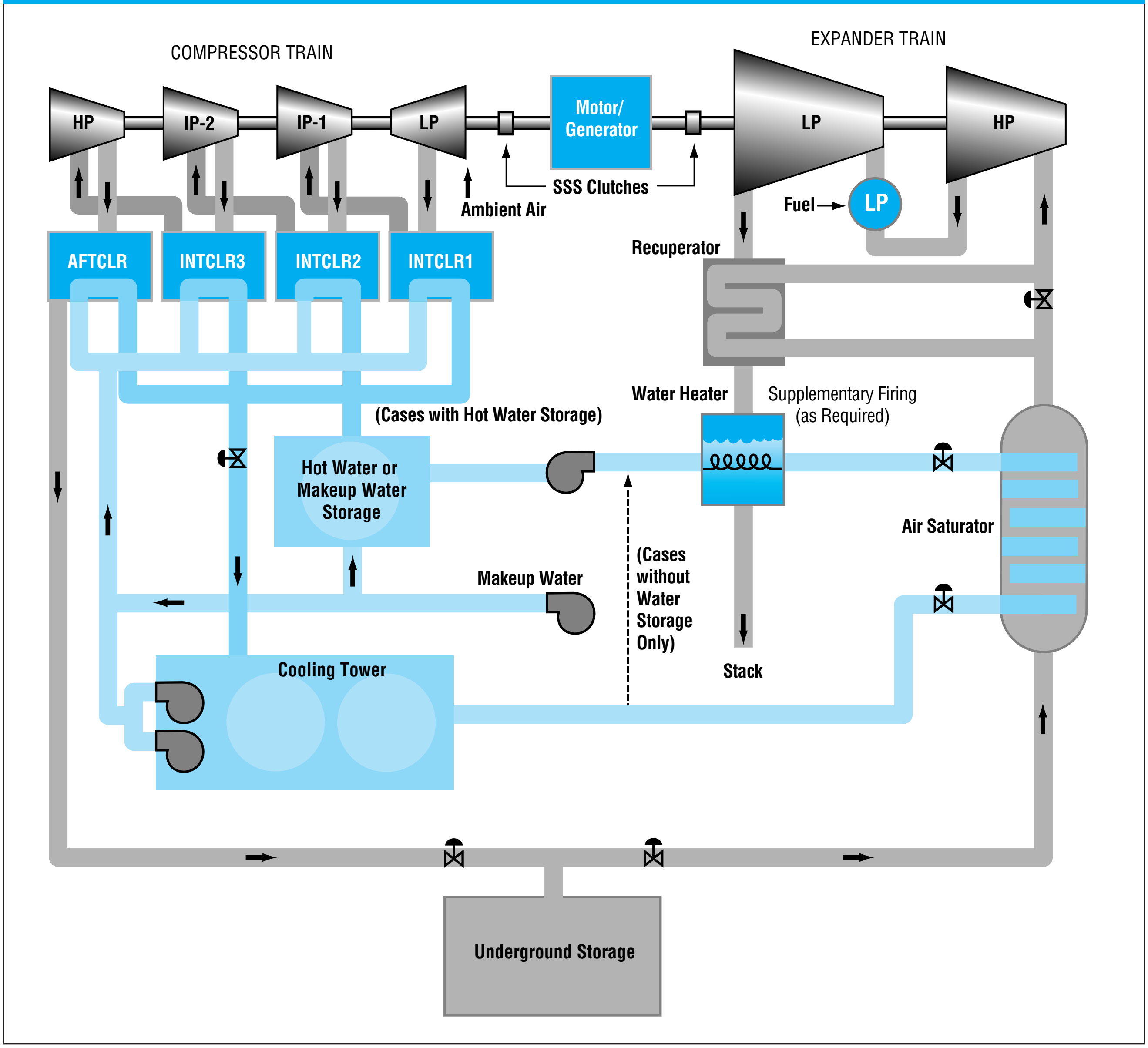
The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 1.2.1.1
STATE-OF-THE-ART PULVERIZED COAL-FIRED POWER PLANT (1X400 MEGAWATTS)

The state-of-the-art pulverized coal-fired power plant (SOAPP-PC) is a concept that is intended to be competitive with other advanced coal-fired technologies such as integrated gasification/combined cycle. Its basic performance and cost goals are to produce power at a heat rate in the low 8,000 Btu per kilowatt-hour range, have the same or lower operating and maintenance costs as a conventional pulverized coal (PC)-fired plant, and achieve this with the same or lower capital investment as a conventional PC-fired plant.

The SOAPP-PC concept is based on a supercritical double reheat steam cycle. The steam is at a 4,500 pounds per

FIGURE T6-4. **Schematic of CAES Plant with Air Humidification**



square inch gauge main steam pressure at 1,100°F. The first and final reheats are at 1,100°F. The steam generator has a spiral wound once-through design to minimize variations in heat absorption patterns. The cycle is equipped with nine stages of regenerative feedwater heating. The plant has conventional flue gas desulfurization and particulate removal, and is equipped with low nitrogen oxides (NO_X) burners and a selective catalytic reduction unit for NO_X control. Heat rejection is through a natural draft cooling tower.

The cost and performance information is obtained from Sargent & Lundy as part of their contract with Electric Power Research Institute to develop SOAPP designs for PC-fired and natural gas-fired combined cycle power plants.

Option 1.2.2.1

COMPRESSED AIR ENERGY STORAGE PLANT WITH HUMIDIFICATION (3X337 MEGAWATTS)

Option 1.2.2.2

COMPRESSED AIR ENERGY STORAGE PLANT WITH RECUPERATION (3X337 MEGAWATTS)

Compressed air energy storage (CAES) combines features from conventional combustion turbines and pumped-hydro storage.

During periods of relatively low electricity demand and, therefore, low power generation costs, air is compressed and stored in an underground reservoir. The equipment is analogous to the compressor used in a combustion turbine and the process is similar to the pumping and storing of water at a higher elevation in pumped hydro.

During periods of high electricity demand, the pressurized air from the underground reservoir is expanded through a high pressure turbine to produce power. The air enters a combustor where its temperature is raised, and then it expands through a low pressure turbine, producing additional power. The exhaust from the low pressure turbine goes to a recuperator to heat the air entering the high pressure turbine.

In CAES with humidification, the air entering the high pressure turbine is saturated with water vapor, which increases the mass flow through the turbines, and increases the amount of power produced per pound of air that has to be compressed. Again, this equipment is roughly analogous to the turbomachinery in a combustion turbine, and the process is similar to the power generation from water stored at a higher elevation in pumped hydro. *Figure T6-4* shows a schematic of a CAES plant with air humidification, and *Figure T6-5* shows a schematic of a conventional CAES plant.

Based on extensive studies of underground storage in the oil and natural gas industry, several geologies appear to be suitable for air storage: salt domes, aquifers including depleted natural gas fields, and hard rock.

The costs for this option assume storage in salt dome geology. The performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 1.2.3.1

BIOMASS WHOLE TREE ENERGY™ BOILER POWER PLANT (1X100 MEGAWATTS)

The Whole Tree Energy™ (WTE) boiler is a new direct combustion technology being developed with support from Electric Power Research Institute and other sponsors for application in large-scale power production from energy crops. The WTE system involves the harvesting of stands of close-growing whole trees, transport by truck, tree storage, and drying using air heated by boiler flue gas, and combustion of the whole trees in a special deep bed burner at the bottom of the furnace.

FIGURE T6-5. **Schematic of Conventional CAES Plant**

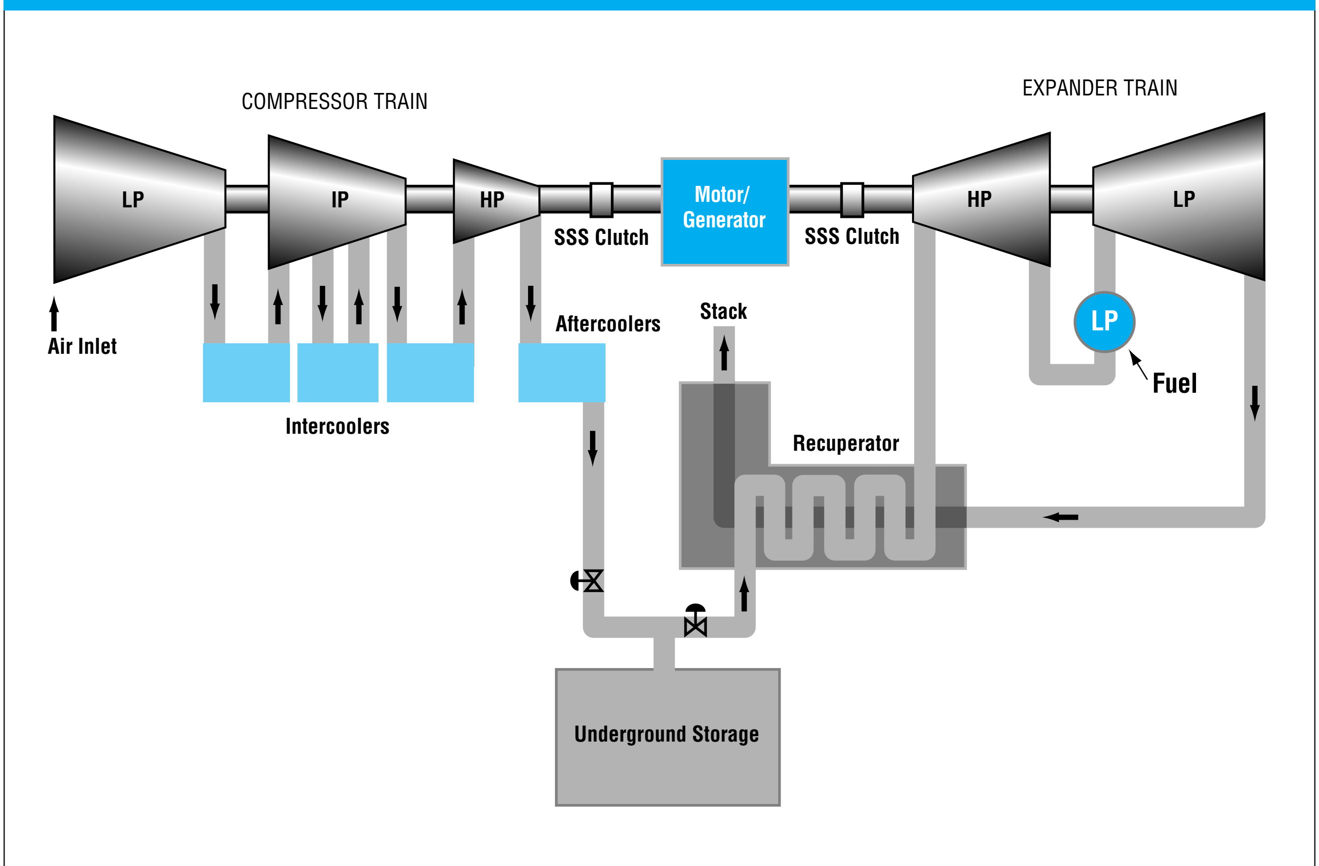
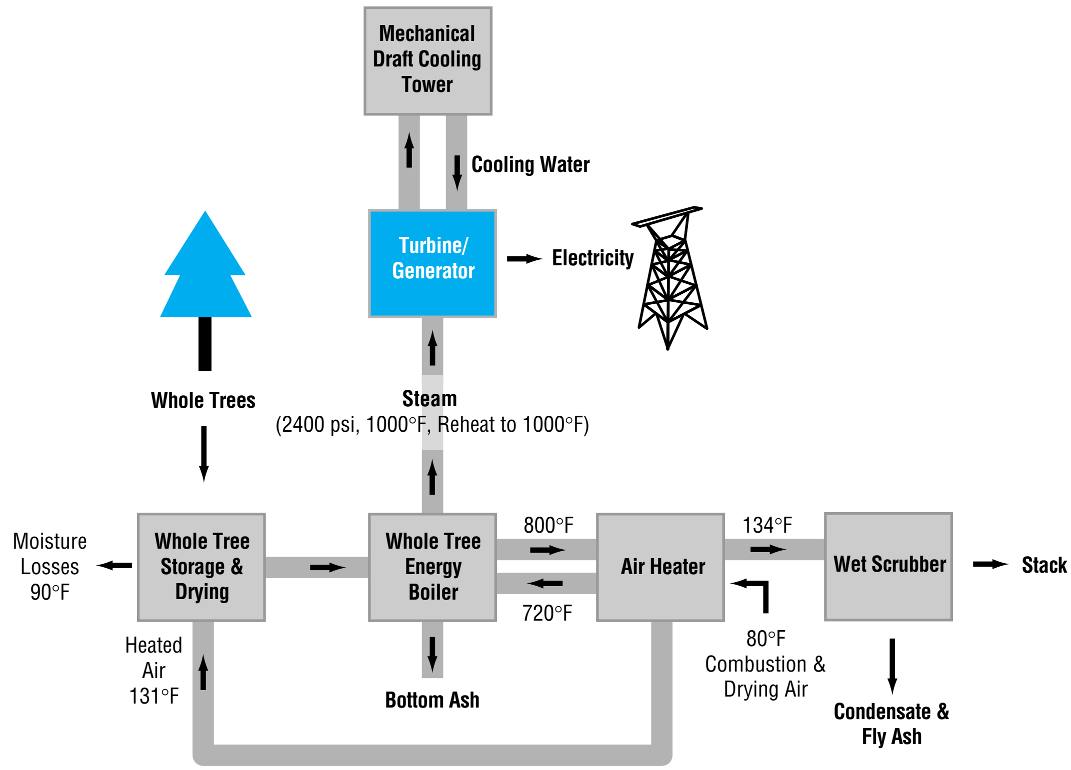


FIGURE T6-6. **Whole Tree Energy™ Boiler Power Plant**



After harvesting and delivery to the plant, the whole trees are stacked in an annular ring in the air-supported fabric dome drying building. Air heated to about 130°F in the boiler air heater is injected under the pile to dry the trees from about 45 to 25 percent moisture content. After 30 days of storage and drying, the trees are removed, cut to uniform length, and loaded through a sealing access door into the deep-bed combustor. Air injected into the bottom of the bed is sufficient to burn out the remaining char, provide heat to drive off volatiles, and gasify the whole trees in the upper bed. Overfire air is injected into the furnace above the bed to complete combustion of the volatiles. The two-stage condensing heat exchanger at the boiler exit cools the flue gases from about 800°F to 134°F, and heats the combustion air to 721°F and wood drying air to 131°F before transport to the drying building. A portion of the flue gas moisture condenses in the second stage and is collected, along with the fly ash, in a wet scrubber. The plant has main steam pressure and temperature of 2,400 pounds per square inch absolute and 1,000°F, with a reheat steam temperature of 1,000°F to achieve maximum thermal efficiency. Other plant components include the ammonia de-NO_X (nitrogen oxides) system, generator, cooling tower, and fans. Due to the relatively low gas velocity in the deep bed combustor, about 60 percent of the wood ash remains behind in the combustor, and the remainder is discharged as fly ash. *Figure T6-6* shows a diagram of a Whole Tree Energy™ boiler power plant

The 100-megawatt Whole Tree Energy™ boiler power plant receives about 2,642 tons of whole trees per day, and after the 30-day drying period, fires about 1,887 tons of dried trees per day. Gross capacity is 107.5 megawatts, auxiliary power consumption is 7.5 megawatts, and the net plant heat rate at full load is 10,654 Btu per kilowatt-hour (32 percent thermal efficiency).

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 1.3.1.1
FIRST GENERATION PRESSURIZED FLUIDIZED BED COMBUSTION REPOWERING, GENERIC (1X156 MEGAWATTS)

Option 1.3.1.2, below, describes the pressurized fluidized bed combustion (PFBC) boiler and other systems. One or more existing coal-fired boilers could be retired and replaced with a PFBC boiler. For each retired boiler, one PFBC boiler, hot gas filter, and expansion turbine would be installed. Steam generated in the PFBC boiler would power the existing steam turbine. The addition of the gas expansion turbine would result in a net capacity increase of approximately 20 percent. The repowered unit efficiency would be improved by about 20 percent. The efficiency would not likely be as high as a greenfield PFBC unit.

Steam cycle systems, plant infrastructure, transmission facilities, fuel handling facilities, and a permitted site would be reused. Therefore, the capital cost for repowering would be less than for a greenfield PFBC unit of similar capacity. Repowering costs are very site-specific. The cost advantage of a repowering installation over a greenfield installation depends on site characteristics.

Sulfur capture in the PFBC boiler would allow a range of fuels to be burned. High sulfur coal would be the design fuel.

Cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide and other information reported from Electric Power Research Institute.

Option 1.3.1.2
FIRST GENERATION PRESSURIZED FLUIDIZED BED COMBUSTION (1X340 MEGAWATTS)

The discussion of circulating atmospheric fluidized bed combustion (AFBC), option 1.1.1.4, describes the fluidized bed combustion (FBC) boiler. In a pressurized fluidized bed combustion (PFBC) unit, the FBC boiler is enclosed in a pressure vessel. The hot (about 1,600°F), pressurized flue gas exiting the cyclone is cleaned of particulates in a ceramic filter. The cleaned gas passes through an expansion turbine that drives an electric generator, as well as an air compressor that pressurizes the PFBC pressure vessel. Energy is recovered from the expansion turbine exhaust gas by boiler feedwater in an economizer before the gas is exhausted to the atmosphere. The PFBC plant consists of four PFB boiler/gas turbine modules powering one steam turbine (ST).

Steam is generated, superheated, and reheated in the PFBC boiler to drive a conventional steam turbine-generator. About 80 percent of the net power output is from the steam turbine, and about 20 percent is from the gas expansion turbine.

The PFBC boiler has a greater energy input per unit of boiler footprint area than either the AFBC or pulverized coal (PC) boilers. Therefore, the PFBC boiler requires less area for installation. The combined cycle feature of the unit (a steam turbine and a gas expansion turbine) provides for greater efficiency than either the AFBC or PC unit.

Sulfur capture in the PFBC boiler would allow a range of fuels to be burned. High sulfur coal would be the design fuel.

PFBC technology is considered to be at the large-scale demonstration stage of development.

Cost and performance data are based on reported information from Electric Power Research Institute.

Option 1.3.1.3
INTEGRATED GASIFICATION COMPRESSED AIR STORAGE WITH HUMIDIFICATION (1X410 MEGAWATTS)

The integrated gasification compressed air storage with humidification (IGCASH) cycle combines important features from compressed air energy storage, the humid air turbine concept, and coal gasification to form a new power cycle with low capital costs and improved operating flexibility compared to other coal-fired power plants.

In an IGCASH plant, the coal gasification system operates continuously to produce syngas, which is burned in a combustion turbine to generate power. The combustion turbine uses compressed air from an underground storage reservoir (e.g., a salt dome or aquifer), which is charged by a compressor train that operates only intermittently. The compressed air from the storage reservoir is humidified in a saturator so that the required air flow is significantly reduced. Reduced air flow from humidification lowers compressor energy requirements and the underground volume required for storage. Before entering the combustion turbine, the humidified air is heated in a recuperator utilizing the hot gas from the turbine exhaust.

During periods when the demand for electricity is low, the compressor train charges the air reservoir and consumes all the power output of the combustion turbine, making the net output of the plant zero. During high load periods, the compressor is shut off and the power output of the combustion turbine is transmitted to the electric grid.

IGCASH plants have the superior environmental emissions performance characteristics of all such integrated gasification plants. Sulfur dioxide (SO_2) and nitrogen oxides (NO_X) emissions are very low, while carbon dioxide (CO_2) emissions are relatively high because of the coal fuel and the heat rate, which is only average. Since the gasification plant runs 24 hours per day while the cycle is only intermediate duty, the gasification plant size is reduced and the plant capital cost is

therefore reduced. This plant should have excellent cycling characteristics since the hot components and gasification plant maintain steady operation.

One disadvantage of this cycle is the heat rate, which is not outstanding. Also, total daily generation is limited by the air stored in the underground reservoir and the amount of air injected into the reservoir by the compressor train.

Most, but not all, of the components needed for this cycle have been used in existing commercial power plants. The major exceptions are the saturator, which operates at high pressure (low pressure saturators are common in the chemical industry), and combustion with very humid air. An IGCASH plant has not yet been demonstrated, and there are no plans at this time for such a demonstration.

The cost and performance data are from Electric Power Research Institute's Technical Assessment Guide. Some performance data are inferred from other cycles.

Option 1.3.1.4
INTEGRATED GASIFICATION COMBINED CYCLE WITH FERTILIZER COPRODUCTION (3X227 MEGAWATTS)

The integrated gasification combined cycle with fertilizer coproduction (IGCC/F) option is similar to the IGCC described in option 1.3.1.5, except that a portion of the syngas is converted into chemical coproducts. A variety of coproducts can be produced from the oxygen-blown gasifier syngas. Sale of the coproduct(s) effectively reduces the cost of electricity from the IGCC/F plant. This option is based on fertilizer production.

The same gasifier capacity was considered for the IGCC option. Since a portion of the syngas is used for coproduct production and is not available for power generation, the electrical capacity of each of the 3 IGCC/F units is reduced to 227 megawatts. Similarly, the efficiency, on a kilowatt-hour basis is less than that for an IGCC plant without coproduction.

Cost and performance data are based on engineering studies performed by TVA and external architects and engineers.

Option 1.3.1.5
INTEGRATED GASIFICATION COMBINED CYCLE (3X245 MEGAWATTS)

Coal gasification is a method of producing relatively clean, burnable gas from almost any type of coal. The basic process involves crushing the coal and partially oxidizing the carbon in the coal. Partial oxidation converts the coal into a gaseous fuel composed primarily of combustible hydrogen and carbon monoxide. The gas can be piped directly into a gas turbine to generate electricity. The exhaust from the gas turbine is ducted into a heat recovery steam generator to produce steam for a conventional steam turbine generator.

The conversion of coal to gas requires more than just a gasifier to perform the gasification process. A coal gasification plant integrates a number of different technologies necessary to make gasification both environmentally safe and thermally efficient.

The integrated gasification combined cycle (IGCC) plant's major systems include fuel preparation, an air separation unit, a gasifier, acid gas removal, sulfur recovery, a combustion turbine-generator (CT), a heat recovery steam generator (HRSG), and a steam turbine-generator. Depending on the gasification technology, a wide variety of solid fuels can be used. This option is based on oxygen-blown gasifier technology with high sulfur coal as the fuel. The plant consists of 3 IGCC units, each generating 245 megawatts. *Figure T6-7* shows the major systems of the IGCC plant.

Coal is pulverized and injected into the pressurized gasifier unit. There, it is mixed with oxygen and partially oxidized at a high temperature to produce a hot, medium Btu gaseous fuel, syngas, that is composed primarily of combustible hydrogen and carbon monoxide. The oxygen is provided by the air separation unit. Coal ash is melted in the gasifier to form a slag that runs down the internal walls of the gasifier into a water bath. The molten slag solidifies in the water into a hard, inert, glassy material. It is removed from the gasifier through a lockhopper system. High pressure steam is generated in the waterwall enclosure of the gasifier.

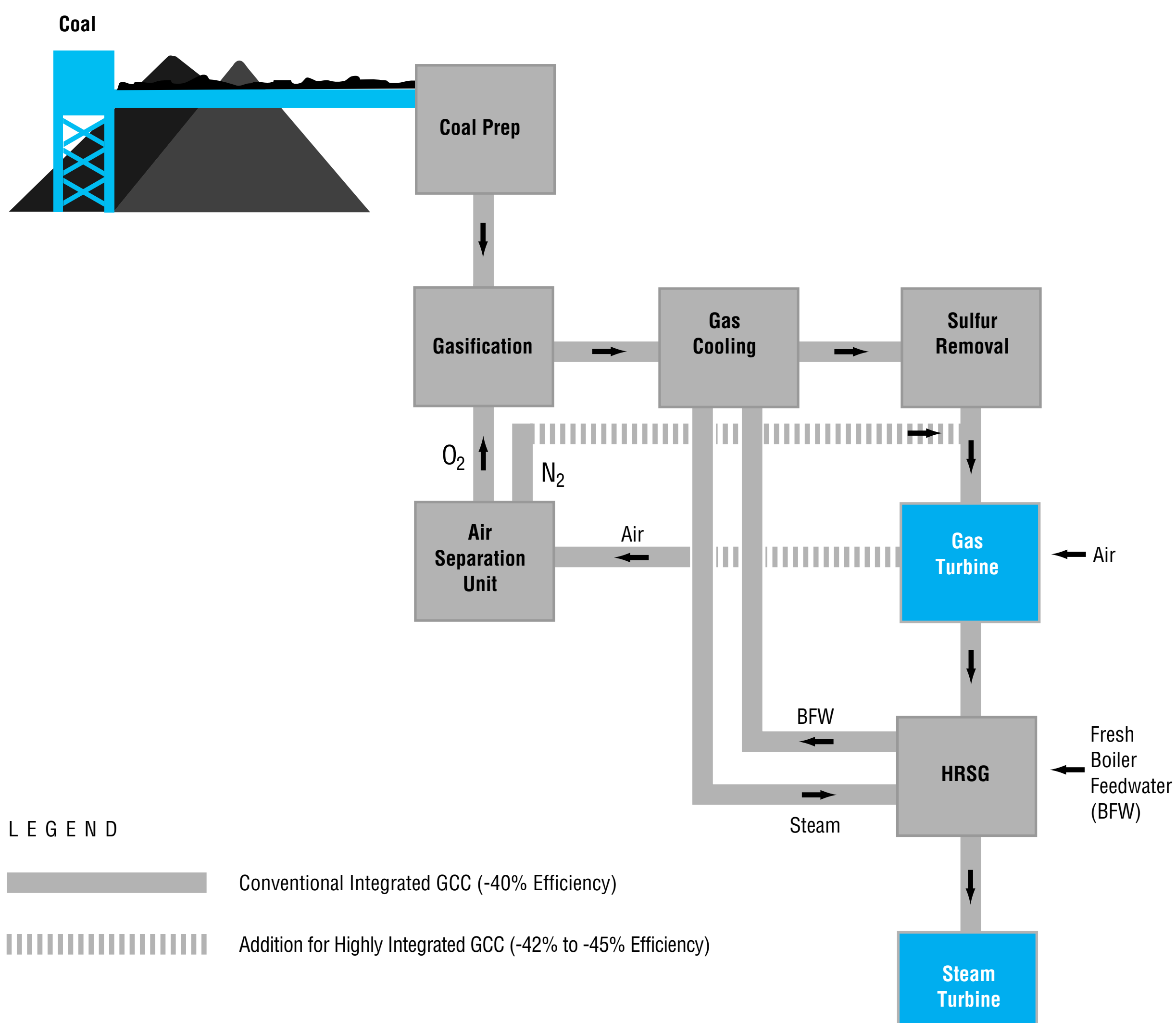
The syngas flows from the gasifier to a cooler. Medium pressure steam is generated in the syngas cooler. Particulate is removed from the cooled syngas by ceramic filters. Collected fly ash is recycled back to the gasifier.

A series of processes remove and/or convert chlorides, ammonia, and various acid gases from the syngas. Sulfur compounds are converted to marketable elemental sulfur. Sulfur recovery exceeds 99 percent.

The clean syngas is combusted with air in the CT to produce electricity. Excess nitrogen from the air separation unit is fed to the CT for power augmentation and to reduce nitrogen oxides (NO_X) emissions. The CT exhausts into the HRSG, where steam is generated to power a steam turbine-generator. The steam generated in the gasification unit and syngas cleanup processes is superheated in the HRSG and fed into the steam turbine. About two-thirds of the plant's net generation is from the CT, and one-third is from the steam turbine. Steam turbine exhaust is condensed and pumped back into the HRSG and gasification unit as feedwater. Heat is rejected from the condenser cooling water to the atmosphere in a mechanical draft cooling tower.

The combined cycle features of the IGCC plant provide a higher efficiency than either a simple cycle CT plant or a

FIGURE T6-7. **Generalized Block Flow Diagram of Coal Gasification of Production of Fuel Gas**



RESOURCE: RHW/Council on Alternative Fuels, 1992.

pulverized coal-fired plant. Higher auxiliary power consumption, primarily by the air separation unit, reduces efficiency below a natural gas-fired combined cycle plant.

Sulfur dioxide emissions are quite low due to the high sulfur recovery from the syngas in the sulfur removal process. The low nitrogen content in the syngas limits NO_X emissions to very low levels, as well.

IGCC plants are currently considered at the initial stage of commercial development. The relatively high capital cost, high efficiency, low emissions, and low fuel cost of the IGCC make it a candidate for future base-load capacity additions.

Cost and performance data are based on engineering studies performed by TVA and external architects and engineers.

Option 1.3.1.6
COMPRESSED AIR STORAGE WITH HUMIDIFICATION WITH INTEGRATED GASIFICATION AND NATURAL GAS PEAKING (1X850 MEGAWATTS)

A compressed air storage with humidification with integrated gasification and natural gas (CASHING) plant is an integrated gasification compressed air storage with humidification (IGCASH) plant with additional natural gas-fired expander trains. The CASHING cycle combines important features from compressed

air energy storage, the humid air turbine concept, coal gasification, and simple cycle combustion turbines to form a new power cycle with low capital costs and improved operating flexibility compared to other coal-fired power plants.

In a CASHING plant, the coal gasification system operates continuously to produce syngas, which is burned in a combustion turbine to generate power. The combustion turbine uses compressed air from an underground storage reservoir (e.g., a salt dome or aquifer), which is charged by a compressor train that operates intermittently. The compressed air from the storage reservoir is humidified in a saturator so that the required air flow is significantly reduced. Reduced air flow from humidification lowers compressor energy and underground volume requirements. Before entering the combustion turbine, the humidified air is heated in a recuperator utilizing the hot gas from the turbine exhaust.

During periods when the demand for electricity is low, the compressor train charges the air reservoir and consumes all the power output of the combustion turbine, making the net output of the plant zero. During high load periods, the compressor is shut off and the power output of the combustion turbine goes to the electric grid. The CASHING cycle differs from the IGCASH cycle in that natural gas-fired expander trains are added. When loads are very high, these natural gas-fired expander trains can be used for additional power generation.

CASHING will have the superior environmental emissions performance of all integrated gasification plants. Sulfur dioxide (SO_2) and nitrogen oxides (NO_X) emissions from the gasification plant would be very low, while carbon dioxide (CO_2) emissions from the overall plant would be somewhat less than those from a pulverized coal plant because of the low CO_2 emissions of the natural gas fuel. However, some consideration may have to be given to NO_X emissions from the additional natural gas-fired expander trains.

The CASHING plant has a much lower capital cost than the IGCASH plant, and one that approaches that of a natural gas-fired combined cycle. Due to the majority of heat input being supplied by coal, it is much less sensitive to the price of natural gas. The plant capital cost is reduced because of two factors. The gasification plant is smaller, since it runs 24 hours per day, while the cycle is only intermediate duty. Also, the natural gas-fired expander trains can be added for a very low incremental cost.

A CASHING plant should have excellent cycling characteristics since most of the hot components and the gasification plant maintain steady operation.

Since the plant uses natural gas for a part of its heat input, it is at least somewhat sensitive to the price of natural gas. Also, total daily generation is limited by the air stored in the underground reservoir and by the amount of air injected into the reservoir by the compressor train.

Most of the components needed for this cycle are currently available. The major exceptions are a saturator, which humidifies the combustion turbine air at high pressure (low pressure saturators are common in the chemical industry), and combustion with very humid air. A CASHING plant has not yet been demonstrated, and there are no plans at this time for such a demonstration.

The cost and performance data are based on studies performed by Energy Storage and Power Consultants under contract to Electric Power Research Institute. Some performance data are inferred from other cycles.

Option 1.3.1.7

ADVANCED PRESSURIZED FLUIDIZED BED COMBUSTOR WITH DEVELOPMENT COST (1X300 MEGAWATTS)

Option 1.3.1.7 describes the pressurized fluidized bed (PFB) boiler and expansion turbine. The expansion turbine inlet temperature is limited to about 1,600°F by the operating temperature of the PFB boiler, thus limiting the cycle efficiency. The efficiency can be increased by raising the expansion turbine inlet temperature. In the advanced PFB option, a fuel gas produced from pyrolysis of coal is used to raise the turbine inlet temperature. The fuel gas from the pyrolysis is cleaned in a high temperature and pressure filtration system before being burned in the combustion turbine. Combustion of the fuel gas will raise the inlet temperature to 2,300°F. Char from the pyrolyzer is used to fuel the circulating PFB boiler in order to generate steam that powers the steam turbine.

This technology is considered to be at the pilot scale of development. Components needing further development include the pyrolyzer, the combustors for the gas turbine, the high temperature and pressure filters, and high temperature gas valves. These development costs have been captured by adding to the capital cost of this option the financial support that TVA has been asked to contribute to a project to demonstrate the advanced PFB technology.

Sulfur capture by limestone fed to the pyrolyzer and PFB boiler would allow a range of fuels to be used. High sulfur coal would be the design fuel.

Performance and cost data for this option are based on Electric Power Research Institute's Technical Assessment Guide and information provided by Air Products, Inc.

Option 1.3.1.8
ADVANCED PRESSURIZED FLUIDIZED BED COMBUSTOR WITH NO DEVELOPMENT COST (1X300 MEGAWATTS)

This option is identical to option 1.3.1.7 except that no development costs for unproved technology components have been added to the option's capital cost. The capital cost used for this option is the projected cost of a commercial 300-megawatt advanced pressurized fluidized bed (PFB) plant after all components have been successfully demonstrated.

Option 1.3.1.9
PARTNERED INTEGRATED GASIFICATION COMBINED CYCLE WITH COPRODUCTION, GREENFIELD SITE (1X530 MEGAWATTS)

This option is similar to option 1.3.1.5 except for the fact that:

- Approximately 70 percent of the synthesis gas produced is utilized for the production of chemicals. Only 30 percent of the synthesis gas is used for power production. The facility will generate approximately 480 megawatts and produce about 6,600 tons of chemicals per day.
- The facility consists of four 3,000 ton per day gasifiers, two combustion turbines with heat recovery steam generators (HRSGs), and one steam turbine, plus a chemical production plant.
- It is assumed that partners would be found to own and operate the gasification plants and the chemical production plant. TVA would own and operate the power block only.

The cost and performance data are extrapolated from information in the Black & Veatch/Bechtel Power Corporation study performed for option 7.1.1.5, the integrated gasification combined cycle with coproduction repowering of Bellefonte.

Option 1.3.1.10
INTEGRATED GASIFICATION COMBINED CYCLE WITH COPRODUCTION, GREENFIELD SITE (1X498 MEGAWATTS)

Option 1.3.1.11
INTEGRATED GASIFICATION CASCADED HUMIDIFIED ADVANCED TURBINE WITH COPRODUCTION, GREENFIELD SITE (1X598 MEGAWATTS)

The coproduction of methanol results in a lower cost of electricity than fertilizer due to the higher net capacity of each unit—250 megawatts for methanol coproduction compared to 227 megawatts for fertilizer coproduction (see option 1.3.1.4). The generic greenfield application for coproduction therefore uses methanol as the coproduct.

These two options—integrated gasification combined cycle (IGCC) and integrated gasification cascaded humidified advanced turbine (IGCHAT)—with coproduction are similar to the IGCC (option 1.3.1.5) and IGCHAT (options 1.3.2.5 and 1.3.2.8). However, for these two options, a portion of the synthesis gas is converted into chemicals through indirect liquefaction of the syngas. A variety of coproducts can be produced by indirect liquefaction, such as ammonia- and methanol-based chemicals, and transportation liquids. Only oxygen-blown gasification can produce chemicals; with air-blown gasification, the nitrogen (N_2) in the fuel gas reduces the hydrogen partial pressure.

The gasification coal feedrate of these two options is the same as both IGCC and IGCHAT. Although the combustion turbine is fully loaded, the reduced capacity is due to the use of steam in the chemical process.

The coproduction of electricity and chemicals reduces the cost of electricity due to (1) economies of scale for the gasification process units and the balance-of-plant units and (2) the anticipated real escalation of prices for natural gas-derived chemicals.

The revenues for the higher valued chemicals subsidize the cost of electricity.

Cost and performance data are based on engineering studies performed by TVA.

Option 1.3.1.12
COAL REFINERY/INTEGRATED GASIFICATION COMBINED CYCLE, GREENFIELD SITE (1X530 MEGAWATTS)

Option 1.3.1.13
COAL REFINERY/INTEGRATED GASIFICATION CASCADED HUMIDIFIED ADVANCED TURBINE, GREENFIELD SITE (1X530 MEGAWATTS)

Coal refining is another form of coproduction (see options 1.3.1.10 and 1.3.1.11). However, coal refining produces chemicals on the front end of coal gasification. Coal refining uses internally generated hydrogen (H_2) to produce coal liquids from the pyrolysis of coal. The resultant char is then used as the feedstock for integrated gasification combined cycle (IGCC) or integrated gasification cascaded humidified advanced turbine (IGCHAT) (see options 1.3.1.5, 1.3.2.5, and 1.3.2.8). The Charfuel coal refining process utilizes flash hydropyrolysis with quenching of the reaction products by H_2 and recycled liquids. Excess syngas—rich in methane (CH_4)—is converted to H_2 in a partial oxidation reactor (POX) to provide the quenching H_2. The char is separated from the syngas, and the syngas is cooled to condense liquids. The coal liquids are then hydrotreated and fractionated to produce benzene, naptha, and fuel oil.

Cost and performance data are based on engineering studies performed by TVA.

Option 1.3.1.14

COAL REFINERY/INTEGRATED GASIFICATION CASCADED HUMIDIFIED ADVANCED TURBINE WITH COPRODUCTION, GREENFIELD SITE (1X180 MEGAWATTS)

This option combines coal refining (see options 1.3.1.12 and 1.3.1.13) with option 1.3.1.11—integrated gasification cascaded humidified advanced turbine (IGCHAT) and coproduction of methanol—in a single plant. The plant consists of one coal refining unit, one char gasification unit, one cascaded humidified advanced turbine (CHAT) unit, and one methanol unit. The coal feed rate is equivalent to a two-train IGCHAT plant.

Option 1.3.2.1

FUEL CELL – MOLTEN CARBONATE OR SOLID OXIDE (1X2 MEGAWATTS)

Fuel cells are a unique advanced power generation technology because they directly convert chemical energy into electricity. All other fossil fuel-based power generation technologies require conversion of thermal energy by combustion, followed by turboexpansion or steam generation. As a result, fuel cells avoid the nitrogen oxides (NO_X) emissions and mechanical limitations of combustion and thermal conversion. This means fuel cells offer lower emissions and higher thermal efficiencies compared to any other fossil fuel-based power generation technologies.

Conceptually, fuel cells are similar to a battery with a continuous supply of chemical energy. In a fuel cell, hydrogen gas is oxidized at the anode, and the oxygen is reduced at the cathode. In this process, fuel and oxygen are supplied to cells, and the carbon dioxide and water byproducts of the reaction are removed. Since fuel cells convert the chemical energy in the fuel directly to electricity, without an intermediate thermal energy stage, theoretical energy conversion efficiencies approach 80 percent. However, practical systems are limited to efficiencies of 40-60 percent due to parasitic losses, which include the electrical resistance of the components. This potential for very high energy efficiencies, combined with relatively minor environmental impacts, makes fuel cells prime candidates for future use in electric power generating systems that must operate under the constraints of high fuel costs and minimal emissions.

Fuel cells can be assembled in building block style to make power plants of specifications tailored to the utility's load growth needs and the constraints of the site. Individual fuel cells produce less than one volt but operate at very high current densities—on the order of hundreds of amperes per square foot of electrode area. Practical output voltages are obtained by connecting many cells in series to constitute a fuel cell stack. Stacks have generating capacities ranging from a few kilowatts to several megawatts. The maximum size of a stack is dictated by engineering constraints, manufacturing technology, and cost trade-offs.

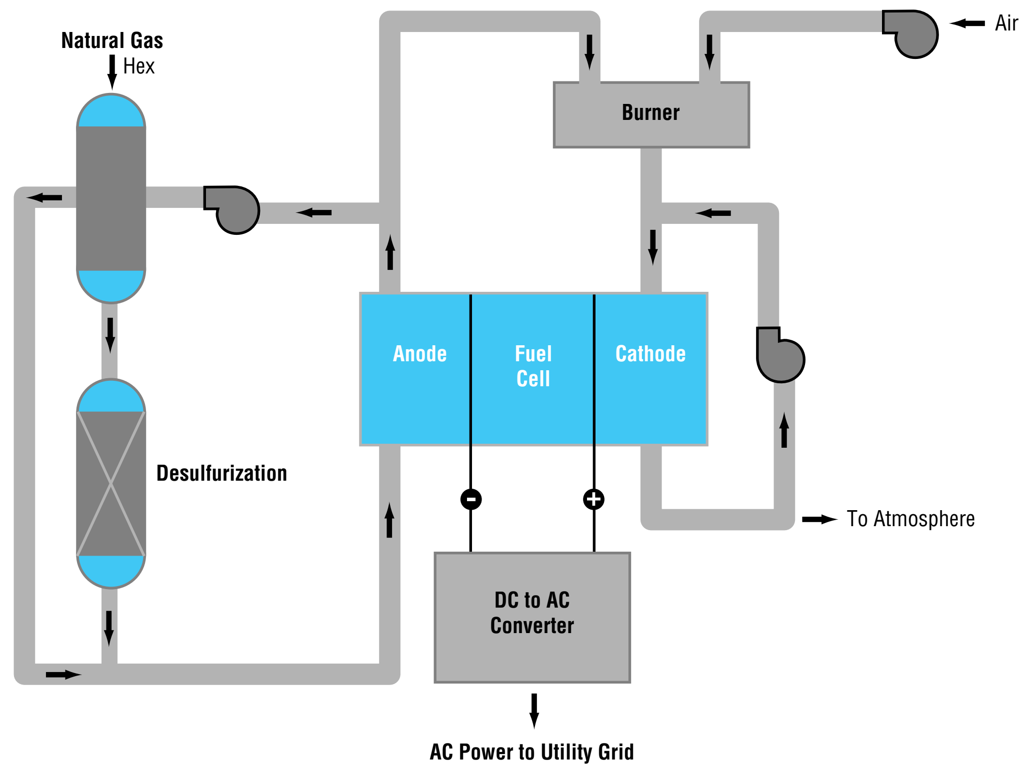
Fuel cell power plants consist of three major subsystems unique to this technology and a general balance-of-plant subsystem. The fuel processing system converts natural gas or distillate fuels to a fuel gas rich in hydrogen and carbon dioxide. Catalytic reforming processes with this capability have been in commercial use for many generations. Alternatively, a coal gasification plant can be substituted to produce the same fuel gas from coal. The fuel cell stack subsystem generates direct current power from the fuel gas while simultaneously emitting a benign exhaust gas. If desired, the system may be designed so that the exhaust gas contains economically significant quantities of thermal energy. The power conditioning subsystem converts the direct current output of the fuel cell stack to alternating current power. If a fuel cell is used for a decentralized application in small sizes, and if the customer needs direct current power, the power conditioning equipment can be removed. The balance-of-plant subsystem—including the plant control systems—provides the water and heat management, and heat recovery if desired. This subsystem also includes physical facilities such as buildings and other site-related items.

Fuel cells operate at a constant temperature and pressure regardless of load. As a result, the thermal energy liberated by the electrochemical reaction can be used in thermal bottoming cycles or for cogeneration of steam. The temperature of the waste heat varies widely with each fuel cell type, system, and design. Generally, the more advanced fuel cell systems provide the highest potential for high-quality waste heat because they operate at higher temperatures.

The commercialization of fuel cells is now targeted at factory-assembled modules. Generating capacities range from 200 kilowatts for single-stack, small-load applications to 10-25 megawatts for generating units. The primary features of these commercial concepts are:

- Modular construction, which combines the economies of mass production in a factory environment with the associated benefits of improved quality control.
- Phased construction of generating units in order to match capacity to load growth with minimal preinvestment.
- Fuel flexibility between natural gas and distillate, which may allow continued use of these fuels despite major price increases in the future.

FIGURE T6-8. **Molten Carbonate Fuel Cell Generating Unit**



- Integration with coal gasification to provide very high efficiency conversion of coal to electric power with minimal emission potential.
- Excellent capability for distributed generation applications due to quiet operation, minimal emissions, low heat rate, small operating staff, and rapid load-following capability.

The cost and performance data are based on fuel cell vendor estimates.

Molten Carbonate Fuel Cells. Molten carbonate fuel cells (MCFC) are a second-generation technology, emerging from laboratory research to engineering development at pilot-plant scale. *Figure T6-8* shows a diagram of a molten carbonate fuel cell generating unit. MCFCs operate at approximately 1,200°F. At this temperature, waste heat from MCFCs can provide the heat of reaction needed to convert light hydrocarbon fuels to synthesis gas, which can be consumed by the fuel cell. As a result, the fuel-processing system can be incorporated within the fuel cell stack. Advantages of this configuration include:

- High plant efficiency: greater than 50 percent higher heating value (HHV) with the possibility of achieving 60 percent (5,600 Btu per kilowatt-hour) on natural gas, alcohols, and light hydrocarbon fuels in small-capacity plants
- Very low emissions: 1 pound per megawatt-day combined nitrogen oxides (NO_X), sulfur oxides (SO_X), hydrocarbons, and particulates
- Low noise
- Air-cooled systems, which minimize siting problems
- A compact system, i.e., 25 megawatts per acre per vertical story

Within the next five years, the MCFC total installed capital cost is likely to be less than $1,000 per kilowatt.

Solid Oxide Fuel Cells. Westinghouse has been developing solid oxide fuel cells (SOFC) for more than 20 years, and they are the world's leader in this technology. Experimental units of 25 kilowatts have been constructed by Westinghouse for evaluation by electric and gas utilities. Westinghouse plans to commercialize a series of SOFC power plants with capacities ranging from hundreds of kilowatts to several megawatts.

The cost and performance data for this technology are under development, but the range seems to be between $750 per kilowatt and $1,000 per kilowatt.

Option 1.3.2.2
INTERCOOLED AERODERIVATIVE COMBUSTION TURBINE (1X125 MEGAWATTS)

The intercooled aeroderivative combustion turbine (ICAD) is one of the advanced combustion turbine cycles being studied in Electric Power Research Institute's Collaborative Advanced Gas Turbine program. Aeroderivative combustion turbines are now available and have excellent efficiencies because of their high pressure ratios.

However, a high pressure ratio causes excessive compressor power consumption. Compressor intercooling would decrease compressor power use, thereby increasing plant efficiency and power output. The ICAD would match intercooling with aeroderivative technology.

The ICAD cycle would be very similar to the simple cycle combustion turbine, option 1.1.2.1, except that an intercooler would be added to cool the compressed air at some point in the compression process to reduce compressor power consumption. The primary fuel would be natural gas with fuel oil as a backup. The performance for this concept is based on a nominal 2,600°F turbine inlet temperature which, because of cooler compressor air being available for turbine blade cooling, will not be technologically difficult to achieve.

The emissions characteristics of the ICAD would be similar to that of a simple cycle combustion turbine. Sulfur dioxide (SO_2) emissions would be negligible and carbon dioxide (CO_2) emissions would be roughly half of a typical pulverized coal plant. Nitrogen oxides (NO_X) emissions would also be low since dry, low NO_X combustors would be used. A selective catalytic reduction (SCR) could further lower NO_X emissions, but it is not included in this configuration.

The major potential advantages of the ICAD are its high simple-cycle efficiency for a cost which should not be much greater than that of current simple-cycle combustion turbines, and its operational flexibility. It can be used for intermediate duty, because of its high efficiency, or for peaking duty, because it appears especially promising for high-cycling use.

However, because of a lower exhaust temperature, the ICAD does not provide commensurate improvement in combined cycle efficiency. Also, because of the complexities of incorporating intercooling into the cycle, development costs are expected to be moderate.

The ICAD is one of the concepts being developed under Electric Power Research Institute's Collaborative Advanced Gas Turbine program. Electric Power Research Institute's goal is to design, build, sell, and test two ICAD units by approximately 1998.

The cost and performance data are based on information from Electric Power Research Institute's Advanced Cycle Evaluation (ACE) Group.

Option 1.3.2.3
CASCADED HUMIDIFIED ADVANCED TURBINE (F SERIES CT) (1X288 MEGAWATTS)

Option 1.3.2.6
CASCADED HUMIDIFIED ADVANCED TURBINE (G SERIES CT) (1X400 MEGAWATTS)

The cascaded humidified advanced turbine (CHAT) is an advanced Ericson cycle that employs intercooling, recuperation, reheating, and humidification of a combustion turbine with a cascaded topping turbine. Heat rates are equivalent to combined cycle plants, and capital costs are projected to be 20 to 30 percent less because the heat recovery steam generator, steam turbine, condenser, etc. are avoided. The exact arrangement of equipment and operating conditions are proprietary, but nearly all components are already available and proven, with only the high pressure combustors, saturator, and the overall integration and control of components requiring development.

The cascaded humidified advanced turbine (CHAT) adds humidification to the cascaded advanced turbine (CAT) cycle downstream of the last compressor stage. Performance improves because the water vapor expands through the turbine and reduces the amount of air which would otherwise have to be supplied by the compressor. Nitrogen oxides (NO_X) levels are thus reduced to near deminimus levels of about 1 to 2 parts per million.

The cost and performance data are based on studies performed by Energy Storage and Power Consultants under contract to Electric Power Research Institute.

Option 1.3.2.4
INTEGRATED GASIFICATION CASCADED HUMIDIFIED ADVANCED TURBINE WITH COPRODUCTION (F SERIES CT) (2X303 MEGAWATTS)

Option 1.3.2.7
INTEGRATED GASIFICATION CASCADED HUMIDIFIED ADVANCED TURBINE WITH COPRODUCTION (G SERIES CT) (2X420 MEGAWATTS)

This technology is the same as the integrated gasification cascaded humidified advanced turbine (IGCHAT) (options 1.3.2.5 and 1.3.2.8) except that the gasifier is oversized to allow for the coproduction of both electricity and chemicals such as fertilizer (urea), methanol, methyl tertiary butyl ether (MTBE), etc. Process steam requirements are produced from oversized intercoolers.

The cost and performance data are based on studies performed by Energy Storage and Power Consultants under contract to Electric Power Research Institute. TVA studies provide the basis for the information on coproduction.

Option 1.3.2.5
INTEGRATED GASIFICATION CASCADED HUMIDIFIED ADVANCED TURBINE (F SERIES CT) (2X303 MEGAWATTS)

Option 1.3.2.8
INTEGRATED GASIFICATION CASCADED HUMIDIFIED ADVANCED TURBINE (G SERIES CT) (2X420 MEGAWATTS)

The integrated gasification cascaded humidified advanced turbine (IGCHAT) integrates a coal gasification plant with the cascaded humidified advanced turbine (CHAT) cycle. The turbine is fired with clean syngas, and emissions of sulfur oxides (SO_X), nitrogen oxides (NO_X), and toxics normally associated with coal plants are extraordinarily low. Because the syngas can be humidified, a low-cost, total quench gasifier can be used, resulting in capital and operating costs that are 25 to 35 percent of those for a conventional integrated gasification combined cycle (IGCC), option 1.3.1.5.

The cost and performance data are based on studies performed by Energy Storage and Power Consultants under contract to Electric Power Research Institute.

Option 1.3.2.9
INTEGRATED FUEL CELL/COMBUSTION TURBINE (1X2.5 MEGAWATTS)

This option integrates a solid oxide fuel cell (as described in option 1.3.2.1) with a small combustion turbine. The fuel cell exhaust gas is at about 1,800°F and is pressurized. In this integrated concept, the exhaust gas is fed into a small combustion turbine to produce additional electricity (beyond the fuel cell output). The fuel cell's efficiency is already high, and integration of the combustion turbine can raise the overall efficiency to about 70 percent.

This concept is still under development. Current studies seek to determine the best overall design, taking into account several variables, such as the number of fuel cells used with a single turbine, identification of the most appropriate design and size of turbine, and variations in fuel cell operating conditions.

The overall characteristics of this option, including likely applications, are very much like the fuel cell (option 1.3.2.1). However, the combustion turbine increases overall efficiency while adding some complexity to the equipment.

The cost and performance data are based on preliminary fuel cell vendor estimates.

Option 1.3.3.1
LARGE SOLAR-PHOTOVOLTAIC – FIXED FLAT PLATE (1X50 MEGAWATTS)

Solar-photovoltaic (PV) power plants convert solar energy to electricity using a semiconductor material, usually silicon doped with phosphorus and boron, to generate a direct current. In order to increase the conversion efficiency, the principal PV technologies are thin-film, polycrystalline silicon, single-crystal silicon, and concentrator technology. Thin-film materials are typically deposited on a glass substrate and include amorphous silicon, copper-indium-diselenide (CIS), and cadmium telluride.

Except for a thin-film module, a typical solar cell produces about 2 amperes of current at 0.5 volts. Individual cells are combined together into modules and connected in series and parallel to provide higher voltage and current levels. The active areas of the modules are typically from 0.1 to 2 square meters, and the modules are typically connected together in flat arrays. Three array configurations are used: (1) fixed-tilt arrays facing south, (2) single-axis tracking of the sun from east to west, and (3) two-axis tracking of the sun to remain perpendicular to the sun's rays. The direct current power generated by the arrays is collected and converted to alternating current power by a power conditioning unit.

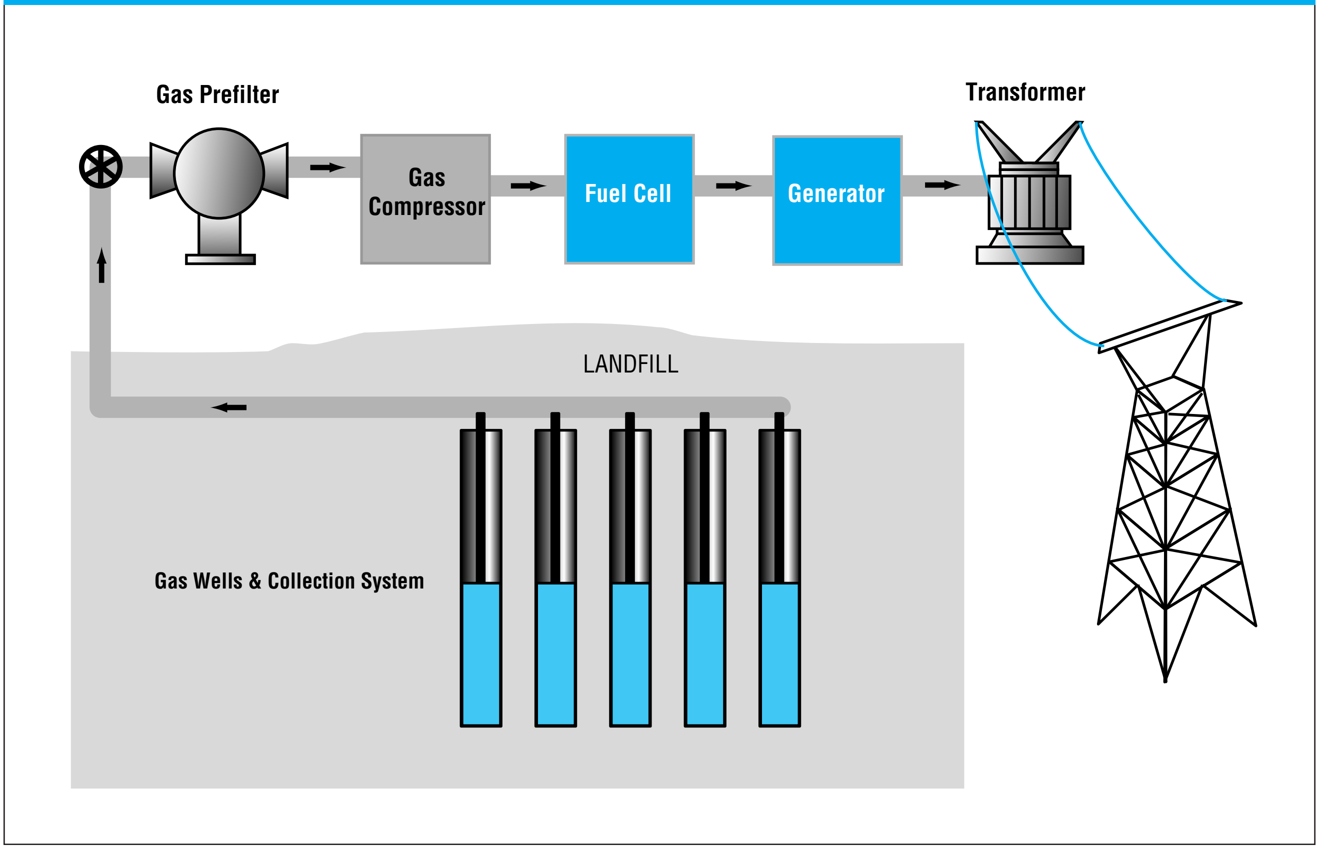
On a typical day, the insolation falling on a surface oriented perpendicularly to the sun's rays reaches a maximum of about 1 kilowatt per square meter at solar noon, and is lower in the morning and afternoon. Because the best commercial solar cells operate at about 12 percent conversion efficiency, the maximum power available is 120 watts per square meter. Thus, a 100-megawatt power plant would require about one square mile of land area. Since PV power output is proportional to the incident solar insolation, it is not dispatchable without energy storage.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 1.3.3.2
LANDFILL METHANE (1X2 MEGAWATTS)

The reasons for recovering landfill gas are numerous. Communities can receive revenue from a successful landfill gas project. Recovering methane helps reduce the odors produced from decomposing garbage, which can be disturbing to individuals living in the vicinity of the landfill. Also, landfill gas recovery

FIGURE T6-9. **Landfill Gas to Electricity**



reduces greenhouse gas emissions, which are potentially harmful to the environment.

As a fuel, landfill gas has a reasonably high heating value in raw form and can be upgraded to pipeline quality if desired. The landfill gas can be flared or used as a fuel on-site to produce electricity in a small combustion turbine, reciprocating engine, boiler, or eventually fuel cells. Cost and performance projections are based on use of fuel cells. Collecting landfill gas can be expensive because it is spread out over a wide area. It is difficult to predict the amount available and also to anticipate fluctuations in supply. Such information is critical to determine the economics of a landfill gas recovery project. Additional expenses are incurred in treating the gas to remove moisture, trace hydrocarbons, carbon dioxide, and especially hydrogen sulfide. A small number of landfill gas production facilities currently exist in the United States. *Figure T6-9* shows a diagram of the process for converting landfill gas to electricity.

The cost and performance data are based on vendor estimates.

Option 1.3.3.3
COALBED METHANE (1X2 MEGAWATTS)

Coalbed methane gas is present in all coal seams located throughout the United States, including the TVA region. The coalbed methane industry has grown during the recent years, powered greatly by new science and better technology. Still, major challenges remain that require research particularly in developing new basins, deeper coals, and geologically complex settings.

Numerous problem areas must be overcome before coalbed methane is accepted as a viable fuel. Estimating coalbed gas productivity and reserves remains a major problem for producers of coalbed methane. Also, the industry has yet to satisfy the financial community that it can reliably determine how much of the gas can be recovered and over what period of time. Most coal companies will find that it is not economically feasible to collect coalbed methane without a federal subsidy or tax credit. Cost and performance projections are based on use of fuel cells. At the present time, these incentive programs are not available to owners of coal mines.

A number of environmental issues, each requiring technologically innovative solutions, are of high concern to devel-

opers of coalbed methane. The most urgent are the disposal or use of coproduced water and the pending regulations on air emissions for gas compression engines. Also, the disturbance of land areas required for well sites, service roads, and gas collection systems are major concerns.

Another major obstacle to coalbed methane development is the legal question of gas ownership. This is a very complex issue and is not easily resolved. Each ownership case is usually decided on a site-specific basis, and legal rulings may vary between sites.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

OPTION 1.3.3.4
BIOREFINERY—COPRODUCTION OF ELECTRICITY AND CHEMICALS FROM BIOMASS (1X100 MEGAWATTS)

The biorefinery coproduces electricity and chemicals. The biomass feedstock consists of mill and wood waste, farm wastes, or dedicated crops (trees and grasses). Municipal solid waste also contains biomass material. All biomass is composed of cellulose, hemicellulose, and lignin. The cellulose and hemicellulose are converted to sugars by acid or enzymatic hydrolysis, and the sugars are fermented to chemicals (such as ethanol, organic acids, and furfural). The residual lignin is converted to electricity by either combustion or gasification. The production of higher valued chemicals significantly reduces the cost of electricity from biomass, in a dedicated biomass plant.

The biorefinery has low sulfur dioxide emissions and solid waste due to the composition of the biomass, and has a zero net production of carbon dioxide.

The cost and performance data are based on TVA internal reports on the biorefinery concept. TVA has been operating laboratory-scale units and a 2 to 10 tons per day pilot unit at the Environmental Research Center in Muscle Shoals, Alabama, for the last 10 years.

Option 1.3.5.1
ADVANCED BATTERY ENERGY STORAGE (1X20 MEGAWATTS)

The advanced energy storage battery is based on a 20-megawatt unit designed for 3-hour and 5-hour storage applications. These two duty cycles are given because for batteries, the cost for the energy component is not a linear function of duty cycle. Incremental off-peak electric energy is used to charge an advanced battery based on either the sodium-sulfur or the zinc-bromine system. The battery plant is composed of modular units. Battery capital costs are based on a production of 2,000 megawatts per year. The environmental emissions of the advanced battery plants are virtually zero. Battery plants have an extremely fast time response capability—full load can be achieved in less than 5 milliseconds.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 1.3.5.2
SUPERCONDUCTING MAGNETIC ENERGY STORAGE (1X500 MEGAWATTS)

Superconducting magnetic energy storage (SMES) technology is applicable to all utility regions in the United States. Low-cost, off-peak energy is stored as direct current in a superconducting coil whose conductor is made of a low temperature niobium titanium alloy. Refrigeration is needed to maintain the low coil core temperature. The refrigeration costs are accounted for in the fixed costs for operating the plant, and as such, affect the plant capital cost and life-cycle cost for purchasing and operating the plant.

Since the stored energy is in the form of electricity which is not converted to some other form of energy, the round-trip efficiency of a superconducting magnetic energy storage (SMES) plant is very high, about 95 percent. The plant power conditioning system is the component that controls the plant and converts the stored direct current energy to the required utility grid alternating current requirements (which can accommodate reactive power control, black-start, and/or system frequency control, just to name a few of the possible plant applications). *Figure T6-10* shows a diagram of a superconducting magnetic energy storage plant.

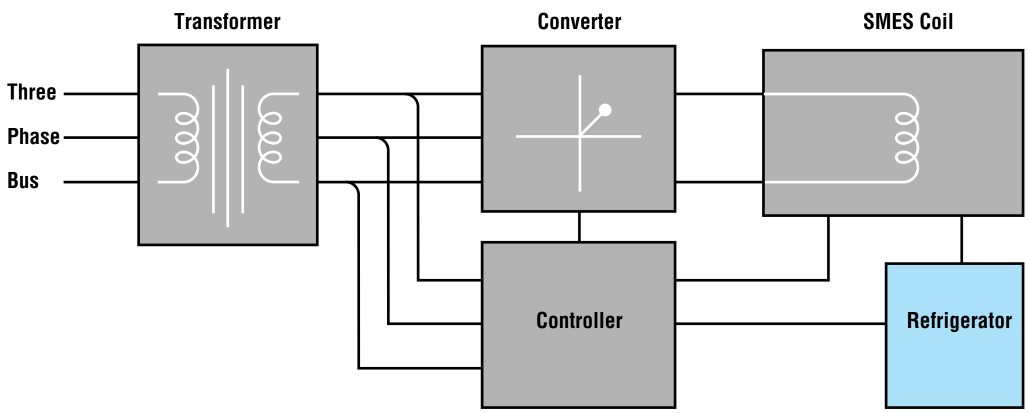
SMES plants would have a very rapid response time of less than one-tenth of a second to reach full load. As such, a major benefit of this technology is the range of dynamic, strategic, and load-leveling benefits that this plant can provide to its owner. The plant would have a 500-megawatt capacity and a two-hour storage discharge time.

There would be no emissions associated with the SMES plant other than the emissions from the generation sources used to charge the coil.

SMES technology is not yet commercially available for energy storage applications of this type but is considered a future option.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

FIGURE T6-10. **Superconducting Magnetic Energy Storage**



Option 2.1.3.1
ADDITIONAL HYDRO GENERATION AT EXISTING NONPOWER PROJECTS (1X10 MEGAWATTS)

Option 2.1.3.2
ADDITIONAL HYDRO GENERATION AT EXISTING PROJECTS (1X24 MEGAWATTS)

Option 2.1.3.3
ADDITIONAL HYDRO GENERATION – NEW CONVENTIONAL PROJECTS (1X65 MEGAWATTS)

This category includes three types of additional hydro generation:

1. Additional units at existing hydro power projects
2. Additional units at existing nonpower hydro projects
3. New conventional projects

These options would be similar to current TVA hydro generation facilities. A dam creates an upper and a lower water reservoir. The potential energy stored in the water in the higher reservoir is converted to electricity as it flows through a hydro turbine to the lower reservoir.

Like other hydro generation, these options would have several advantages over other generating technologies:

- Very low operating costs
- Zero emissions
- Excellent operational flexibility (e.g., low startup and shutdown costs and rapid ramp rates)

However, there are some disadvantages in these hydro options:

- Very high capital cost
- Limited energy
- Limited amount of generation
- Environmental impacts on the river
- In the case of new conventional projects, environmental impacts on the local area

This power generation technology is commercially mature. Water Resources Projects in Knoxville, Tennessee, provided the cost and generation data from studies done many years ago. The three options listed above refer to studies conducted in the years 1983, 1977, and 1965, respectively.

Option 2.1.3.4
HYDRO MODERNIZATION AT EXISTING PROJECTS

TVA's hydro system was installed in the 1940s and 1950s. Since that time, technology has advanced significantly on several fronts of hydro plant design. A modernization project is currently underway to take advantage of advances that have produced the largest benefit to the TVA hydro system, but there are still several remaining upgrades that could be performed. These remaining projects could increase the summer capability of the hydro system by over 160 megawatts.

The cost and performance information for modernization projects at existing hydro sites was provided by the TVA organization responsible for fossil and hydro projects.

Option 3.3.1.1
GENERIC PRESSURIZED FLUIDIZED BED COMBUSTION COGENERATION (1X70 MEGAWATTS)

Option 12.1.2.1
GENERIC COMBINED CYCLE COGENERATION (2X210 MEGAWATTS)

Cogeneration is defined as the sequential production of electricity and useful thermal energy (generally steam or hot water) from a single fuel source. Cogeneration utilizes the thermal energy normally discharged as waste heat in a conventional power generation process. It thus provides a higher overall efficiency (often more than double that of the conventional generation system) in fuel utilization, but often at the expense of lower electric output.

A number of different cogeneration technologies are available, including some of those already considered under the fossil and hydro options. With steam turbine technology (for example, using pulverized coal or the fluidized bed technology discussed before) steam is expanded in the turbine to the condensing pressure for pumping back to the boiler as feedwater. With an extraction turbine, steam is removed from the turbine at one or more intermediate points and used for process requirements, with the remaining steam expanded in the turbine to condensing pressure to generate power. In a backpressure turbine, the steam is expanded in the turbine to the pressure required for the process.

In gas turbine systems, the exhaust gases from the turbine are used to generate steam in a heat recovery steam generator. The steam generator may also have supplementary firing in order to increase the quantity of thermal energy without degrading the electric output.

Combined cycle systems consist of a gas turbine and steam turbine in combination. The gas turbine exhaust is used to generate steam for process heating and to generate electricity in a steam turbine. Process steam can also be extracted from the steam turbine.

Cost and performance data are based on cogeneration technology proposals presented to TVA.

Option 4.1.1.1
LIGNITE-FIRED CIRCULATING FLUIDIZED BED COMBUSTION PLANT (1X200 MEGAWATTS)

The lignite-fired circulating fluidized bed combustion (CFBC) plant is essentially the same plant as the circulating atmospheric fluidized bed combustion plant, option 1.1.1.4, described earlier, except for the fact that the fuel is lignite rather than Illinois Basin coal.

The cost and performance information for this plant were obtained primarily from Electric Power Research Institute's Technical Assessment Guide with additional information provided by various industry sources.

Option 5.1.1.1
NON-UTILITY GENERATION – GENERIC INDEPENDENT POWER PRODUCER LIGNITE CIRCULATING FLUIDIZED BED COMBUSTION PLANT (1X300 MEGAWATTS)

Option 13.1.2.1
NON-UTILITY GENERATION – GENERIC INDEPENDENT POWER PRODUCER COMBINED CYCLE (2X260 MEGAWATTS)

Option 13.1.2.2
NON-UTILITY GENERATION – GENERIC NATURAL GAS INDEPENDENT POWER PRODUCER COMBINED CYCLE (1X150 MEGAWATTS)

Option 19.3.1.1
NON-UTILITY GENERATION – GENERIC INTEGRATED GASIFICATION COMBINED CYCLE (1X110 MEGAWATTS)

Option 22.1.1.1
NON-UTILITY GENERATION – GENERIC INDEPENDENT POWER PRODUCER PULVERIZED COAL WITH COGENERATION (2X170 MEGAWATTS)

Option 23.1.3.1
NON-UTILITY GENERATION – GENERIC INDEPENDENT POWER PRODUCER RUN OF RIVER HYDRO (4X20 MEGAWATTS)

Option 29.1.5.1
NON-UTILITY GENERATION – GENERIC INDEPENDENT POWER PRODUCER PUMPED-HYDRO STORAGE

Non-utility generation (NUG) is a broad term used to designate power producing facilities that are not majority-owned by utilities.

NUG can be classified as a qualifying facility (QF) if it meets certain criteria defined in the Public Utilities Regulatory Policies Act of 1978 (PURPA) and subsequent implementation rules established by the Federal Energy Regulatory Commission (FERC). QFs are exempt from most federal and state utility regulations. Utilities are required to purchase power from a QF at less than or equal to its avoided cost and must provide standby (backup) power on a nondiscriminatory basis.

Non-QFs are the NUG facilities that do not satisfy these FERC criteria. The non-QFs that sell electricity are designated as independent power producers (IPPs). An IPP that is either partially or wholly owned by a traditional utility is defined as an affiliated power producer (APP).

The Energy Policy Act of 1992 created a new class of independent power producers called exempt wholesale generators (EWG). EWGs are exempt from the Public Utilities Holding Company Act (PUHCA) and sell electric energy at wholesale rates, either directly or through an affiliate. This allows utilities to own one or more EWGs or foreign utilities without PUHCA jurisdiction and provides expanded access to utility-owned transmission systems.

The Public Utilities Regulatory Policies Act of 1978 (PURPA) was enacted as a part of the National Energy Act of 1978 to encourage the conservation and efficient use of energy resources by electric utilities. PURPA encourages production of electric power by cogeneration and by small power producers. TVA was given regulatory responsibility for implementing PURPA in the area served with TVA power.

Cost and performance data are based on non-utility generation proposals presented to TVA.

Option 6.3.2.7

GAS TURBINE – MODULAR HELIUM REACTOR (3X289 MEGAWATTS)

This option, often called the modular helium reactor or MHR, is derived from several years of work to develop a high temperature gas-cooled reactor. Although the concept benefits greatly from prior development work, several more years of development and design work are needed before the characteristics and availability of the option can be guaranteed.

The MHR option has several distinctive characteristics. First, it extracts heat from a graphite nuclear core using helium as the coolant and working fluid. (The other nuclear options included in Energy Vision 2020 use water to remove heat from a metal-clad core.) Second, the thermal energy is converted to power by expanding helium through a closed-cycle gas turbine with intercooling, recuperation, and precooling. (Most other options in Energy Vision 2020 convert thermal energy to power by expanding steam through a closed-cycle turbine or expanding combustion gases through an open-cycle turbine.) Third, a plant would consist of at least three small modular units. The small unit size allows use of passive safety features to achieve nuclear safety. Fourth, the reactor and helium operate at high temperatures to achieve higher efficiency than conventional nuclear units (approximately 48 percent compared to 32 percent). Compared with conventional nuclear plants, the higher thermal efficiency, modular design, elimination of the steam cycle, and simpler safety systems of this option are expected to offset the lack of economy of scale associated with it.

Option 6.3.4.1

ADVANCED LIGHT WATER REACTOR (1X1300 MEGAWATTS)

U.S. and foreign utilities, reactor designers, and the U.S. Department of Energy have been developing new nuclear reactor power plant designs over the past several years for possible near-term and mid-term deployment in the United States and overseas. These reactor designs are collectively identified as advanced light water reactors (ALWR).

There are four advanced light water reactor plants under various stages of development and licensing in the U.S. The four plants include two technologies (the evolutionary designs) with a nominal power rating of approximately 1,300 megawatts, and two technologies (the passive designs) with a nominal power rating of 600 megawatts. While either the evolutionary or passive designs may ultimately emerge as a preferred design for the next generation of nuclear power plants in the United States due to performance and economic performance, both offer significantly enhanced safety performance. At the present time, the evolutionary reactors have achieved a more advanced developmental status than the passive reactors both in terms of design detail and Nuclear Regulatory Commission review. Consequently, the advanced light water reactor option considered in Energy Vision 2020 is primarily based on the evolutionary design, but this is not intended to preclude consideration of a passive design, as well.

The two evolutionary designs (advanced boiling water reactor (ABWR) and System 80+) are extensions of current technology and experience that employ advanced design features compared to existing nuclear power plants. For example, the System 80+ utilizes a large spherical containment with a wraparound auxiliary building. The ABWR eliminates recirculation piping by using wet motor glandless pumps located in the reactor vessel bottom head.

The evolutionary ALWR designs are expected to be commercially available by the year 2000. These designs are being guided by Volumes I (Top Tier Requirements) and II (Evolutionary Plant) of the Utility Requirements Document (URD), which have been developed jointly by domestic and foreign industry and the U.S. government. The Final Safety Evaluation Report has been issued for Volume II. Volume I does not require a Safety Evaluation Report.

Both of the evolutionary reactor designs have recently been granted final design approval (FDA) by NRC under 10CFR Part 52. Each design must now undergo a final evaluation that is

open to the public in a rule-making process known as design certification. Design certification is expected in 1995. First-of-a-kind-engineering (FOAKE) for both evolutionary designs was initiated in 1993, and is expected to be completed by 1996. Separate programs for site selection and site characterization are being funded by domestic industry. When the design certification, FOAKE, and site programs are completed, pre-approved sites and designs will be available to support restoration of the nuclear option as a safe and economic alternative power source.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 7.1.1.1
BELLEFONTE REPOWERING WITH INTEGRATED GASIFICATION COMBINED CYCLE (9X250 MEGAWATTS)

The two units at TVA's Bellefonte Nuclear Plant (BLN) have been identified as two of four nuclear units whose disposition is being determined in Energy Vision 2020. In order to properly evaluate all of the options for BLN, it is necessary to include a conversion option of the facility to utilize other fuels. The integrated gasification combined cycle (IGCC) repowering option has been conceived to provide essentially the same station generation capability, using coal gasification technology, as would be provided by the nuclear plant.

The IGCC option for BLN consists of 9 modules, each consisting of 1 gasifier plant, 1 combustion turbine rated at about 190 megawatts, and a heat recovery steam generator (HRSG). The steam produced by the nine HRSGs is collected and routed to the BLN Unit 1 steam turbine. The current BLN high pressure turbine is replaced by a turbine designed to receive steam at 1,250 pounds per square inch absolute and 990°F, and to discharge steam to the existing BLN low pressure turbine. Approximately 1,030 megawatts would be generated by the modified BLN Unit 1 steam turbine. The gasification plant air separation units and other users of station service power consume approximately 500 megawatts, thus reducing the overall plant output to 2,250 megawatts.

The repowered facility utilizes existing BLN equipment such as:

- BLN Unit 1 steam turbine and condenser
- natural draft cooling towers
- station auxiliaries (compressed air and service water)
- switchyard and transmission system
- office and service buildings

New equipment added consists of items such as:

- gasification plant modules
- syngas-fired combustion turbines and heat recovery steam generators
- coal and combustion waste handling and storage equipment
- coal receiving equipment for coal received by barge
- upgraded railroad for receiving coal by rail

The cost and performance data provided are based upon data from a study performed by an external architect and engineer under contract to TVA.

Option 7.1.1.2
BELLEFONTE REPOWERING WITH PULVERIZED COAL (4X616 MEGAWATTS)

The two units at TVA's Bellefonte Nuclear Plant (BLN) have been identified as two of four nuclear units whose disposition is being determined in Energy Vision 2020. In order to properly evaluate all of the options for BLN, it is necessary to include a conversion option of the facility to utilize other fuels. The pulverized coal (PC) repowering option has been conceived to provide essentially the same station generation capability, using conventional PC-firing technology, as would be provided by the nuclear plant.

The PC option for BLN consists of four modules, each comprising one subcritical PC-fired boiler and one high pressure (HP) turbine. Each HP turbine generates about 200 megawatts. The steam leaving each HP turbine is returned to the boiler associated with the HP turbine for reheating. The hot reheat steam from the first pair of boilers is collected and routed to the BLN Unit 1 steam turbine. The current BLN high pressure turbine is replaced by an intermediate pressure (IP) turbine designed to receive steam at 500 pounds per square inch gauge and 950°F and to discharge steam to the existing BLN low pressure turbine. Approximately 930 megawatts would be generated by the modified BLN Unit 1 steam turbine. The hot reheat steam from the second pair of boilers is collected and routed to the BLN Unit 2 steam turbine. It has a configuration similar to the BLN Unit 1 steam turbine and would also produce about 930 megawatts. The users of station service power consume approximately 200 megawatts, thus reducing the overall plant output to about 2,450 megawatts.

The repowered facility utilizes existing BLN equipment such as:

- BLN Units 1 and 2 steam turbines and condensers
- natural draft cooling towers
- station auxiliaries (compressed air and service water)
- switchyard and transmission system
- office and service buildings

New equipment added consists of items such as:

- PC-fired boilers with emissions control equipment
- HP topping turbines and modified BLN steam turbine
- coal and combustion waste handling and storage equipment
- coal receiving equipment for coal received by barge
- upgraded railroad for receiving coal and limestone by rail

The cost and performance data provided are based upon data from a study performed by an external architect and engineer under contract to TVA.

Option 7.1.1.3

BELLEFONTE REPOWERING – PHASED COMBINED CYCLE/INTEGRATED GASIFICATION COMBINED CYCLE – PHASE A – COMBINED CYCLE (9X222 MEGAWATTS)

Option 7.1.1.4

BELLEFONTE REPOWERING – PHASED COMBINED CYCLE/INTEGRATED GASIFICATION COMBINED CYCLE – PHASE B – INTEGRATED GASIFICATION COMBINED CYCLE (9X250 MEGAWATTS)

The phased integrated gasification combined cycle (IGCC) repowering of Bellefonte Nuclear Plant is essentially a combination of the natural gas-fired combined cycle (NGCC) repowering, option 1.1.2.3, followed by an IGCC repowering. The primary differences lie in the number of combustion turbines initially installed and the layout of the facility. Phase A of the phased IGCC repowering would utilize nine advanced combustion turbines arranged so as to accommodate the future integration of gasification plant modules on site. Phase A would also include the construction of a natural gas pipeline for fuel supply to the facility.

Phase B of the phased IGCC repowering would consist of constructing the gasification plant modules, along with the necessary material handling systems and connections necessary for integration of the gasification modules into the overall plant heat cycle. It should be noted that the total plant generating capability would be marginally greater due to optimization for NGCC in the beginning followed by IGCC operation.

The cost and performance data provided are based upon data from a study performed by an external architect and engineer under contract to TVA.

Option 7.1.1.5

BELLEFONTE REPOWERING – INTEGRATED GASIFICATION COMBINED CYCLE WITH COPRODUCTION (11X229 MEGAWATTS)

The two units at TVA's Bellefonte Nuclear Plant (BLN) have been identified as two of four nuclear units whose disposition is being determined in Energy Vision 2020. In order to properly evaluate all of the options for BLN, it is necessary to include a conversion option of the facility to utilize other fuels. The integrated gasification combined cycle (IGCC) with coproduction repowering option has been conceived to provide essentially the same station generation capability as would be provided by the nuclear plant using coal gasification technology, along with coproduction of chemicals to reduce electricity production costs through the sale of chemicals. Methanol and several of its derivatives were chosen for economic evaluation.

The IGCC with coproduction option for BLN consists of 10 modules, each consisting of 1 gasifier plant, 1 combustion turbine rated at about 190 megawatts, and a heat recovery steam generator (HRSG). The steam produced by the 10 HRSGs is collected and routed to the BLN Unit 1 steam turbine. The current BLN high pressure turbine is replaced by a turbine designed to receive steam at 1,215 pounds per square inch absolute and 1,000°F, and to discharge steam to the existing BLN low pressure turbine. Approximately 1,240 megawatts are generated by the modified BLN Unit 1 steam turbine. The gasification plant air separation units and other users of station service power consume approximately 720 megawatts, thus reducing the overall plant output to 2,420 megawatts. The gasification modules produce excess syngas, which is transported to the chemical production unit, along with some steam. Total chemical production would be about 6,600 tons per day. A single biomass gasifier with gas turbine and HRSG is also included in the design. This facility would produce approximately 100 megawatts, increasing the total net output of the facility to 2,520 megawatts.

The repowered facility utilizes existing BLN equipment such as:

- BLN Unit 1 steam turbine and condenser
- natural draft cooling towers
- station auxiliaries (compressed air and service water)
- switchyard and transmission system
- office and service buildings

New equipment added consists of items such as:

- gasification plant modules
- syngas-fired combustion turbines and heat recovery steam generators
- chemical production unit

- coal and combustion waste handling and storage equipment
- coal receiving equipment for coal received by barge
- upgraded railroad for receiving coal by rail
- facilities for shipping chemicals

The cost and performance data provided are based upon data from a study performed by Black & Veatch and Bechtel Power Corporation.

Option 7.1.1.6

BELLEFONTE REPOWERING – INTEGRATED GASIFICATION COMBINED CYCLE WITH COPRODUCTION WITH PARTNERS (2X242 MEGAWATTS)

This option is very similar to option 7.1.1.5, integrated gasification combined cycle repowering, except for the fact that:

- It is assumed that partners would be found to own and operate the gasification plant and the chemical production plant. TVA would own and operate the power block only.
- Seventy percent of the synthesis gas is allocated for coproduction instead of 30 percent, as in option 7.1.1.5. As a result, the power output is reduced to approximately 480 megawatts, while producing the same amount of chemicals as for option 7.1.1.5.
- Only four gasifiers and two combustion turbines/heat recovery steam generators are included rather than 10 each, as included in option 7.1.1.5. To maintain chemical production, the chemical plant is essentially the same as for option 7.1.1.5.

The cost estimate and performance data are extrapolated from information in the Black & Veatch/Bechtel Power Corporation study performed for option 7.1.1.5.

Option 7.1.1.7

BELLEFONTE REPOWERING – INTEGRATED GASIFICATION COMBINED CYCLE DEMONSTRATION WITH PARTNERS (1X400 MEGAWATTS)

This option is similar to option 7.1.1.6 except that it is smaller, has no coproduction, and could be a first module of option 7.1.1.6. It is predicated on receiving funding from the Department of Energy (DOE) through the Clean Coal Technology program. The facility would generate approximately 400 megawatts. No coproduction is assumed with the first module.

As with option 7.1.1.6, the cost and performance data are extrapolated from information in the Black & Veatch/Bechtel Power Corporation study performed for option 7.1.1.5.

Option 7.1.2.1

BELLEFONTE REPOWERING – NATURAL GAS COMBINED CYCLE (10X222 MEGAWATTS)

The two units at TVA's Bellefonte Nuclear Plant (BLN) have been identified as two of four nuclear units whose disposition is being determined by TVA's integrated resource planning process. In order to properly evaluate all of the options for BLN, it is necessary to include a conversion option of the facility to utilize other fuels. The natural gas-fired combined cycle (NGCC) repowering option has been conceived to provide essentially the same station generation capability as would be provided by the nuclear plant using conventional gas-fired combined cycle technology.

The NGCC option for BLN consists of 10 modules, each comprising 1 advanced technology combustion turbine and 1 heat recovery steam generator (HRSG). Each combustion turbine generates about 150 megawatts. The steam leaving each HRSG is collected and routed to the BLN Unit 1 steam turbine. The current BLN high pressure turbine is replaced by a new HP turbine designed to receive steam at 900 pounds per square inch gauge and 1,000°F, and to discharge steam to the existing BLN low pressure turbine. Approximately 750 megawatts are generated by the modified BLN Unit 1 steam turbine. The users of station service power consume approximately 50 megawatts, thus reducing the overall plant output to about 2,220 megawatts.

The repowered facility utilizes existing BLN equipment such as:

- BLN Unit 1 steam turbine and condenser
- natural draft cooling towers
- station auxiliaries (compressed air and service water)
- switchyard and transmission system
- office and service buildings

New equipment added consists of items such as:

- advanced technology combustion turbines with HRSGs
- modified BLN steam turbine
- natural gas pipeline

The cost and performance data provided are based upon data from a study performed by an external architect and engineer under contract to TVA.

Options 7.1.4.1 and 7.1.4.2

COMPLETION OF BELLEFONTE UNITS 1 AND 2 AS NUCLEAR (1X1212 MEGAWATTS)

The Bellefonte Nuclear Plant is located in Jackson County, Alabama, on a peninsula at Tennessee River mile 392. The site

is on the west shore of Guntersville Lake about seven miles east-northeast of Scottsboro, Alabama.

Preliminary construction on the Bellefonte site was started in 1974. In 1985, the pace of construction was slowed due to forecasts which showed that generation would not be required until the late 1990s. In 1988, construction activities were deferred, with plant systems being maintained to allow reactivation on a schedule to meet future power requirements. The units were officially returned to construction status in 1993, but engineering and construction activities remained at a very low level of activity. At the current time, all construction work on the units is suspended pending the outcome of Energy Vision 2020. The Bellefonte Nuclear Plant Units 1 and 2 are approximately 90 percent and 58 percent complete, respectively.

The decision regarding the completion and commercial operation dates for the two-unit Bellefonte Nuclear Plant is being evaluated as part of Energy Vision 2020.

The Bellefonte supply-side option is whether each of the units will be completed as nuclear units. Each of the two Babcock and Wilcox pressurized water reactors (PWRs) has a net capacity of 1,212 megawatts, for a total generating capacity of 2,424 megawatts.

The nuclear fuel is contained inside each of the reactor pressure vessels. The fuel is in sealed metal tubes and consists of slightly enriched uranium dioxide pellets. The fission process in the fuel produces heat. Water serves as both the moderator of the fission process and the coolant. The primary coolant water is pumped through the reactor from below the fuel and is heated by contact with the fuel element tubes. The reactor power is controlled by control rods, lumped burnable poison rods, and a neutron-absorbing boric acid solution. The heated coolant flows in two closed-loop circuits through tubes in steam generators and is then pumped back into the reactor. In each steam generator, a separate body of water flows in contact with the outside surfaces of the tubes and absorbs heat from the reactor coolant, producing steam to power the turbine generator. Once the steam has passed through the turbines, it is exhausted to a condenser, where the steam is condensed back into a liquid to be pumped back to the steam generators to begin the process over again. The condenser has tubes through which raw water is circulated in order to condense the steam. The raw water is then pumped to the cooling towers, where the waste heat is emitted. The waste heat is emitted into the atmosphere through two natural-draft hyperbolic cooling towers. The electrical power thus produced by the turbine generator is fed through the switchyard and transmission line connections into the TVA system to meet system power needs.

The cost and performance data are based on site business plans and completion studies performed by a series of external architect and engineering firms under contract to TVA. Sources for other site information are final safety analysis reports (FSARs) for the project, TVA informational brochures, and TVA Nuclear Power Licensing/Engineering.

Option 7.1.4.3
BELLEFONTE UNITS 1 AND 2 CANCELLATION

A decision to cancel the Bellefonte Nuclear Plant Units 1 and 2 would entail selling to the extent possible the equipment, material, and supplies that currently exist as part of the project. Any remaining investment not recovered through these sales would have to be written off by TVA.

Based on previous TVA and industry experience with nuclear plant cancellations, it appears that the majority of such endeavors result in essentially breaking even (i.e., the costs incurred in selling the assets are offset by the receipts from the sales with little or no net profit). This is due to several considerations including the limited market for nuclear-grade materials, the vintage of nuclear technology, and the uncertainty in nuclear market conditions.

The undepreciated investment in the Bellefonte project is approximately $3,762 million for Unit 1 and $793 million for Unit 2.

The source for this information is TVA Nuclear Power Licensing/Project Engineering.

Option 7.1.4.4
BELLEFONTE NUCLEAR PLANT – PARTNERSHIP FOR COMPLETION AND OPERATION

The Bellefonte Nuclear Plant Units 1 and 2 are approximately 90 percent and 58 percent complete, respectively. These units have been placed in a protective lay up status since 1985. TVA has invested approximately $4.5 billion for the completion of these units. Repeated external reviews of the Bellefonte Construction Program indicate that the work quality is sound, and that the remaining completion scope is well defined. Several external groups have expressed interest in participating in the completion of the Bellefonte Nuclear Project.

Under the partnership, TVA and the partner would form a separate corporate entity to complete, operate, and ultimately decommission the Bellefonte Nuclear Plant. TVA would contribute the equity invested in the plant to date; the partner would contribute the remaining completion cost. TVA and the partner would have access to the capacity and energy output of the plant, and share the net revenues and cash flows of sales from the plant. Sharing arrangements have yet to be negotiated, and general estimates are used for the ranking studies

for Energy Vision 2020. Revenues from the plant would cover operating costs, taxes, decommissioning costs, coverage of additional debt and principle, the partner's return on equity, and provide a return on TVA's sunk cost.

The completed plant would have operating characteristics similar to a TVA completion of Bellefonte Units 1 and 2 as nuclear (options 7.1.4.1 and 7.1.4.2). For purposes of evaluating this option in Energy Vision 2020, the Bellefonte partnership option is modeled in a manner similar to a non-utility generator (see option 13.1.2.1 for example). In this evaluation, it is assumed that TVA receives no net revenue from the partnership. The exact amount of capacity that this option would provide TVA would be negotiated with the other partners and could range anywhere from none to the full 2,412 megawatts represented by both units. Energy Vision 2020 considers a capacity addition of 600 megawatts to represent the option.

Option 8.1.4.1
RECOVER BROWNS FERRY UNIT 1 (1X1065 MEGAWATTS)

The Browns Ferry Nuclear Plant is located in Limestone County, Alabama, on the Tennessee River 10 miles southwest of Athens, Alabama. It is on the north shore of Wheeler Reservoir, 19 miles upstream from Wheeler Dam.

Preliminary construction on the Browns Ferry Nuclear Plant started in 1966. The first of the plant's three units was placed in commercial operation on August 1, 1974, about eight years after construction began. The second unit went into commercial operation in March 1, 1975. The third unit went into commercial operation in March 1977. TVA shut down the plant in March 1985 as part of a review of its nuclear power program. At the present time, Units 1 and 3 at Browns Ferry are not operational. Unit 3 has undergone extensive rework and is scheduled to resume commercial operation in the spring of 1996. Unit 1 is presently idle. The decision regarding the rework and commercial operation of the unit is being evaluated in TVA's integrated resource planning process.

The Browns Ferry supply-side option is whether to complete Browns Ferry Unit 1 as a nuclear unit. Unit 1 of the Browns Ferry facility is a General Electric boiling water reactor (BWR) capable of generating 1,065 megawatts of net electrical capacity.

During operation, nuclear fuel is contained inside the reactor pressure vessel of Unit 1. The fuel is sealed in zircalloy tubes, and consists of slightly enriched uranium dioxide pellets. The fission process in the fuel produces heat. The reactor power level is regulated primarily by control rods. Boron, a chemical element that absorbs neutrons and thereby retards nuclear fission, is sealed within the control rods. The power of the reactor, therefore, can be controlled by positioning the control rods in the core. The power is increased by slowly withdrawing the control rods from the core. The power level may also be controlled, but to a lesser extent, by regulating the flow of the water that is circulated through the reactor core.

Water enters the pressure vessel below the fuel and moves through the assembly of fuel tubes called the reactor core. As the water passes through the core, the heat converts it to steam. The steam leaves the reactor through pipes near the top of the reactor, then passes through the turbogenerator, which generates electricity. The steam is then condensed into water and returned to the reactor, where the cycle is repeated. Waste heat is emitted in the atmosphere through a series of mechanical draft cooling towers. The electrical power thus produced by the turbogenerator is fed through the switchyard and transmission line connections into the TVA system to meet system power needs. *Figure T6-11* shows a diagram of the Browns Ferry Plant simplified steam cycle.

The sources for this information are the site business plans, site Public Relations/Engineering, and Tennessee Valley Authority Environmental Statement, Browns Ferry Nuclear Plant – Units 1, 2, and 3, July 1971.

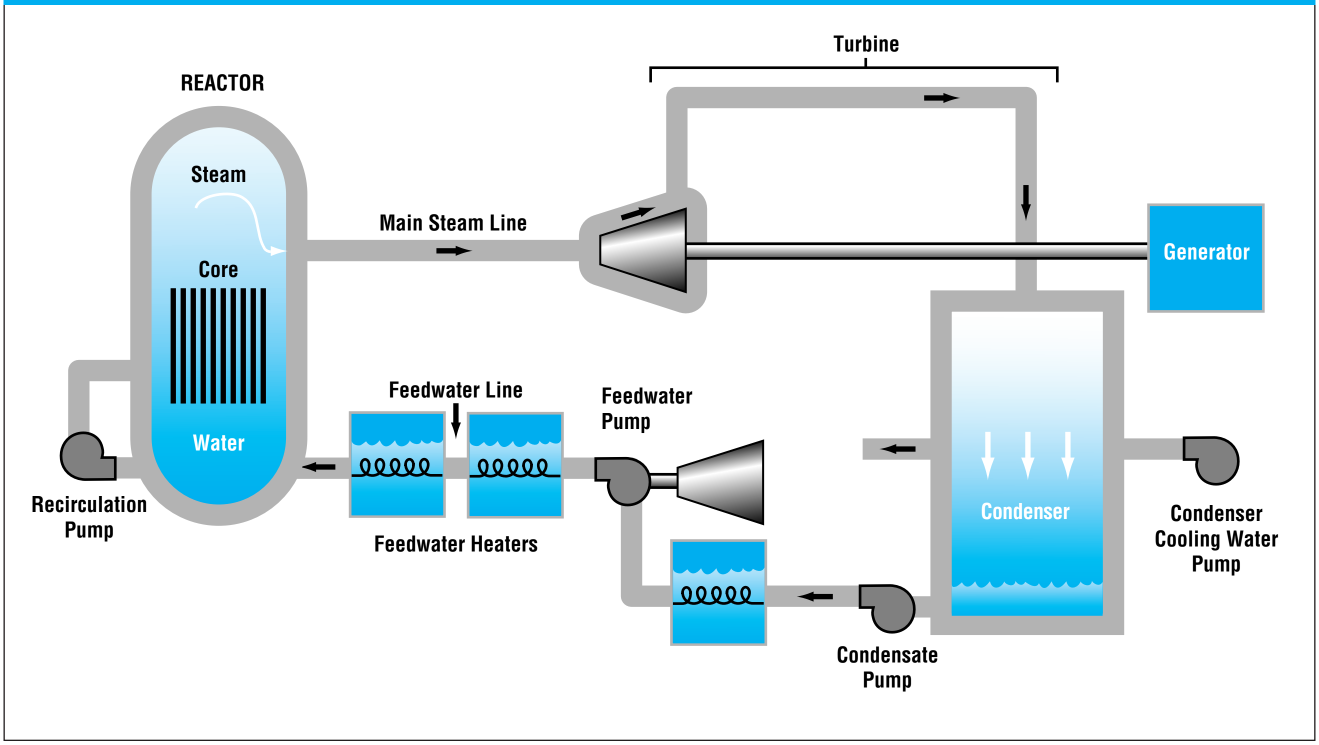
Option 8.1.4.2
BROWNS FERRY UNIT 1 CANCELLATION

A decision to cancel the Browns Ferry Nuclear Plant Unit 1 is simply a decision not to complete the unit now or in the future. Unit 1 at Browns Ferry is an integral part of the Browns Ferry site, which also includes the operating Unit 2 and soon to be restored Unit 3. This complexity, along with the fact that Browns Ferry Unit 1 has operated in the past, makes it impossible to cancel this project in the same manner as was described for Bellefonte in option 7.1.4.3.

While some surplus equipment from Browns Ferry Unit 1 could be sold, previous TVA and industry experience with nuclear plant cancellations suggests that this would most likely be a break-even proposition (i.e., the cost incurred in selling the assets are offset by the receipts from the sales with little or no net profit). This is due to several considerations including the limited market for nuclear-grade materials, the vintage of nuclear technology, and the uncertainty in the nuclear market conditions.

The undepreciated investment in the Browns Ferry Unit 1 is approximately $708 million. A portion of the plant represented by this investment will remain useful to support operation of Units 2 and 3 even if Unit 1 is cancelled. The fraction of the investment that would be useful has not yet been determined, and has been assumed to be zero in the Energy Vision 2020 evaluation.

FIGURE T6-11. **Browns Ferry Simplified Steam Cycle**



The source for this information is TVA Nuclear Power Licensing/Project Engineering.

Option 8.1.4.3

BROWNS FERRY UNIT 1 RECOVERY WITH FIXED COST TO COMPLETE (1X1065 MEGAWATTS)

One option for Browns Ferry Nuclear Plant Unit 1 is to contract with an outside engineering firm to recover the unit for a fixed cost and operation date. This would remove TVA's exposure to the schedule and completion cost risk. TVA would operate the unit once it had been recovered. All characteristics and costs, except for the capital costs for recovery, would be the same as those for option 8.1.4.1.

Option 9.1.4.1

COMPLETION OF WATTS BAR UNIT 2 (1X1170 MEGAWATTS)

The Watts Bar Nuclear Plant is located in Rhea County, Tennessee, adjacent to the TVA Watts Bar Dam Reservation at Tennessee River mile 528. The plant is on the west shore of Chickamauga Lake about 8 miles southeast of Spring City, Tennessee, and 50 miles northeast of Chattanooga, Tennessee.

Preliminary construction on the Watts Bar Nuclear Plant started in December, 1972. The major construction elements were largely completed by 1985. Since 1985, Watts Bar has been undergoing extensive reviews and modifications. Construction work at Watts Bar was put on hold in December 1990. Work resumed in November 1991, and after extensive site review in May of 1992, the Nuclear Regulatory Commission (NRC) gave the site the go-ahead to resume full construction activities. The first of the plant's two units is scheduled for commercial operation in 1996. The decision regarding completion of the plant's second unit is being evaluated as part of Energy Vision 2020.

The Watts Bar supply-side option is whether to complete the second nuclear unit. Watts Bar Unit 2 is a Westinghouse pressurized water reactor (PWR). The Westinghouse reactor is capable of producing 1,170 MW net of electrical capacity.

During operation, the nuclear fuel is contained inside the Unit 2 reactor pressure vessel. The fuel is in sealed metal tubes and consists of slightly enriched uranium dioxide pellets. The fission process in the fuel produces heat. Water serves as both the moderator of the fission process and the coolant. The primary coolant water is pumped through the reactor from below the fuel and is heated by contact with the fuel element tubes. The heated coolant flows in four closed-loop circuits through tubes in steam generators, and is then pumped back into the reactor. In the steam generator, a separate body of water flows in contact with the outside surfaces of the tubes and absorbs heat from the reactor coolant, producing steam to power the

turbine generator. The reactor power is controlled by control rods and a neutron-absorbing boric acid solution.

The nuclear steam supply system is housed in an individual containment structure. The primary containment consists of a free-standing steel structure with an ice condenser. A separate reinforced reactor shield building encloses the primary containment. The steam power conversion system is designed to remove heat energy from the reactor coolant in the four steam generators and to convert it to electrical energy. The waste heat is emitted in the atmosphere through two natural-draft hyperbolic cooling towers.

The sources for this information are the site business plan, site Public Relations/Engineering, and Tennessee Valley Authority Environmental Report, Watts Bar Nuclear Plant, November 1972.

Option 9.1.4.2
WATTS BAR UNIT 2 CANCELLATION

A decision to cancel the Watts Bar Nuclear Plant Unit 2 would create the need for additional decisions concerning the utilization and/or disposition of the investment to date. The decisions would be to cancel the project and either sell the surplus equipment, material, and supplies, or convert the unfinished nuclear plant to a fossil-fired facility. Finally, any remaining investment not recouped through either the sale of assets or its conversion would have to be written off by TVA.

If the cancel-and-sell decision were made, materials and equipment would be sold to recoup as much of the total investment to date as possible from the project. Based on TVA's experience with nuclear plant cancel-and-sell programs and industry experience, it appears that the majority of such operations result in breaking even (i.e., it costs a dollar to recoup a dollar investment).

This is due to several considerations including the limited market for nuclear-grade materials, the vintage of nuclear technology, and the uncertainty in nuclear market conditions.

The conversion of Watts Bar Unit 2 to a fossil-fired facility is a very difficult option. The major constraints to the conversion option at Watts Bar are:

- Engineering and operational interface problems associated with Units 1 and 2 of the nuclear plant.
- Operational incompatibilities associated with a nuclear and fossil-fired unit at the same site.
- Nuclear Regulatory Commission licensing constraints that would be applied to the fossil-fired unit.

The sunk cost to date in the Watts Bar Unit 2 project is approximately $1,651 million.

The source of this information is TVA Nuclear Power Licensing/Project Engineering.

Option 10.1.2.1
INLET AIR PRECOOLING WITH STORAGE (16X61 MEGAWATTS)

Option 10.1.2.4
WATER SPRAY COOLING OF COMBUSTION TURBINE INLET AIR

Inlet air precooling with ice storage is a technology that allows combustion turbines (CTs) to operate at higher output levels during hot weather than would normally be possible. Combustion turbine performance decreases significantly as the air temperature at the compressor inlet increases. Inlet air precooling provides a mechanism to cool the air entering the compressor inlet to approximately 40°F, thus increasing the turbine output to the levels normally achievable in cool weather. This is achieved by producing and storing ice during off-peak conditions using excess system generation to operate industrial-sized chillers. When the additional combustion turbine output is required during warm weather, water is circulated through the ice storage and routed to fin coils located in the compressor inlet ducting to cool the compressor inlet air. Thus, inlet air precooling is an energy storage technology that is applicable for peaking usage during hot weather. It provides no system benefits during the rest of the year.

Water spray cooling is similar to inlet air precooling with ice storage, except for the method and extent of precooling. A fine mist of water is sprayed into the inlet air stream during hot weather operation. Evaporation of the water reduces the air temperature by 10 to 20 degrees, depending upon ambient conditions. This can increase the turbine output by 5 to 10 percent, depending upon ambient conditions. Spray cooling is more effective in conditions of lower relative humidity and higher dry bulb temperature. Compared to precooling with ice storage, water spray cooling is much simpler and less expensive to install, but provides a smaller gain in turbine output.

Cost and performance data were obtained from Electric Power Research Institute studies and from industry reports on newly installed and operational inlet air precooling systems, with calculations performed by TVA to adjust the performance to the environmental conditions found in the TVA region.

Option 10.1.2.2
NEW COMBUSTION TURBINE AT JOHNSONVILLE TO SUPPLY STEAM TO DUPONT (1X174 MEGAWATTS)

TVA has contracted with DuPont to supply process steam from TVA's Johnsonville coal-fired plant to their New Johnsonville, Tennessee, industrial plant. Currently the steam is extracted from the boilers of Units 1-4.

This supply-side option is an alternative method of supplying this steam while at the same time adding capacity to the power system. In this concept, a new high-efficiency combustion turbine is installed at Johnsonville, and the exhaust gases are routed to a heat recovery steam generator to produce steam for a steam turbine and for extraction to supply DuPont's needs. The steam turbine can increase its generation during those periods when DuPont's steam demand decreases. A backup natural gas-fired boiler provides the reliability required by DuPont.

By providing steam from the combustion turbine, the fossil Units 1-4 would no longer have to provide steam; therefore, the capacity of the station would increase by about 50 megawatts. In addition, Units 1-4 could then be dispatched according to power system needs.

If a natural gas "connector" pipeline was constructed from an interstate pipeline to the plant for this option, it would probably be very inexpensive to increase the capacity of the connector pipeline to convert the existing Johnsonville combustion turbines to natural gas, thereby lowering their fuel cost.

The technologies required for this option are commercially mature.

The source for the cost and performance data is an internal TVA study performed in fiscal year 1994.

Option 10.1.2.3

REPOWERING ONE OF JOHNSONVILLE FOSSIL UNITS 7-10 WITH NATURAL GAS/COMBINED CYCLE (1X465 MEGAWATTS)

Option 25.1.2.1

REPOWERING ALLEN FOSSIL PLANT WITH NATURAL GAS/COMBINED CYCLE (1X705 MEGAWATTS)

Repowering is defined as the reuse of the existing site infrastructure and major power generation equipment to convert an existing fossil fuel unit to a new power generation technology. In most repowering applications, the boiler is replaced, while major equipment, such as the turbine generator, feedwater system, and condenser, is reused in the new plant. Some of the advantages of repowering are:

- Extension of plant life
- Increase in generating capacity
- Improvement in unit efficiency
- Decrease in emissions

Repowering does have some disadvantages. Space availability at the existing plant can be a problem since most plants are fairly "tight." Also, the cost for additional generating capacity is relatively high when compared to a greenfield or new site.

In this particular application of repowering, the boiler and coal handling facilities would be retired while the steam turbine generator, feedwater system, and condenser would be reused. A combustion turbine(s) (CT) and a heat recovery steam generator (HRSG) would be added. The CT's hot exhaust gases generate steam in the HRSG for the existing steam turbine. The steam turbine would generate a significant amount of power (although usually less than before) and the CTs add a large amount of generation.

The unit efficiency and emission characteristics of this option appear very attractive, the capital cost and operation and maintenance costs are relatively low, and the technology is commercially mature. However, the cost of fuel (natural gas) is significantly higher than coal.

The cost and performance data are based on a study conducted by Stone & Webster Engineering Corporation for TVA in 1994.

Option 10.3.1.1

REPOWERING ONE OF JOHNSONVILLE FOSSIL UNITS 1-6 WITH INTEGRATED GASIFICATION COMBINED CYCLE (1X242 MEGAWATTS)

Option 10.3.1.2

REPOWERING ONE OF JOHNSONVILLE FOSSIL UNITS 7-10 WITH INTEGRATED GASIFICATION COMBINED CYCLE (1X250 MEGAWATTS)

Option 20.3.1.1

REPOWERING TWO UNITS OF WATTS BAR FOSSIL PLANT WITH INTEGRATED GASIFICATION COMBINED CYCLE (1X242 MEGAWATTS)

Option 25.3.1.1

REPOWERING ALLEN FOSSIL PLANT WITH INTEGRATED GASIFICATION COMBINED CYCLE (1X500 MEGAWATTS)

Repowering is defined as the reuse of the existing site infrastructure and major power generation equipment to convert an existing fossil fuel unit to a new power generation technology. In most repowering applications, the boiler is replaced, while major equipment such as the turbine-generator, feedwater system, and condenser, is reused in the new plant. Some of the advantages of repowering are:

- Extension of plant life
- Increase in generating capacity
- Improvement in unit efficiency
- Decrease in emissions

Repowering does have some disadvantages. Space availability at the existing plant can be a problem since most plants are fairly "tight." Also, the cost for additional generating capacity is relatively high compared to a greenfield or new site.

In this particular application of repowering, the boiler and coal handling facilities would be retired while the steam turbine-generator, feedwater system, and condenser would be reused. An integrated gasification combined cycle (IGCC) system is added. The major components of the IGCC plant are the gasification plant, the combustion turbine(s) (CT), and a heat recovery steam generator (HRSG). The gasifier would use coal to produce a medium syngas, which is burned to produce power in the CTs. The CT's hot exhaust gases generate steam in the HRSG for the existing steam turbine. The steam turbine would generate a significant amount of power (although usually less than before) and the CTs would add a large amount of generation.

The unit efficiency and emission characteristics of this option appear very attractive, the fuel cost (coal) is very low since high sulfur coal can be used, and the technology is quite close to being commercially mature. However, the capital cost of IGCC repowering is quite high.

The cost and performance data are based on a study conducted by Stone & Webster Engineering Corporation for TVA in 1994.

Option 11.1.5.1

LAUREL BRANCH PUMPED-HYDRO STORAGE (4X386 MEGAWATTS)

Option 15.1.5.1

REYNOLDS CREEK PUMPED-HYDRO STORAGE (3X366 MEGAWATTS)

Option 17.1.5.1

ROREX CREEK PUMPED-HYDRO STORAGE (3X292 MEGAWATTS)

The benefit of energy storage facilities is in the ability to store low-cost, off-peak energy and to discharge it during high peak demand periods. Energy storage facilities can also provide spinning reserve capacity and contribute to solving minimum overnight turndown problems.

In pumped-hydro storage, water is pumped from a lower reservoir to the upper reservoir using off-peak power. During the generating cycle, water is discharged from the upper reservoir through the reversible pump/turbine-generators located in an underground powerhouse. Pumped-hydro storage facilities have relatively long storage times of 10 to 20 hours, relative to other storage technologies.

The emissions from a pumped-hydro plant are essentially zero. There are emissions associated with the source of the power used during the pumping cycle.

Limited sites can be considered for conventional pumped-hydro installations because of the required elevation difference between the two reservoirs. Several sites have been identified in the TVA region, and preliminary engineering studies on these sites have been made.

The cost and performance data are based on a TVA study completed in November 1994.

Option 14.1.3.1

WIND – 33 METER VARIABLE SPEED ADVANCED WIND TURBINE (285X0.35 MEGAWATTS)

Option 14.3.3.1

WIND – 39 METER VARIABLE SPEED ADVANCED WIND TURBINE (444X0.45 MEGAWATTS)

Wind turbines capture the wind's energy with blades that operate as airfoils. Current commercial wind turbine designs produce electrical power at wind speeds exceeding about 10 miles per hour. The energy extractable from the wind is proportional to the cube of the wind speed; if the wind speed doubles, eight times as much power is available.

The most common turbine configuration is a horizontal axis design. A gearbox is used to step up the low hub speed to the generator's nearly synchronous speed of 1,800 revolutions per minute. Most generators now in service are squirrel cage induction generators, although some synchronous machines have been tested. A variable speed turbine using modern power electronics has been developed. This turbine, first offered commercially in 1992, is expected to be widely used during the mid- to late 1990s.

Wind turbine control options include active or passive yawing to track wind direction and stall regulation or blade pitch regulation to control power output. Both stall- and pitch-regulated turbines start turning and generating electricity at a particular wind speed, called "cut-in," and the output power increases as the wind speed increases, up to the wind speed for which it is rated. The turbine will produce its rated output at speeds between the rated wind speed and the "cut-out" speed, the speed at which the turbine stops. Stall-regulated airfoils lose their lifts at high wind speed and are therefore self-regulating. When pitch-regulated turbines are in the presence of wind speeds at or above the turbine's rated wind speed, the pitch of the blade is changed to hold the power at a given level. If the wind speed rises to a cut-out value, the blade feathers and the turbine stops to avoid excessive loads. A number of vertical axis

machines have also been deployed. They have the advantage that all of their heavy components are essentially on the ground. However, as of 1992, no commercial units were being manufactured.

The turbine ratings of state-of-the-art utility-grade turbines have increased from an average of about 50 kilowatts in 1981 to over 300 kilowatts by 1992. Well-designed machines with good maintenance service have all-wind-condition availabilities of 96 to 98 percent.

Each wind turbine has a unique transfer function (power curve) that relates a given wind speed condition to the nominal electrical output of the turbine. This curve is a function of the area swept by the rotor, the capacity of the turbine's generator(s), and the unit's energy conversion efficiency. In general, a variable-pitch turbine is more efficient than a fixed-pitch turbine, but it may also have more moving parts, and thus a higher initial cost. Variable-speed turbines can convert more of the energy in higher speed winds to electrical output. Modern power electronics are required to convert the generator's variable frequency power to constant 60 hertz power.

A wind power plant is composed of a number of wind turbines connected to the utility grid system through one or more interconnections. Typically the turbines are arranged in rows perpendicular to the prevailing wind direction. Turbines are at least 10 rotor-diameters apart in the downwind direction and about 3 diameters apart in the crosswind direction.

When the wind speeds are in the proper range, the turbines operate automatically under the control of their on-board processors. A modern power plant is monitored and controlled by means of telecommunication to a remote computer terminal located at a utility control facility. The operational status of each unit is known at all times and can be changed to meet the required operating conditions. Alarms are identified and diagnosed at the remote facility, and maintenance crews are dispatched as needed.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 16.1.5.1

RACCOON MOUNTAIN PUMPED-HYDRO ENERGY STORAGE ADDITION (3X255 MEGAWATTS)

The TVA Raccoon Mountain pumped-hydro energy storage facility is a four-unit plant. Three additional generation/pumping units could be added to the facility to increase the total power output. Since the size of the upper storage reservoir would not be increased, the duration of full-load generation at the new, higher power output would be decreased.

The cost and performance information is extrapolated from recent TVA cost studies for new pumped-storage sites (options 11.1.5.1, 15.1.5.1, and 17.1.5.1).

Option 16.1.5.2

RACCOON MOUNTAIN PUMPED-STORAGE MODERNIZATION

TVA's Raccoon Mountain pumped-hydro plant was designed and installed in the 1970s. Since that time, technology has advanced significantly on several fronts of pumped-storage plant design. A modernization project has been identified that will increase the capacity and efficiency of the plant. This project would increase the plant output by approximately 76 megawatts.

The cost and performance information for modernization projects at existing hydro sites was provided by the Fossil and Hydro Projects organization.

Option 18.1.1.1

SHAWNEE UNIT 11 (1X168 MEGAWATTS)

Since 1988, the TVA Shawnee Fossil Plant Unit 10 turbine-generator has been powered by a new atmospheric fluidized bed combustion boiler. The original Unit 10 pulverized coal boiler is idle. A new steam turbine-generator and associated auxiliary systems could be installed as Unit 11. The original Unit 10 boiler could be refurbished to supply steam to the new Unit 11 turbine-generator. This option includes a mechanical draft cooling tower for condenser heat rejection. The other 10 units have no cooling towers.

The original Unit 10 boiler has no flue gas desulfurization (FGD) system, or scrubber capabilities. No new FGD facilities would be installed. Consequently, the fuel would be low sulfur coal.

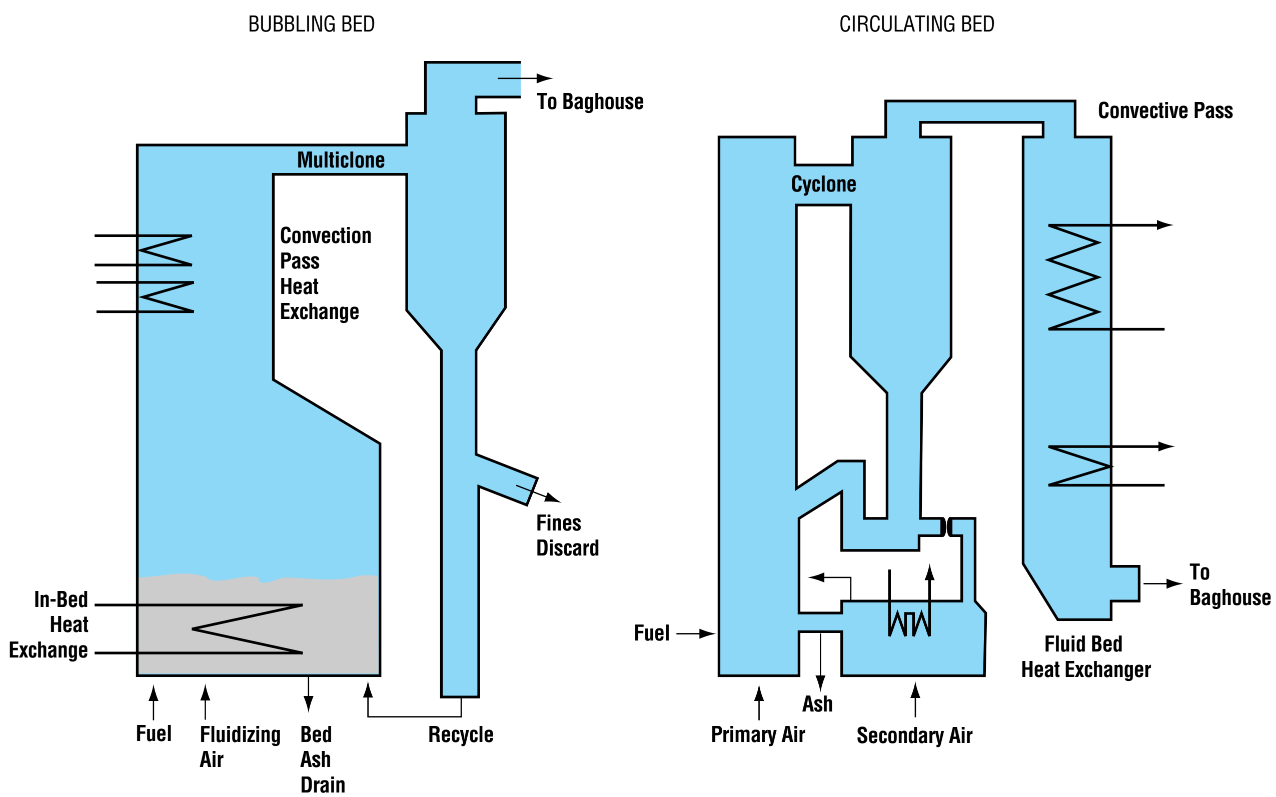
The cost data are based on results from an engineering study performed by an external architect and engineer.

Option 20.1.1.1

RESTART ONE UNIT OF WATTS BAR FOSSIL PLANT (1X56 MEGAWATTS)

TVA's Watts Bar Fossil Plant was initially placed in service in 1945. It was operated until the 1960s, when it was placed in storage status in anticipation of new nuclear capacity coming on line. It was reactivated in the mid-1970s and operated until 1982, when it was again placed in storage status. Except for some particulate collection equipment added in the 1970s, the plant is still in essentially the same configuration as when initially placed in service. Several modifications that have been identified must be performed before the plant can be returned to service. These modifications range from replacement of

FIGURE T6-12. **Atmospheric Fluidized Bed Combustion Boiler Types**



equipment that is no longer functional to modifications required to meet new emissions requirements.

The cost and performance information was taken from a study performed by an external architect and engineer with some adjustments by TVA.

Option 20.1.3.1

REFUSE-DERIVED FUEL – FLUIDIZED BED COMBUSTION REPOWERING OF ONE UNIT OF WATTS BAR FOSSIL PLANT (1X56 MEGAWATTS)

Fluidized bed combustion burns fuel that is suspended in a moving air stream. An atmospheric fluidized bed combustion (AFBC) generating unit is similar to a conventional pulverized coal unit and includes fuel receiving and handling, an air heater, a steam turbine generator and auxiliaries, particulate removal, ash handling, plant cooling, and other balance-of-plant equipment. In bubbling bed AFBC generating units, the heat transfer surface is located both in the bed and in the convection pass above the bed.

In some circulating bed AFBC generating units, the heat transfer surface is located downstream of the cyclone separators, and in a separate fluidized bed heat exchanger that recovers heat from the cyclone catch before the solids are reinjected into the furnace. Other circulating fluidized bed designs locate the superheater surface at the top of the furnace shaft and do not use the separate fluidized bed heat exchanger. *Figure T6-12* shows a diagram of two atmospheric fluidized bed combustor boiler types (the bubbling bed and the circulating bed).

Nitrogen oxides (NO_X) emissions are inherently low. With staged combustion, they can be easily limited to 0.2-0.3 pounds of NO_X per million Btu for bubbling bed units, and to 0.1-0.2 pounds of NO_X per million Btu for circulating bed units. Particulate emissions can be reduced to less than 0.03 pounds per million Btu using a fabric filter.

Due to its fuel flexibility, the AFBC boiler design is only moderately affected by fuel properties, and the boiler size is mostly dependent on flue gas volume. Thus, it could economically burn low-cost high-sulfur petroleum coke (50 cents per million Btu to 70 cents per million Btu) and coal fines, or blends of pet coke and coal fines.

The cost and performance data are based on information from Electric Power Research Institute's Technical Assessment Guide.

Option 23.1.2.1
POWER PURCHASE – BASE LOAD (1X300 MEGAWATTS)

Option 23.1.2.2
POWER PURCHASE – PEAKING (1X300 MEGAWATTS)

TVA considers the market clearing price for power purchases to be related to the technology that is available to generate this power. The peaking power purchase option is based on existing simple cycle combustion turbine technology dispatched as a peaking unit. The operation and maintenance costs reflect the production cost and capital recovery incurred by the owner of this unit. The performance and emission characteristics are similar to those for option 1.1.2.1. The basis for the base-load power purchase option is existing gas-fired combined cycle technology dispatched as a base unit. These operation and maintenance costs reflect the production cost and capital recovery incurred by the owner of this unit. The performance and emission characteristics are similar to those for option 1.1.2.2.

Option 24.1.1.1
UNIT POWER PURCHASE 15 YEAR

A neighboring utility has offered TVA the option to purchase power from one of its existing coal-fired units. The operation and maintenance costs reflect the production cost and capital recovery incurred by the owner of this unit. The performance and emission characteristics reflect those of the coal-fired unit.

Option 24.1.1.2
PARTIALLY COMPLETE PULVERIZED COAL PLANT (1X710 MEGAWATTS)

A neighboring utility has purchased the major capital equipment and completed the siting work and final design of a 710-megawatt pulverized coal (PC) plant. This utility has since deferred the completion of the plant. The plant equipment remains warehoused. The utility has offered to sell the equipment site and design. The capital cost is very competitive as compared to current market prices.

This pulverized coal plant would use midwest 5 pound per million Btu sulfur coal and a wet scrubber sulfur dioxide removal system. The utility is contiguous with the TVA service area and thus no wheeling charges were included in the option. The plant description is similar to that of the subcritical pulverized coal-fired plant, option 1.1.1.5.

Option 26.1.3.1
BIOMASS COFIRING – CUSTOMER SERVICE

The cofiring of biomass with coal in pulverized coal and cyclone-fired units at relatively low biomass percentages has been demonstrated to be a technically feasible and cost-effective method to reduce emissions from coal-fired plants, and in many cases to reduce fuel costs. The level of biomass cofiring, expressed as a percentage of the total fuel energy input to the unit, determines the capital cost of modifications required for a plant to continuously cofire biomass.

The only biomass considered for cofiring is untreated, unpainted wood waste from wood products industries. No trees would be cut to supply biomass for cofiring projects.

The customer service cofiring option would be implemented at plants in the vicinity of wood products industries that are actively seeking cost-effective alternate means of disposing of their wood wastes. TVA has had discussions with several of the industries that have indicated that costs of current disposal methods, typically landfill, have increased to the point that these costs are impacting their competitiveness.

The level of biomass cofiring for the customer service option would be low—less than 0.5 percent. The capital cost would also be low and the cost to TVA of the wood waste, expected to be only transportation cost, would be significantly lower than coal on a Btu basis.

The capital cost estimates are based on conceptual designs and cost estimates made by Ensearch Environmental Corporation in 1994. The fuel cost estimates are based on the report "Biomass Resource Assessment for Twelve TVA Plants" prepared jointly by the University of Tennessee, Oak Ridge National Laboratory, and TVA in 1994.

Option 26.2.3.1
BIOMASS COFIRING – LOW LEVEL

This biomass cofiring option is similar to option 26.1.3.1 except for the level of cofiring. In this option, wood waste would be cofired up to about 1.3 percent at various plants. The level for each plant would depend on the wood cost and supply in the vicinity of the plant. The wood waste cost would be higher than that for the biomass cofiring customer service option and would include transportation and energy costs, but would still be lower than coal costs on a Btu basis. Capital costs would be higher than for the biomass cofiring customer service option, as well.

The capital cost estimates are based on conceptual designs and cost estimates made by Ensearch Environmental Corporation in 1994. The fuel cost estimates are based on the report "Biomass Resource Assessment for Twelve TVA Plants" prepared jointly by the University of Tennessee, Oak Ridge National Laboratory, and TVA in 1994.

Option 26.3.3.1

BIOMASS COFIRING – LESS THAN $5.00 PER TON OF CARBON DIOXIDE EMISSIONS REDUCTION

One of the benefits of biomass cofiring is the reduction of greenhouse gas emissions, i.e., carbon dioxide (CO_2). The reduction is the result of fossil fuel being displaced by biomass. When the wood waste is the biomass, methane emissions are also reduced due to the avoidance of wood conversion to methane in decomposition. Methane is a more potent greenhouse gas than CO_2 (by about 20 times).

This option includes cofiring wood waste in various plants up to the level at which the cost of greenhouse gas emission reductions, expressed in terms of CO_2 equivalents, is less than $5.00 per ton. Costs include the capital cost of plant modifications, additional plant operation and maintenance costs, and increased (or reduced) fuel costs relative to the cost of coal. The level of wood waste cofiring at a particular plant would depend on the wood cost and supply in the vicinity of the plant.

The capital cost estimates are based on conceptual designs and cost estimates made by Ensearch Environmental Corporation in 1994. The fuel cost estimates are based on the report "Biomass Resource Assessment for Twelve TVA Plants" prepared jointly by the University of Tennessee, Oak Ridge National Laboratory, and TVA in 1994.

Option 28.2.3.2

BIOMASS COFIRING – MODERATE LEVEL AT COLBERT FOSSIL PLANT UNIT 5

Resource assessments indicate there are large amounts of favorably priced wood waste available in the vicinity of the Colbert Fossil Plant (COF). The amounts are such that they could potentially support moderate level, up to 10 percent energy input, at COF Unit 5. The capacity of COF Unit 5 is about 500 megawatts. At this level of cofiring in a pulverized coal-fired unit, a dedicated wood waste preparation and feed system would be required. Consequently, the capital cost of this option is higher than that of other cofiring options. Wood waste costs would remain lower than coal costs on a Btu basis.

The capital cost estimates are based on conceptual designs and cost estimates done by Ensearch Environmental Corporation in 1994. The fuel cost estimates are based on the report "Biomass Resource Assessment for Twelve TVA Plants" prepared jointly by the University of Tennessee, Oak Ridge National Laboratory, and TVA in 1994.

Energy Vision 2020

7

Volume 2, Technical Document

Customer Service Options

Volume 2, Technical Document 7

Customer Service Options

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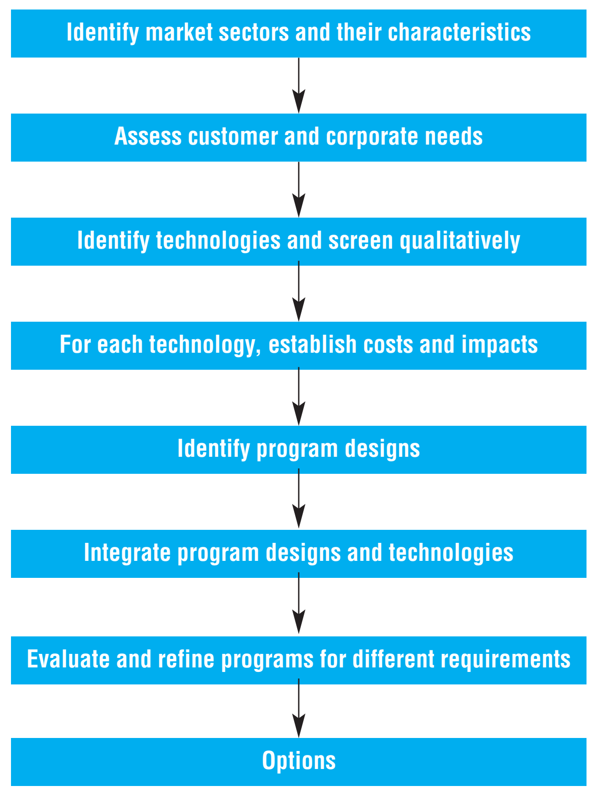
INTRODUCTION

TVA has developed more than 60 customer service options for consideration in Energy Vision 2020. Options were developed for all of the sectors and many of the end uses in the Valley economy. TVA developed options that impact the system load shape in a variety of ways, including energy efficiency, load management, self-generation, beneficial electrification, and rate options. The options include many different technologies that can be used to achieve a significant improvement in the efficiency of electricity use and deliver value to the residences and businesses throughout the Valley.

Technical Document 7, Customer Service Options, describes the methodology and data used for development of the options. This technical document contains a description of how customer service options were evaluated both at the program level and in the resource integration process. The criteria for ranking the technologies for inclusion in the options and prioritizing the options for inclusion in the different resource strategies are also discussed. Descriptions of all the customer service options are provided and include detailed impact and cost information. The last section of this technical document records the development of the technology data base and the technology screening process.

FIGURE T7-1. **Process for Development of Customer Service Options**



Methodology for Option Development

A seven-step process was used to develop and evaluate the initial set of customer service options. *Figure T7-1* illustrates the process used to develop customer service options, including energy efficiency, load management, self-generation, beneficial electrification, and to a limited extent, rate options.

IDENTIFICATION OF MARKET SECTORS AND ASSESSMENT OF CUSTOMER NEEDS

TVA identified different market sectors and their characteristics to assess customer needs and to better understand the kinds of technologies and programs that would be most beneficial. TVA also met with distributors of its power to obtain their input for promoting energy-efficient technologies to end-use customers.

IDENTIFICATION AND QUALITATIVE SCREEN OF THE TECHNOLOGIES

To ensure that a wide range of options was developed for analysis in Energy Vision 2020, TVA identified a wide variety of efficient technologies. TVA received assistance in developing technology data from several organizations that are particularly qualified to provide technology information: E-Source, Tellus Institute, the National Renewable Energy Laboratory, Barakat & Chamberlin, Inc., Synergic Resources Incorporated, and Unimar, as well as TVA sources and the Energy Vision 2020 Review Group.

Technologies were qualitatively screened to ensure their appropriateness and applicability for the region. For example, evaporative air conditioners were dismissed because they are not compatible with the Valley's humid climate. An emerging technology could be discarded if adequate data to assess its costs and impacts were unavailable or could not be estimated. Considerable care was taken not to eliminate technologies prematurely and to carry forward as many technologies as possible to the next stage of the analysis.

ESTABLISH AND RANK TECHNOLOGY COSTS AND IMPACTS

For all selected technologies, TVA gathered information on costs, energy requirements, and impacts on its capacity. This information was stored in a detailed database. Engineering simulations, as well as data from other utilities, technology vendors, and TVA field tests all contributed information to the database. Once the database was developed, it was reviewed by a number of technology experts, including the companies and agencies identified above.

For each market segment, TVA ranked energy efficiency technologies from a total resource cost perspective. To ensure that TVA would have a comprehensive set of options, some technologies with benefits less than the costs of the technology were included in one or more program options. Beneficial electrification measures were ranked according to their impact on electricity prices. This ranking identified the technologies to be included in one or more of the beneficial electrification options.

IDENTIFICATION OF PROGRAM DESIGNS

A critical step in the option development process was the design of programs that would encourage customer acceptance, meet economic and financial objectives, and provide options for all customer classes. TVA reviewed other programs to identify good strategies that would meet TVA, distributor, and customer objectives. Past and present TVA programs, other integrated resource plans, and other utility programs were examined to find best practices and program characteristics providing the greatest chance for success. Programs included in TVA's customer service options were designed to:

- Increase energy efficiency by overcoming obstacles to the adoption of a new technology
- Provide customer value
- Promote market changes

Programs providing customer value, such as microwave heating or laser cutting options, address environmental concerns and increase productivity. These factors often have a greater impact on business profits than do energy costs.

INTEGRATION OF PROGRAM DESIGNS AND TECHNOLOGIES

For customer service options, TVA combined technologies with delivery strategies to provide economical and efficient services to customers. Technologies were integrated with program designs based on likely distribution channels, customer needs, and the characteristics and economics of the different technologies.

EVALUATION AND REFINEMENT OF OPTIONS TO MEET DIFFERENT REQUIREMENTS

The customer service options were checked for completeness and correctness, and to ensure a sufficient number of options were available for the construction of a wide range of strategies. TVA looked for a wide variety of different options to ensure diversity and comprehensiveness. TVA evaluated each option to determine its likely impact on the utility, its customers, and society. Delivery of technologies through a variety of program designs ensures that different customer needs are met.

Program Designs Used to Deliver Technologies and Meet Customer Objective Needs

Figure T7-2 lists the program designs or delivery mechanisms that were used to develop the customer service options and shows the customer objectives that can be satisfied by these program designs. Some program designs are more technology-specific, while others are designed to assist customers in identifying efficiency opportunities unique to their homes or businesses. These program designs provide value to the customer by making technologies more accessible to them and by overcoming obstacles that prevent customers from adopting energy efficiency measures on their own.

The obstacles to adopting energy-efficient technologies, often referred to as market barriers, can be classified into five types:

- Inadequate information
- Inconvenience and hassle
- Excessive risk
- Financial barriers
- Equipment availability

Figure T7-3 shows how different program designs can overcome the market barriers identified above. Some program designs are more technology-specific than others.

Programs such as the following can be used to overcome these market barriers:

Financing/Leasing. Financing is offered to utility customers or the utility owns the technology itself and leases it to customers.

Technical Assistance. Architectural and engineering firms, utility personnel, equipment vendors, or manufacturers assist customers with the new technologies.

Operating and Maintenance Assistance. Customers receive ongoing assistance in operating and maintaining equipment.

Rebates. Customers, equipment installers, or manufacturers receive monetary incentives for high-efficiency energy systems.

Direct Install. Customers receive high-efficiency equipment and direct installation at no charge or at reduced charge.

Audit. Customers are offered help to determine the most cost-effective energy efficiency options for their homes or businesses. Tools and information also may be given to facilitate a self-audit.

Mail Order. Catalogs are promoted as a source of appliances that are not widely available, in order to discount cost and provide information for customers. Catalogs are most appropriate for smaller, easily installed items. This program is particularly attractive for people in rural or remote areas and for the elderly.

Rates. Customers get a special electricity rate that encourages use of various equipment or influences energy use patterns.

Custom Programs. Customers receive site-specific assistance to identify and install energy efficiency measures or make changes that will save energy.

Shared Savings. Utilities provide financing and assistance in implementing an efficiency program and share the savings with the customer.

Market Transformation. Programs designed to increase the supply and demand of efficient technologies through manufacturer alliances, customer education, and establishment of new standards and building codes.

FIGURE T7-2. **Objectives Satisfied by Program Designs**

	PROGRAM OBJECTIVES					
Program Concepts	Minimum Rates	Low Cost	Large Impact	Diversity	Customer Service	Social Equity
Financing/Leasing	●			●	●	
Technical Assistance					●	
Assistance with O & M					●	
Rebates			●	●		●
Direct Install			●		●	●
Audit	●	●		●	●	
Mail Order		●	●			●
Rates	●	●		●		
Custom Programs			●	●	●	
Shared Savings	●	●		●	●	
Market Transformation			●			

Option Evaluation

DSMANAGER & MIDAS

All of the customer service options developed for consideration in Energy Vision 2020 have been evaluated to determine option benefits and costs. DSManager, Version 2.5, was used to develop and evaluate all the customer service options. DSManager is software developed by the Electric Power Research Institute (EPRI) to analyze demand-side management (DSM) programs. The information from DSManager was then fed into MIDAS (Multiobjective Integrated Decision Analysis System, software devel-

FIGURE T7-3. **Market Barriers Overcome by Program Designs**

	MARKET BARRIERS				
Program Designs	Information	Inconvenience & Hassle	Risk	Financial	Availability
Financing/Leasing		●	●	●	
Technical Assistance	●		●		
O & M Assistance	●	●	●		
Rebates			●	●	
Direct Install	●	●	●	●	●
Audit	●				
Mail Order	●	●	●	●	●
Rates				●	
Custom Programs	●		●	●	
Shared Savings			●	●	
Market Transformation	●	●			●

oped by EPRI) to integrate and evaluate both demand-side (customer service) and supply-side options.

Customer service options change the way that customers use energy. DSManager traces these changes to quantify the change in electricity used by the customer over time. DSManager calculates the monetary impact of customer service options using data that describe how these changes in electricity use affect customer costs, as well as detailed descriptions of the production costs and rates (prices) for energy. DSManager calculates the costs and benefits of the customer service options for end-use customers, distributors, and the TVA system.

Once the customer service options had been defined and evaluated using DSManager, their impact and cost data were transferred to MIDAS. MIDAS was used to study and compare the system load impacts and rate impacts of different resource options. MIDAS performs a variety of calculations, including load analysis, capacity planning, production costing, financial projections, and rate calculations. Although available from DSManager, the demand and energy impacts shown in this technical document are from MIDAS. MIDAS provides a more dynamic description of the power system and takes into account the interactions between options and other resources in determining option impacts. Also, the supply costs avoided by implementing customer service options are determined in MIDAS, based on the alternative resource options considered.

CUSTOMER SERVICE OPTION BLOCKS

The customer service options were grouped into four blocks to be combined with supply-side options to create resource strategies. Each block is approximately the size of a generating unit, between 1,000 megawatts and 1,500 megawatts. The different resource strategies were then analyzed at the integration level using MIDAS. The options were divided into the blocks shown below based on the following criteria: (1) option cost; (2) impact on rates; (3) customer value and competitiveness (e.g., long-term customer relationships); and (4) equity (i.e., whether customers have opportunities to participate in programs).

Options in Block 1 provide energy savings at the lowest average total resource cost (described in the next section) of any block, or 2.7 cents per kilowatt-hour. Block 1 also has a minimal impact on average rates or does not cause rates to increase. The average total resource cost of Block 2 options is 2.8 cents per kilowatt-hour, but Block 2 options have a greater impact on average rates than the Block 1 options. The average total resource cost of the options in Block 3 is 3.9 cents per kilowatt-hour and in Block 4 is 5.2 cents per kilowatt-hour. The peak demand savings potential in year 2010 from Blocks 1 and 2 represents 8.7 percent of the forecast summer peak demand, and energy savings constitute 6.3 percent of the total projected system sales in the same year. *Figure T7-4* shows how the customer service options are divided into the four blocks considered in Energy Vision 2020.

BENEFIT/COST TESTS

The outputs from DSManager and MIDAS can be expressed in the terms of the cost-effectiveness tests used to examine the relative benefits and costs of the customer service options from several perspectives. The standard cost-effectiveness tests (Participant Test, Rate Impact Measure Test, and Total Resource Cost Test) measure whether particular customer service options achieve their intended goals.

The Participant Test examines the benefits and costs of the options from the perspective of end-use customers participating in a customer service option. The Rate Impact Measure (RIM) Test takes the perspective of non-participants and quantifies the change in rates due to options. Thus, a program that passes the RIM Test will cause overall system rates to decrease. The Total Resource Cost (TRC) Test looks at options from the perspective of both participants and non-participants and measures the achievement of a goal of providing energy services at the lowest resource cost.

TVA also evaluated the customer service options using the Customer Value Test. This test combines both the RIM Test and the TRC Test, as well as other factors, such as external benefits, quality gains, and long-run rate impacts resulting from customer service options. The Customer Value Test allows comparison of both energy efficiency programs and programs designed to promote new beneficial uses of electricity with supply-side resource options. The results of all the cost-effectiveness tests were considered when options were placed in the blocks to be included in the different resource strategies in Energy Vision 2020.

Option Descriptions

For each of the customer service options, information documenting the program costs and impacts has been provided. There is a written description of each option, typically discussing the applicable target market, implementation strategy, incentive strategy, and the monitoring and evaluation approach to be used to verify program benefits and costs.

The descriptions are intended to give a feel for how an option would be implemented if it were chosen as a viable resource option in the Energy Vision 2020. The option descriptions are intended to identify the appropriate delivery mechanisms for the measures involved and also to quantify the costs and impacts of these measures. Once an option has been selected, a detailed

FIGURE T7-4. **Customer Service Option Blocks**

Block 1

Commercial Cool Storage
Rooftop Cool Storage
Commercial Group Load Curtailment
Residential Load Management—Air Conditioning
Residential Existing Load Management—Air Conditioning
Residential Existing Load Management—Water Heaters
Residential Heat Pump Leasing/Financing Program
Residential Efficiency Products Catalog
Industrial Technology Rebates—High-Efficiency Motors
Residential Lighting Products—Retail Component
Comprehensive Measure Financing
Residential Ground-Source Heat Pump Leasing

Block 2

Residential Self-Audit
Residential New Homes
Commercial Lighting Technology Rebates
Residential Low Income Program
Residential Load Management—Water Heaters
Commercial New Construction
Commercial Technology Rebates—Other
Refrigerator Turn-In
Residential Student Self-Audit
Small Commercial Retrofit

Block 3

Residential Load Management—SCADA
Comprehensive Measure Rebates
Industrial Process Energy Efficiency—Distributor Served
Industrial Process Energy Efficiency—Direct Served
Industrial Technology Rebates—Adjustable Speed Drives
“Opt-Out” or Energy-Efficient Rates
Residential Heat Pump Water Heating Leasing
Residential Direct Install
Commercial HVAC Technology Rebates
Residential Manufactured Housing Program

Block 4

Residential Load Management—New Technology
Commercial HVAC Maintenance Program
Residential Heat Pump Loans
Residential Efficient Air Conditioning
Residential Heat Pump Rebates
Residential Load Management—Storage Water Heaters
Industrial Technology Rebates—Compressed Air Efficiency
Residential Appliance Rebates Program
Residential Low Income Weatherization Program
Residential Solar Water Heater Program
Commercial New Construction—Renewables

program implementation plan must be developed before the program can commence. The detailed development of all DSM programs is done in cooperation with the power distributors, as is their implementation.

PROGRAM ASSUMPTIONS

The option descriptions are followed by the Program assumptions data. This data is divided into three sections. The top section provides some important facts about each option. The second section or table shows option participation by year. Finally, the third section shows program cost data. Each of the sections and variables contained within are discussed in more detail below.

Program Constants

Package Measure Life. This is the average life of the measures installed in a program. For programs with multiple measures, the life is a weighted average of the life of the constituent measures.

Free-Rider Rate. The percentage of customers who would have adopted recommended program actions even without its existence, but who also participate directly in the program (e.g., they do claim rebates).

Free-Driver Rate. The percentage of customers who take program recommended actions because of the program, but who do not participate directly in the program (e.g., they do not claim rebates).

Dropouts. The percentage of program participants who drop out before the equipment or measure in a particular program reaches the end of its life.

Take-Back Percentage. The percentage of a measure's energy savings taken back by the program participant. Energy savings in some end-use technologies will affect a participant's bill significantly enough to influence the participant's energy usage. For example, a weatherization program may lower homeowners' heating bills such that they adjust their thermostat to achieve a more comfortable temperature, thereby "taking back" some of the energy savings to increase comfort. This variable is used only for calculations involving the Customer Value Test.

Free-Rider Market Barrier Costs Eliminated. The percentage of transaction costs, hidden costs, or other market barrier costs eliminated from free riders in the program. This variable is used in Customer Value Test calculations.

Non-Free-Rider Market Barrier Costs Eliminated. The percentage of transaction costs, hidden costs, or other market barrier costs eliminated from program participants who are not free riders in the program. This variable is used in Customer Value Test calculations.

Annual Energy Impact (kWh). The change in average annual energy usage resulting from the measures installed in the program. For programs with multiple measures, the energy impact is a weighted average of all program measures. This value is utilized to scale overall program impacts. Load management programs may not have significant energy impacts relative to their demand impacts. For program analysis, an appropriate load shape (a unitized hourly electrical demand profile) was used to determine the hourly demand impacts corresponding to the annual energy impact.

Participation Data

Year. The option start date is flexible for the Energy Vision 2020 analysis so actual dates are not shown. Participation and costs are shown for the year of the program life. Up to 12 years of program data is shown regardless of the actual length of the program.

Annual Eligible Population. The number of eligible participants determined by the program target market (all customers or annual equipment failures), market segmentation (end use, building type, SIC code), and other factors including the percentage of distributors expected to participate in the program.

New Participants. The estimated number of new program participants by year. For different program sectors, the definition of participant varies. For the residential sector, one participant refers to one unit or one home. In the commercial sector, participation is measured by each thousand square-foot area. In the industrial sector, participation is measured in terms of each one million kilowatt-hours of electric usage.

Total Participants. The cumulative participation in the program from its first year, not accounting for free riders, free drivers, or dropouts.

Cumulative Participation Rate. The ratio of total program participants to cumulative eligible participation.

Cost Data

Fixed Administrative Cost. The program costs not directly proportional to the number of participants are shown in this column. Typical items would include some staff or contract labor costs, training costs, database or software development costs, program design costs, marketing and advertising costs, and monitoring and evaluation costs.

Variable Administrative Cost. The single value indicates the per participant variable administrative cost per participant, and the table shows the annual total for these costs for all participants. Typical items included are inspection fees, program paperwork costs, survey costs, technical assistance costs, billing fees, and financing initiation fees.

Participant Measure Cost. The incremental installed cost of the program measures. This cost is the incremental cost above the base or equivalent technology. The single value shows the cost per participant, and the table shows the annual totals for all participants in a given year. In many cases a portion of this cost will be offset by participant incentives, which are shown separately.

Participant Incentives. Any incentive provided to the participant is indicated here. The single value shows the incentive per participant, and the table shows the annual totals for all participants in a given year. Incentives include one-time rebates, equipment maintenance, price buy-downs arranged with wholesale equipment dealers, or installation of equipment free of charge for some programs.

OPTION-SPECIFIC CALCULATIONS

Following the basic program assumptions in the case of most options, there is an additional table of calculations or details pertinent to the option's costs or impacts. Most options promote more than one technology or measure. A mix of these measures is utilized to determine the average weighted impacts and costs for the measures. For the beneficial electrification options, the determination of the estimated quality gain is also provided.

Many of the values shown in the detailed option descriptions have been calculated. Due to rounding, some values may not be exactly reproduced using the numbers shown.

RESIDENTIAL ENERGY EFFICIENCY OPTIONS

SUMMARY OF PROJECTED IMPACTS IN YEAR 2010

Residential Energy Efficiency	Winter MW	Summer MW	Million kWh	Thousands of Units	TRC ¢/kWh
Heat Pump Loans	433	469	1,347	254	5.0
Heat Pump Leasing	581	518	1,688	266	1.6
Heat Pump Rebates	627	527	1,787	375	3.3
Ground-Source Heat Pump Leasing	58	62	179	26	8.1
Efficient Air Conditioning	0	133	233	124	7.6
New Homes	402	184	1,142	118	3.0
Manufactured Housing	164	53	358	131	4.4
Direct Install	845	386	2,399	1,163	2.3
Low Income	165	75	467	251	2.8
Low Income Weatherization	12	6	36	10	12.9
Heat Pump Water Heater Leasing	262	103	995	452	3.2
Solar Water Heater	11	4	41	15	22.1
Efficiency Products Catalog	234	107	665	714	1.4
Lighting Products Retail Component	225	103	639	687	2.5
Appliance Rebates	39	41	304	1,518	9.1
Refrigerator Turn-In & Recycling	10	13	93	91	3.5
Student Self-Audit	53	23	150	1,235	4.3
Self-Audit	42	19	120	102	2.6
Residential Load Management					**$/kW**
Load Management—Air Conditioners	0	53	21	39	58
Load Management—Water Heaters	212	84	0	158	55
Load Management—Storage Water Heaters	100	39	0	75	934
Load Management w/SCADA	0	0	0	67	140
Load Management—New Technology	0	0	0	276	2,039

Values are the impacts occuring only in the year 2010 for the cumulative participation in the program to that date.

TVA developed 23 residential options for evaluation in Energy Vision 2020 with applications for all major end uses of electricity and for all types of housing.

HEAT PUMP LOANS PROGRAM

Overview

The Heat Pump Loans Program promotes quality installations of higher efficiency heat pumps. The program provides financing for units that meet the minimum performance criteria. Incentives are provided for higher efficiency heat pumps. Weatherization measures can also be financed, if needed to meet minimum insulation and infiltration standards.

Target Market

All residential customers in participating power distributor areas

Implementation Strategy

The Heat Pump Loans Program is designed to promote quality installations of higher efficiency heat pumps. The program will continue the long-term financing effort already in place for heat pumps that meet a minimum SEER 12 performance criterion. In addition, cash or other financial incentives are proposed for dealers or consumers installing heat pumps that have SEERs higher than 12 and HSPFs higher than 7.5. Several levels of incentives will be offered, with greater incentives provided for units with greater performance efficiencies. To ensure optimal performance, a minimum attic insulation level of R-19 and infiltration reduction through weather-stripping and caulking are also included.

The program emphasizes the responsibility of the dealer to provide a quality installation. The Quality Contractor Network provides training for dealers, execution of post-inspection checklists, and awards for maintaining high installation standards. Standards will be established for all program installations to ensure the satisfaction of the consumer and the efficient operation of the system.

Incentives

- Financing of the heat pump and installation costs
- Financing of needed weatherization measures
- Rebates for high-efficiency heat pumps

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	15%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	60%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	4,630

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	57,300	11,200	11,200	20%
2	58,200	12,600	23,800	21%
3	59,100	13,500	37,300	21%
4	60,100	14,500	51,800	22%
5	61,000	15,500	67,300	23%
6	62,000	16,600	83,900	23%
7	62,900	17,000	100,900	24%
8	63,800	17,200	118,100	24%
9	64,800	17,500	135,600	25%
10	65,700	17,700	153,300	25%
11	66,700	17,000	171,300	25%
12	67,600	18,300	189,600	25%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	**Fixed Administrative Cost**	**$324 Total Variable Admin. Cost**	**$1,048 Total Part. Measure Cost**	**$0 Total Part. Incentive**
1	$1,286,000	$3,628,800	$11,737,600	$0
2	$1,286,000	$4,082,400	$13,204,800	$0
3	$1,286,000	$4,374,000	$14,148,000	$0
4	$1,286,000	$4,689,000	$15,196,000	$0
5	$1,286,000	$5,022,000	$16,224,000	$0
6	$1,286,000	$5,378,400	$17,396,800	$0
7	$1,286,000	$5,508,000	$17,816,000	$0
8	$1,286,000	$5,572,800	$18,025,600	$0
9	$1,286,000	$5,670,000	$18,340,000	$0
10	$1,286,000	$5,734,800	$18,549,600	$0
11	$1,286,000	$5,832,000	$18,864,000	$0
12	$1,286,000	$5,929,200	$19,178,400	$0

Monitoring and Evaluation

Program impacts will be evaluated through pre- and post-billing analysis of homes that have not changed their level of insulation. Adjustment factors will be calculated for homes that have upgraded insulation as part of the program. Quality assurance inspections are performed for 100 percent of program installations. Inspections will verify appropriate equipment sizing, air flow and balance, and duct insulation and sealing.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	# /home	Weighted Energy (kWh/yr)	Weighted Cost ($)
Base ASHP10 to ASHP12	3,489	590	0.78	2,721	460
Base ASHP10 to ASHP14	6,989	708	0.14	978	99
Base ASHP10 to GSHP	5,035	2,250	0.08	403	180
Attic Insulation	683	650	0.40	273	260
Programmable Thermostat	637	122	0.40	255	49
			Total	**4,630**	**1,048**

#/home: Based on current program experience

HEAT PUMP LEASING/FINANCING PROGRAM

Overview

The Heat Pump Leasing Program allows for certain technologies to be selected by a customer and installed by the utility, with the customer paying a monthly "service charge" or loan payment on their electric bill. This program is designed to promote efficient electrical products where first cost is a significant barrier to customer participation. Additionally, this program simplifies maintenance and service of complicated equipment by moving the risk to the utility.

Target Market

This program targets residential customers who own or are purchasing their dwelling.

Implementation Strategy

The program works in conjunction with local equipment retailers as a financing program. The customer selects the contractor, eligible equipment, and contacts the utility for an installation inspection and to complete the necessary paperwork. Two payment options are offered. The first is a continual monthly charge with the utility maintaining ownership of the equipment and providing all necessary maintenance and repair of the equipment for as long as the customer is in the program. Early termination (before the customer has repaid his/her debt) requires the customer to settle for the remaining debt.

The second option is a larger monthly payment designed to pay back the debt. During the repayment period, the utility maintains and repairs the equipment free of charge. At the end of the repayment period, the customer can change to a maintenance/replacement contract payment if so desired.

The specified lease equipment must meet applicable SEER and HSPF efficiency levels. The heat pump installation will include an adaptive recovery programmable thermostat and must meet specific installation requirements.

Repair and replacement work will be performed by local contractors. A local phone number with answering service will be available 24 hours per day, 365 days per year. The customer is guaranteed replacement or repair within 48 hours of the call.

Incentives

A service contract will be provided for each heat pump.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	15%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	60%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	5,478

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	57,300	11,220	11,220	20%
2	58,200	12,600	23,820	21%
3	59,100	13,500	37,320	21%
4	60,100	14,500	51,800	22%
5	61,000	15,500	67,300	23%
6	62,000	16,600	83,900	23%
7	62,900	17,000	100,900	24%
8	63,800	17,200	118,100	24%
9	64,800	17,500	135,600	25%
10	65,700	17,700	153,300	25%
11	66,700	18,000	171,300	25%
12	67,600	18,300	189,600	25%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
		$125	$848	$242
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$750,000	$1,400,000	$9,497,600	$2,710,400
2	$700,000	$1,575,000	$10,684,800	$3,049,200
3	$700,000	$1,687,500	$11,448,000	$3,267,000
4	$700,000	$1,812,500	$12,296,000	$3,509,000
5	$700,000	$1,937,500	$13,114,000	$3,751,000
6	$700,000	$2,075,000	$14,076,800	$4,017,200
7	$700,000	$2,125,000	$14,416,000	$4,114,000
8	$700,000	$2,150,000	$14,585,600	$4,162,400
9	$700,000	$2,187,500	$14,840,000	$4,235,000
10	$700,000	$2,212,500	$15,009,600	$4,283,400
11	$700,000	$2,250,000	$15,264,000	$4,356,000
12	$700,000	$2,287,500	$15,518,400	$4,428,600

Monitoring and Evaluation

Some equipment monitoring is required for program analysis purposes. Inspections will be performed on 100 percent of program installations for QA purposes. HVAC inspections will verify appropriate equipment sizing, equipment charge, airflow and balance, and duct insulation and sealing. A complaint phone number also listed on the appliance will provide significant feedback on the equipment and its timely repair.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	# /home	Weighted Energy (kWh/yr)	Weighted Cost ($)
Base ASHP 10 to ASHP 12	3,489	590	0.75	2,617	443
Base ASHP 10 to ASHP 14	6,989	708	0.25	1,747	177
Programmable Thermostat	637	122	1.00	637	122
Maintain ASHP	477	106	1.00	477	106
			Total	**5,478**	**848**

HEAT PUMP REBATES PROGRAM

Overview

The Heat Pump Rebates Program will promote efficient heat pumps using rebates and point-of-sale displays. The rebate structure is tiered corresponding to equipment efficiency levels and is designed to offset the majority of the incremental cost of the more efficient heat pumps. This program would be implemented in cooperation with heat pump manufacturers, distributors, dealers, and installers to promote the rebates to all applicable customers. Contractor/dealer training would be provided to increase understanding of the benefits and fuel cost savings for the more efficient equipment, as well as proper installation and maintenance practices.

Target Market

The program targets the two-thirds of residential heat pumps that are not installed through the TVA Heat Pump Loan Program.

Implementation Strategy

Rebate coupons, point-of-sale displays, and appliance labeling are utilized to promote efficient appliances. Utility representatives will work with manufacturers, dealers, and contractors to distribute displays and coupons. Additionally, coupons will be distributed through other compatible DSM programs, power distributor offices, and upon phone request.

Incentives

Rebate coupons will be provided.

Monitoring and Evaluation

Rebate coupons will provide initial information on replacement and usage patterns. A database will be completed from returned rebate coupons. Follow-up surveys of equipment installed and usage patterns will be conducted.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	25%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	20%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	30%
Annual Energy Impact (kWh)	4,103

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	36,600	5,500	5,500	15%
2	38,400	7,700	13,200	18%
3	40,400	10,100	23,300	20%
4	42,400	14,800	38,100	24%
5	44,500	20,000	58,100	29%
6	46,700	23,400	81,500	33%
7	49,100	24,500	106,000	36%
8	51,500	25,800	131,800	38%
9	54,100	27,000	158,800	39%
10	56,800	28,400	187,200	41%
11	59,600	29,800	217,000	42%
12	62,600	31,300	248,300	43%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$25 Total Variable Admin. Cost	$739 Total Part. Measure Cost	$568 Total Part. Incentive
1	$1,500,000	$137,500	$4,064,500	$3,124,000
2	$1,200,000	$192,500	$5,690,300	$4,373,600
3	$1,200,000	$252,500	$7,463,900	$5,736,800
4	$1,200,000	$370,000	$10,937,200	$8,406,400
5	$1,200,000	$500,000	$14,780,000	$11,360,000
6	$1,200,000	$585,000	$17,292,600	$13,291,200
7	$1,200,000	$612,500	$18,105,500	$13,916,000
8	$1,200,000	$645,000	$19,066,200	$14,654,400
9	$1,200,000	$675,000	$19,953,000	$15,336,000
10	$1,200,000	$710,000	$20,987,600	$16,131,200
11	$1,200,000	$745,000	$22,022,200	$16,926,400
12	$1,200,000	$782,500	$23,130,700	$17,778,400

GROUND SOURCE HEAT PUMP LEASING PROGRAM

Overview

The Ground Source Heat Pump Leasing Program allows for certain technologies to be selected by a customer and installed by the utility, with the customer paying a monthly "service charge" on his/her electric bill. This program is designed to promote ground source heat pumps, for which initial cost is a significant barrier to customer participation. Additionally, this program simplifies maintenance and service of complicated equipment by moving the risk to the utility.

Target Market

This program targets residential customers who own or are purchasing their dwelling.

Implementation Strategy

The program works in conjunction with local equipment retailers similar to a financing program. The customer selects the contractor, eligible equipment, and contacts the utility for an installation inspection and to complete the necessary paperwork. Two payment options are offered. The first is a continual monthly charge with the utility maintaining ownership of the equipment and providing all necessary maintenance and repair of the equipment for as long as the customer is in the program. Early termination (before the customer has repaid his/her debt) requires the customer to settle for the remaining debt.

The second option is a larger monthly payment designed to pay back the debt. Once the debt has been fully repaid, ownership of the equipment is transferred to the homeowner. During the repayment period, the utility maintains and repairs the equipment free of charge. At the end of the repayment period, the customer can change to a maintenance/replacement contract payment if so desired.

The specified lease equipment must meet applicable SEER and HSPF efficiency levels. The heat pump installation will include an adaptive recovery programmable thermostat, and must meet specific installation requirements.

Repair and replacement work will be performed by local contractors. A local phone number with answering service will be available 24 hours per day, 365 days per year. The customer is guaranteed replacement or repair within 48 hours of the call.

Incentives

A service contract will be provided for each ground source heat pump.

Monitoring and Evaluation

Some equipment monitoring is required for program analysis purposes. Inspections will be performed for 100 percent of program installations for QA purposes. The heat pump inspection will verify appropriate equipment sizing, equipment charge, air flow and balance, and duct insulation and sealing. A complaint phone number also listed on the appliance will provide significant feedback on the equipment and its timely repair.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	1%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	40%
Non-Free-Rider Market Barrier Costs Eliminated	50%
Annual Energy Impact (kWh)	6,046

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	79,700	100	100	0%
2	79,700	200	300	0%
3	79,700	300	600	0%
4	79,700	400	1,000	0%
5	79,700	500	1,500	0%
6	79,700	700	2,200	0%
7	79,700	800	3,000	1%
8	79,700	1,000	4,000	1%
9	79,700	1,200	5,200	1%
10	79,700	1,400	6,600	1%
11	79,700	1,500	8,100	1%
12	79,700	1,700	9,800	1%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$75 Total Variable Admin. Cost	$2,250 Total Part. Measure Cost	$242 Total Part. Incentive
1	$300,000	$7,500	$225,000	$24,200
2	$200,000	$15,000	$450,000	$48,400
3	$150,000	$22,500	$675,000	$72,600
4	$150,000	$30,000	$900,000	$96,800
5	$150,000	$37,500	$1,125,000	$121,000
6	$150,000	$52,500	$1,575,000	$169,400
7	$150,000	$60,000	$1,800,000	$193,600
8	$150,000	$75,000	$2,250,000	$242,000
9	$150,000	$90,000	$2,700,000	$290,400
10	$150,000	$105,000	$3,150,000	$338,800
11	$150,000	$112,500	$3,375,000	$363,000
12	$150,000	$127,500	$3,825,000	$411,400

EFFICIENT AIR CONDITIONING PROGRAM

Overview

This program will promote efficient central air conditioners using rebates. Utility representatives will work with HVAC contractors, HVAC distributors, and trade associations to promote applicable appliances and to distribute displays and coupons.

Target Market

All residential customers with central air conditioning in participating power distributor areas are targeted.

Implementation Strategy

Rebate coupons, point-of-sale displays, and appliance labeling are utilized to promote efficient appliances. Utility representatives will work with HVAC contractors, HVAC distributors, and trade associations to promote applicable appliances and to distribute displays and coupons. Additionally, coupons will be distributed through other compatible DSM programs, power distributor offices, and upon phone request.

Incentives

Rebate coupons will be provided.

Monitoring and Evaluation

Program impacts will be evaluated through pre- and post-billing analysis. Quality assurance inspections are performed for approximately 10 percent of program installations, with emphasis on new dealers and problem dealers. Inspections will verify appropriate equipment sizing, air flow and balance, and duct insulation and sealing.

Rebate coupons will provide initial information on replacement and usage patterns. A database will be completed from returned rebate coupons. Follow-up surveys of equipment installed and usage patterns will be conducted.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	15%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	20%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	30%
Annual Energy Impact (kWh)	1,632

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	19,300	2,900	2,900	15%
2	19,300	3,900	6,800	18%
3	19,300	4,800	11,600	20%
4	19,300	5,800	17,400	23%
5	19,300	6,700	24,100	25%
6	19,300	7,700	31,800	28%
7	19,300	8,700	40,500	30%
8	19,300	9,600	50,100	33%
9	19,300	9,600	59,700	34%
10	19,300	9,600	69,300	36%
11	19,300	9,600	78,900	37%
12	19,300	9,600	88,500	38%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$25 Total Variable Admin. Cost	$708 Total Part. Measure Cost	$500 Total Part. Incentive
1	$700,000	$72,500	$2,053,200	$1,450,000
2	$500,000	$97,500	$2,761,200	$1,950,000
3	$500,000	$120,000	$3,398,400	$2,400,000
4	$500,000	$145,000	$4,106,400	$2,900,000
5	$500,000	$167,500	$4,743,600	$3,350,000
6	$500,000	$192,500	$5,451,600	$3,850,000
7	$500,000	$217,500	$6,159,600	$4,350,000
8	$500,000	$240,000	$6,796,800	$4,800,000
9	$500,000	$240,000	$6,796,800	$4,800,000
10	$500,000	$240,000	$6,796,800	$4,800,000
11	$500,000	$240,000	$6,796,800	$4,800,000
12	$500,000	$240,000	$6,796,800	$4,800,000

NEW HOMES PROGRAM

Overview

The New Homes Program promotes higher efficiency standards and quality construction in new homes. Incentives are provided for homebuilders who meet the weatherization and equipment efficiency requirements of a basic package, with additional incentives for specific thermal envelope and equipment upgrades beyond the basic package.

Target Market

This program targets homebuyers in participating power distributor areas.

Implementation Strategy

The New Homes Program will promote higher efficiency standards and quality construction in new homes. Incentives are proposed for homebuilders who meet the weatherization and equipment efficiency requirements of a basic package, and additional incentives will be available for specific thermal envelope and equipment upgrades beyond the levels of the basic package. The thermal performance requirements of the basic package will exceed the standards of the Model Energy Code. The proposed minimum performance requirements for equipment are SEER 12/HSPF 7.5 or SEER 12/AFUE 90. Trade-offs will be allowed for some measures.

The program will provide training for homebuilders and trade allies to ensure the proper installation of efficiency measures. Technical requirements with an emphasis on quality installation should produce significant improvement in the energy efficiency of new homes.

The program will emphasize the responsibility of the dealer to provide a quality installation. A Quality Contractor Network provides training for dealers, execution of post-inspection checklists, and awards for maintaining high installation standards. Standards will be established for all program installations to ensure the satisfaction of the consumer and the proper operation of the system. Inspections during the building process will ensure adherence to program standards.

Incentives

- Builder incentives are provided for meeting the base program standards.
- Builder incentives are provided for additional measures that exceed the base standard.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	15%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	60%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	4,187

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	17,500	3,000	3,000	17%
2	17,500	3,800	6,800	19%
3	17,500	5,000	11,800	22%
4	17,500	6,000	17,800	25%
5	17,500	7,200	25,000	29%
6	17,500	8,600	33,600	32%
7	17,500	8,800	42,400	35%
8	17,500	8,800	51,200	37%
9	17,500	8,800	60,000	38%
10	17,500	8,800	68,800	39%
11	17,500	8,800	77,600	40%
12	17,500	8,800	86,400	41%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$25 Total Variable Admin. Cost	$627 Total Part. Measure Cost	$723 Total Part. Incentive
1	$1,070,000	$75,000	$1,881,000	$2,169,000
2	$1,070,000	$95,000	$2,382,600	$2,747,400
3	$1,070,000	$125,000	$3,135,000	$3,615,000
4	$1,070,000	$150,000	$3,762,000	$4,338,000
5	$1,070,000	$180,000	$4,514,400	$5,205,600
6	$1,070,000	$215,000	$5,392,200	$6,217,800
7	$1,070,000	$220,000	$5,517,600	$6,362,400
8	$1,070,000	$220,000	$5,517,600	$6,362,400
9	$1,070,000	$220,000	$5,517,600	$6,362,400
10	$1,070,000	$220,000	$5,517,600	$6,362,400
11	$1,070,000	$220,000	$5,517,600	$6,362,400
12	$1,070,000	$220,000	$5,517,600	$6,362,400

Monitoring and Evaluation

For impact evaluation estimates, state energy codes will be assumed as the baseline for new construction. Prototype simulation models will be developed to determine the impacts of both the base package and the additional measures package. Additionally, billing analysis will be performed on a sample of participants for comparison with non-participating homes. QA inspections are performed to verify measures in 10 percent of program homes.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	Incentive ($)	# /home	Weighted Energy (kWh/yr)	Weighted Cost ($)	Weighted Incentive ($)
Compact Fluorescent Light	57	13	3	8.00	456	102	20
DHW Pipe Insulation	78	20	—	1.00	78	20	—
Programmable Thermostat	1,057	122	31	0.25	264	31	7
Ceiling Insulation—New	1,995	266	640	1.00	1,995	266	640
Bottom Board	75	3	3	1.00	75	3	3
Low Flow Showerhead	271	20	—	2.50	677	50	—
Base ASHP 12 to ASHP 14	3,500	118	63	0.14	490	17	9
Base ASHP 12 to GSHP	1,546	1,660	500	0.08	124	133	40
Efficient Dishwasher	111	20	15	0.25	28	5	4
				Total	**4,187**	**626**	**723**

MANUFACTURED HOUSING – NEW CONSTRUCTION PROGRAM

Overview

This program will promote the installation of efficient HVAC and water heating equipment by the manufacturer during the construction process. The program also promotes improved methods of connecting and sealing ductwork when the home is readied for occupancy. New HUD standards have increased the building shell requirements to optimal cost-effective levels for new construction, so the program will not address them. This program is simiilar to TVA's Energy Efficient New Manufactured Home Plan.

Target Market

Buyers of residential new construction manufactured housing including single- and double-wide mobile homes, as well as slab-sited pre-manufactured housing are targeted.

Implementation Strategy

TVA will work with stakeholders in the manufactured housing industry to ensure comprehensive coverage of the market. For manufacturers, training classes will explain the benefits of heat pumps and proper installation practices for water heaters and HVAC systems, including pipe insulation and ductwork.

Dealers will receive information, promotional materials, and financial incentives to promote the use of heat pumps in homes. Customer education materials will detail the energy and economic benefits of heat pumps and other retrofit measures, including insulated skirting. Additional educational materials including lesson plans and handouts will be provided to high school teachers in areas of high manufactured housing growth.

Related efforts for this program include lobbying lenders to consider the implications of lower utility bills from heat pumps on the financing process. Additionally, participating power distributors will be encouraged to waive or reduce hook-up charges for program housing as an additional participation incentive.

Incentives

The cost of pipe insulation in the water heater compartment and reduced duct leakage measures are paid by TVA. Four compact fluorescent light bulbs are installed in each program home. Seventeen percent of the estimated cost of the heat pump will be paid to the manufacturer. Dealers will be paid $100 for each qualifying home sold, and an additional $150 will be provided for up to two homes ordered for stock on the dealer's lots.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	5%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	90%
Annual Energy Impact (kWh)	2,366

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	8,000	2,400	2,400	30%
2	8,200	4,900	7,300	45%
3	8,300	7,500	14,800	60%
4	8,500	8,100	22,900	69%
5	8,700	8,200	31,100	75%
6	8,800	8,400	39,500	78%
7	9,000	8,600	48,100	81%
8	9,200	8,700	56,800	83%
9	9,400	8,900	65,700	84%
10	9,600	9,100	74,800	85%
11	9,800	9,300	84,100	86%
12	9,900	9,400	93,500	87%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$20 Total Variable Admin. Cost	$615 Total Part. Measure Cost	$381 Total Part. Incentive
1	$575,000	$48,000	$1,476,000	$914,400
2	$500,000	$98,000	$3,013,500	$1,866,900
3	$500,000	$150,000	$4,612,500	$2,857,500
4	$500,000	$162,000	$4,981,500	$3,086,100
5	$500,000	$164,000	$5,043,000	$3,124,200
6	$500,000	$168,000	$5,166,000	$3,200,400
7	$500,000	$172,000	$5,289,000	$3,276,600
8	$500,000	$174,000	$5,350,500	$3,314,700
9	$500,000	$178,000	$5,473,500	$3,390,900
10	$500,000	$182,000	$5,596,500	$3,467,100
11	$500,000	$186,000	$5,719,500	$3,543,300
12	$500,000	$188,000	$5,781,000	$3,581,400

Monitoring and Evaluation

A database will be developed to track the incentives paid to manufacturers and dealers; another will contain information on customers buying program homes. Program impacts will be estimated with engineering calculations representing average savings per home. The engineering assumptions will be compared and calibrated to monitored field data after the first year of the program. A process evaluation will also be conducted after the first year of the program to improve the administrative processes and customer, dealer, and manufacturer satisfaction.

Approximately 25 percent of heat pumps installed will be inspected, with particular focus on new manufacturers.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	Incentive ($)	# /home	Weighted Energy (kWh/yr)	Weighted Cost ($)	Weighted Incentive ($)
Compact Fluorescent Light	57	13	13	4.00	228	51	51
DHW Pipe Insulation	78	8	8	1.00	78	8	8
Reduced Duct Leakage	1,905	275	275	1.00	1,905	275	275
High Efficiency Heat Pump	2,133	4,865	811	0.03	64	146	24
Insider Heat Pump	1,517	2,250	375	0.06	91	135	23
				Total	**2,366**	**615**	**381**

DIRECT INSTALL PROGRAM—SITE VISIT

Overview

This is a direct install program. A neighborhood is targeted and a contractor goes door-to-door. In a single visit, installation crews install energy efficient lighting, attic insulation, water heater tank wraps, pipe insulation, faucet aerators, low-flow shower heads, caulking, and clean equipment coils and filters.

Target Market

This program targets all residential customers in selected neighborhoods.

Implementation Strategy

All residents in a neighborhood, including single-family homes and individually metered multi-family homes are eligible to participate. The installation crew will spend from one to two weeks in a target neighborhood, depending on the size of the area. Initial contact is made through a postcard or brochure mailed to each home. A canvasser will precede the crews, going door-to-door to make installation appointments, if possible on the same day. Installers will be radio-dispatched to the appointment. Advertisements on the installation crews' program vans will also promote the program.

One crew member will perform a quick site survey and provide a computerized printout of recommended improvements to the homeowner. The installation crew then installs appropriate measures and performs a walk-through with the customer to explain what they have done and how this benefits the customer. This educational portion of the program is extremely important in ensuring energy savings.

TVA and its distributors will work with community-based organizations to coordinate the program. Neighborhood and community groups will be recruited to assist in advertising the program.

Incentives

The measures are provided and installed free of charge.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	20%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	10%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	90%
Annual Energy Impact (kWh)	1,803

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,510,000	25,100	25,100	1%
2	2,513,900	75,400	100,500	4%
3	2,467,500	123,400	223,900	9%
4	2,373,100	142,400	366,300	15%
5	2,259,700	135,600	501,900	20%
6	2,153,100	129,200	631,100	25%
7	2,053,000	123,200	754,300	30%
8	1,958,800	117,500	871,800	35%
9	1,870,200	112,200	984,000	39%
10	1,787,000	89,400	1,073,400	43%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$40 Total Variable Admin. Cost	$295 Total Part. Measure Cost	$295 Total Part. Incentive
1	$1,650,000	$1,004,000	$7,404,500	$7,404,500
2	$1,550,000	$3,016,000	$22,243,000	$22,243,000
3	$1,300,000	$4,936,000	$36,403,000	$36,403,000
4	$1,300,000	$5,696,000	$42,008,000	$42,008,000
5	$1,300,000	$5,424,000	$40,002,000	$40,002,000
6	$1,300,000	$5,168,000	$38,114,000	$38,114,000
7	$1,300,000	$4,928,000	$36,344,000	$36,344,000
8	$1,300,000	$4,700,000	$34,662,500	$34,662,500
9	$1,300,000	$4,488,000	$33,099,000	$33,099,000
10	$1,300,000	$3,576,000	$26,373,000	$26,373,000

Monitoring and Evaluation

Engineering estimates calibrated with information on hours of use and consumption patterns gathered for each participant will be used to estimate program savings. Spot inspections will be done on homes receiving attic insulation.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	# /home	Weighted Energy (kWh/yr)	Weighted Cost ($)
Compact Fluorescent Light	57	13	6.00	342	77
DHW Pipe Insulation	78	20	1.00	78	20
DHW Tank Wrap	271	35	0.50	136	18
Attic Insulation R0-R30 ASHP	2,042	590	0.03	61	17
Attic Insulation R0-R30 ER/AC	2,544	590	0.04	110	25
Attic Insulation R11-R30 ASHP	1,480	393	0.04	65	17
Attic Insulation R11-R30 ER/AC	1,842	393	0.06	117	25
Low Flow Showerhead/Aerator	271	20	2.50	678	50
Maintain ASHP	477	106	0.18	84	19
Maintain ER/AC	520	106	0.25	132	27
			Total	**1,803**	**295**

#/home: in some cases reflects market share
Homes will receive all applicable measures

LOW INCOME PROGRAM—SITE VISIT

Overview

This is a direct install program for targeted low-income neighborhoods. The program uses a contractor to perform the site visits. The installation crew, in a single visit, installs energy efficient lighting, attic insulation, water heater tank wraps, pipe insulation, faucet aerators, low-flow shower heads, caulking, and cleans equipment coils and filters.

Target Market

This program targets residential low-income customers.

Implementation Strategy

All residents in a neighborhood, including single-family homes and individually metered multi-family homes, are eligible to participate. The installation crew will spend from one to two weeks in a target neighborhood, depending on the size of the area. Initial contact is made through a postcard or brochure mailed to each home. A canvasser will precede the crews, going door-to-door to make installation appointments, if possible on the same day. Installers will be radio-dispatched to the appointment. Advertisements on the installation crews' program vans will also promote the program.

One crew member will perform a quick site survey and provide a computerized printout of recommended improvements to the homeowner. Most of the program measures will be cost-effective for almost every home. The installation crew then installs appropriate measures and performs a walk-through with the customer to explain what they have done and how this benefits the customer. This educational portion of the program is extremely important in ensuring energy savings.

TVA and its distributors will work with community-based organizations to coordinate the program. This program can leverage federal low income weatherization efforts, as well as state and local low income programs, to increase the energy efficiency services provided to these customers. Neighborhood and community groups will be recruited to assist in advertising the program, and program displays will be provided for community centers.

Incentives

The measures are provided and installed free of charge.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	5%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	15%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	90%
Annual Energy Impact (kWh)	1,638

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	475,000	4800	4,800	1%
2	475,900	14,300	19,100	4%
3	467,200	23,400	42,500	9%
4	449,400	27,000	69,500	15%
5	428,100	25,700	95,200	20%
6	408,000	24,500	119,700	25%
7	389,100	23,300	143,000	30%
8	371,300	22,300	165,300	35%
9	354,700	21,300	186,600	39%
10	339,000	16,900	203,500	43%
11	327,600	16,400	219,900	46%
12	316,900	15,800	235,700	50%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$40 Total Variable Admin. Cost	$304 Total Part. Measure Cost	$304 Total Part. Incentive
1	$300,000	$192,000	$1,459,200	$1,459,200
2	$250,000	$572,000	$4,347,200	$4,347,200
3	$250,000	$936,000	$7,113,600	$7,113,600
4	$250,000	$1,080,000	$8,208,000	$8,208,000
5	$250,000	$1,028,000	$7,812,800	$7,812,800
6	$250,000	$980,000	$7,448,000	$7,448,000
7	$250,000	$932,000	$7,083,200	$7,083,200
8	$250,000	$892,000	$6,779,200	$6,779,200
9	$250,000	$852,000	$6,475,200	$6,475,200
10	$250,000	$676,000	$5,137,600	$5,137,600
11	$250,000	$656,000	$4,985,600	$4,985,600
12	$250,000	$632,000	$4,803,200	$4,803,200

Monitoring and Evaluation

Engineering estimates calibrated with information on hours of use and consumption patterns gathered for each participant will be used to estimate program savings. Spot inspections will be done on homes receiving attic insulation.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	# /home	Weighted Energy (kWh/yr)	Weighted Cost ($)
Compact Fluorescent Light	57	13	4.00	228	51
DHW Pipe Insulation	78	20	1.00	78	20
DHW Tank Wrap	271	35	0.50	136	18
Attic Insulation R0-R30 ASHP	2,042	590	0.06	119	34
Attic Insulation R0-R30 ER/AC	2,544	590	0.08	213	49
Attic Insulation R11-R30 ASHP	1,480	393	0.06	86	23
Attic Insulation R11-R30 ER/AC	1,842	393	0.08	155	33
Low Flow Showerhead	271	20	1.50	407	30
Maintain ASHP	477	106	0.18	84	19
Maintain ER/AC	520	106	0.25	132	27
			Total	**1,638**	**304**

#/home: in some cases reflects market share
Homes will receive all applicable measures

LOW INCOME WEATHERIZATION PROGRAM

Overview

This program complements the Low Income Program by providing for more extensive home repairs identified during the direct install site visit. The program is coordinated with state and local agencies to leverage existing low income efforts.

Target Market

This program targets residential low-income customers.

Implementation Strategy

During the Low Income Program site survey, homes needing significant improvements are identified. These homes may need insulation, infiltration reduction or significant HVAC equipment improvements. The necessary measures will be provided and installed free of charge. The weatherized structure will provide a more comfortable living space for tenants, and will increase property value and lower electric bills as a result of the efficiency improvements.

TVA and its distributors will work with community-based organizations to coordinate the program. This program can leverage federal low income weatherization efforts, as well as state and local low income programs, to increase the energy efficiency services provided to these customers. Neighborhood and community groups will be recruited to assist in advertising the program, and program displays will be provided in community centers.

Incentives

The measures are provided and installed free of charge.

Monitoring and Evaluation

Both engineering estimates calibrated with information on hours of use and consumption patterns gathered for each participant will be used to estimate program savings. Spot inspections will be done on homes receiving attic insulation.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	5%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	25%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	90%
Annual Energy Impact (kWh)	3,100

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	356,300	400	400	0%
2	360,200	700	1,100	0%
3	363,800	1,000	2,100	1%
4	367,300	1,000	3,100	1%
5	370,700	1,000	4,100	1%
6	374,200	1,000	5,100	1%
7	377,600	1,000	6,100	2%
8	381,100	1,000	7,100	2%
9	384,500	1,000	8,100	2%
10	388,000	1,000	9,100	3%
11	391,400	1,000	10,100	3%
12	394,900	1,000	11,100	3%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$1,000 Total Variable Admin. Cost	$2,000 Total Part. Measure Cost	$2,000 Total Part. Incentive
1	$300,000	$400,000	$800,000	$800,000
2	$250,000	$700,000	$1,400,000	$1,400,000
3	$250,000	$1,000,000	$2,000,000	$2,000,000
4	$250,000	$1,000,000	$2,000,000	$2,000,000
5	$250,000	$1,000,000	$2,000,000	$2,000,000
6	$250,000	$1,000,000	$2,000,000	$2,000,000
7	$250,000	$1,000,000	$2,000,000	$2,000,000
8	$250,000	$1,000,000	$2,000,000	$2,000,000
9	$250,000	$1,000,000	$2,000,000	$2,000,000
10	$250,000	$1,000,000	$2,000,000	$2,000,000
11	$250,000	$1,000,000	$2,000,000	$2,000,000
12	$250,000	$1,000,000	$2,000,000	$2,000,000

HEAT PUMP WATER HEATER LEASING PROGRAM

Overview

The Heat Pump Water Heater Leasing Program allows for a qualified heat pump water heater to be selected by a customer and installed by the utility, with the customer paying a monthly "service charge" on his electric bill. This program is designed to promote efficient heat pump water heaters which have an initial cost that is a significant barrier to customer participation. Additionally, this program simplifies the maintenance and service of complicated equipment by moving the risk to the utility.

Target Market

This program targets residential customers who own or are purchasing their dwelling.

Implementation Strategy

The program works in conjunction with local equipment retailers similar to a financing program. The customer selects the contractor and appropriate equipment and contacts the utility for an installation inspection and to complete the necessary paperwork. Two payment options are offered. The first is a continual monthly charge with the utility maintaining ownership of the equipment and providing all necessary maintenance and repair of the equipment for as long as the customer is in the program. Early termination (before the customer has repaid the debt) requires the customer to settle for the remaining debt.

The second option is a larger monthly payment designed to pay back the debt. Once the debt has been repaid, ownership of the equipment is transferred to the homeowner. During the repayment period, the utility maintains and repairs the equipment free of charge. At the end of the repayment period, the customer can change to a maintenance/replacement contract payment if so desired.

The specified lease equipment must meet minimum Energy Factor (EF) levels.

Repair and replacement work will be performed by local contractors. A local phone number with answering service will be available 24 hours per day, 365 days per year. The customer is guaranteed replacement or repair within 48 hours of the call.

Incentives

A service contract will be provided for each heat pump water heater.

Monitoring and Evaluation

Some equipment monitoring is required for program analysis purposes. Inspections will be performed for 100 percent of program installations for QA purposes. Inspections will verify appropriate equipment sizing, equipment charge, air flow, and location. A complaint phone number also listed on the appliance will provide significant feedback on the equipment and its timely repair.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	40%
Non-Free-Rider Market Barrier Costs Eliminated	50%
Annual Energy Impact (kWh)	1,990

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	198,000	9,900	9,900	5%
2	198,000	19,800	29,700	8%
3	198,000	29,700	59,400	10%
4	198,000	33,700	93,100	12%
5	198,000	37,600	130,700	13%
6	198,000	41,600	172,300	15%
7	198,000	43,600	215,900	16%
8	198,000	44,600	260,500	16%
9	198,000	45,500	306,000	17%
10	198,000	45,500	351,500	18%
11	198,000	45,500	397,000	18%
12	198,000	45,500	442,500	19%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
		$10	$500	$192
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$850,000	$99,000	$4,950,000	$1,900,800
2	$800,000	$198,000	$9,900,000	$3,801,600
3	$800,000	$297,000	$14,850,000	$5,702,400
4	$800,000	$337,000	$16,850,000	$6,470,400
5	$800,000	$376,000	$18,800,000	$7,219,200
6	$800,000	$416,000	$20,800,000	$7,987,200
7	$800,000	$436,000	$21,800,000	$8,371,200
8	$800,000	$446,000	$22,300,000	$8,563,200
9	$800,000	$455,000	$22,750,000	$8,736,000
10	$800,000	$455,000	$22,750,000	$8,736,000
11	$800,000	$455,000	$22,750,000	$8,736,000
12	$800,000	$455,000	$22,750,000	$8,736,000

SOLAR WATER HEATER PROGRAM

Overview

This program will promote solar water heaters through the use of a significant upfront rebate and an equipment lease. The lease includes a maintenance contract for the equipment. These incentives are designed to offset two significant market barriers to solar water heating: initial cost and maintenance.

Target Market

All residential customers in participating power distributor areas are targeted.

Implementation Strategy

The program works in conjunction with local equipment retailers similar to a financing program. The customer selects the contractor and appropriate equipment and contacts the utility for an installation inspection and to complete the necessary paperwork. Two payment options are offered. The first is a continual monthly charge with the utility maintaining ownership of the equipment and providing all necessary maintenance and repair of the equipment for as long as the customer is in the program. Early termination (before the customer the repaid his debt) requires the customer to settle for the remaining debt.

The second option is a larger monthly payment designed to pay back the debt. Once the debt has been repaid, ownership of the equipment is transferred to the homeowner. During the repayment period, the utility maintains and repairs the equipment free of charge. At the end of the repayment period, the customer can change to a maintenance/replacement contract payment if so desired.

Repair and replacement work will be performed by local contractors. A local phone number with answering service will be available 24 hours per day, 365 days per year. The customer is guaranteed replacement or repair within 48 hours of the call.

Incentives

- First cost buy-down will be offered.
- Equipment maintenance will be provided.

Monitoring and Evaluation

Program impacts will be evaluated through pre- and post-billing analysis of program homes. Quality assurance inspections are performed for approximately 25 percent of program installations, with emphasis on new installers and problem installers. Inspections will verify appropriate equipment sizing, orientation, tank and pipe insulation, controls, and freeze protection. A complaint phone number provided to the participant will provide significant feedback on the equipment and its timely repair. Follow-up surveys of equipment operation and usage patterns will also be conducted.

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	20%
Free-Rider Market Barrier Costs Eliminated	40%
Non-Free-Rider Market Barrier Costs Eliminated	50%
Annual Energy Impact (kWh)	2,500

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	50,300	200	200	0%
2	50,300	600	800	1%
3	50,300	1,000	1,800	1%
4	50,300	1,000	2,800	1%
5	50,300	1,000	3,800	2%
6	50,300	1,000	4,800	2%
7	50,300	1,000	5,800	2%
8	50,300	1,000	6,800	2%
9	50,300	1,000	7,800	2%
10	50,300	1,000	8,800	2%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$10 Total Variable Admin. Cost	$3,000 Total Part. Measure Cost	$1,956 Total Part. Incentive
1	$550,000	$2,000	$600,000	$391,200
2	$500,000	$6,000	$1,800,000	$1,173,600
3	$500,000	$10,000	$3,000,000	$1,956,000
4	$400,000	$10,000	$3,000,000	$1,956,000
5	$400,000	$10,000	$3,000,000	$1,956,000
6	$400,000	$10,000	$3,000,000	$1,956,000
7	$400,000	$10,000	$3,000,000	$1,956,000
8	$400,000	$10,000	$3,000,000	$1,956,000
9	$400,000	$10,000	$3,000,000	$1,956,000
10	$400,000	$10,000	$3,000,000	$1,956,000

EFFICIENCY PRODUCTS CATALOG—MAIL ORDER

Overview

This program makes it easy for customers to purchase smaller, easily installed technologies that are not readily available in the marketplace. The product descriptions in the catalog will also educate customers about the benefits of each technology. For many products, TVA will “buy down” the cost to encourage people to adopt unfamiliar technologies. Promoted products could include efficient lighting, motion sensors, flow restricters, pipe insulation, and outlet insulation.

Target Market

This program targets all residential customers.

Implementation Strategy

Through the services of a professional fulfillment company, TVA will offer a catalog featuring a variety of shippable, easily installed energy efficiency technologies. Quantity limits may be imposed on certain products. The catalog will offer information on applications and how to select the appropriate models for various uses.

Consumers will obtain the catalog through a 1-800 number and may place their orders via the same number or by mail. A retail component will also be developed to provide local shopping options after the catalog effort is launched. By educating Valley consumers on the benefits and applications of energy-efficient products and offering them the opportunity to purchase these products conveniently at a reduced price, the catalog should stimulate the development of a retail infrastructure through increased demand for the products.

Incentives

- Specific measures have discounted purchase prices in the catalog.
- Overhead and administrative costs for the fulfillment contractor are paid by TVA.

Program Assumptions

Package Measure Life (Years)	7
Free-Rider Rate	15%
Free-Driver Rate	0%
Dropouts	5%
Take-Back Percentage	10%
Free-Rider Market Barrier Costs Eliminated	65%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	823

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,985,000	35,800	35,800	1%
2	3,020,000	67,000	102,800	3%
3	3,055,000	73,300	176,100	6%
4	3,090,000	74,200	250,300	8%
5	3,125,000	83,400	333,700	11%
6	3,160,000	88,500	422,200	13%
7	3,195,000	95,900	518,100	16%
8	3,230,000	96,900	615,000	19%
9	3,265,000	98,000	713,000	22%
10	3,300,000	99,000	812,000	25%
11	3,335,000	100,100	912,100	27%
12	3,370,000	101,100	1,013,200	30%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
		$17	$70	$9
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$430,000	$608,600	$2,506,000	$322,200
2	$430,000	$1,139,000	$4,690,000	$603,000
3	$430,000	$1,246,100	$5,131,000	$659,700
4	$430,000	$1,261,400	$5,194,000	$667,800
5	$430,000	$1,417,800	$5,838,000	$750,600
6	$430,000	$1,504,500	$6,195,000	$796,500
7	$430,000	$1,630,300	$6,713,000	$863,100
8	$430,000	$1,647,300	$6,783,000	$872,100
9	$430,000	$1,666,000	$6,860,000	$882,000
10	$430,000	$1,683,000	$6,930,000	$891,000
11	$430,000	$1,701,700	$7,007,000	$901,000
12	$430,000	$1,718,700	$7,077,000	$910,000

Monitoring and Evaluation

Phone surveys of program participants will provide feedback on the equipment installed and its hours of use. This information will be incorporated into engineering impacts developed for each measure to estimate program-wide energy benefits.

Measure	Incremental Energy (kWh/yr)	Wholesale Cost ($)	Incentive ($)	# /home	Weighted Energy (kWh/yr)	Weighted Cost ($)	Weighted Incentive ($)
Compact Fluorescent Light	57	13	2.05	4.00	228	51	8
Motion Detectors (Outdoor)	53	10	1.60	0.25	13	3	0
High Pressure Sodium Light	1,604	34	5.37	0.05	80	2	0
DHW Pipe Insulation	78	10	1.00	0.25	20	3	0
DHW Tank Wrap	271	10	1.00	0.50	136	5	1
Low Flow Showerhead	271	10	1.00	1.50	407	15	2
Programmable Thermostat	1,273	92	9.15	0.18	224	16	2
			Weighted Total For 5 Products		**823**	**70**	**9**

Wholesale cost is known for lighting, calculated at 75 percent of retail for thermostats, calculated at 50 percent of retail for other measures.
Incentive is buy-down of wholesale cost.

LIGHTING PRODUCTS RETAIL COMPONENT

Overview

This program augments the Efficiency Products Catalog, which makes it easy for customers to purchase smaller, easily-installed technologies that are not readily available in the marketplace. This program works by influencing customers to purchase additional quantities of the same efficient products from their local retailers. This market transformation will help to encourage people to adopt unfamiliar technologies. Promoted products could include efficient lighting, motion sensors, flow restricters, pipe insulation, and outlet insulation.

Target Market

This program targets all residential customers.

Implementation Strategy

TVA will offer a catalog featuring a variety of energy efficiency technologies. Coupons in the catalog will be redeemable in local retail outlets to purchase the same efficiency technologies at discounted prices. The coupons can also be distributed through other complimentary DSM programs, power distributor displays, direct mail, or by customer request.

By working with manufacturers and distributors of these products, TVA will encourage local retailers to participate in the program. The coupon booklet will educate Valley consumers on the benefits and applications of energy-efficient products and will offer them the opportunity to purchase these products at a reduced price. Customer information completed on the coupon will provide feedback on customer purchases and utilization of the efficient products.

Incentives

Retail rebate coupons will be provided.

Monitoring and Evaluation

The rebate coupon will provide information on participant usage. Additionally, phone surveys of program participants will provide feedback on the equipment installed and its hours of use. This information will be incorporated into engineering impacts developed for each measure to estimate program-wide energy benefits.

Program Assumptions

Package Measure Life (Years)	7
Free-Rider Rate	15%
Free-Driver Rate	0%
Dropouts	5%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	60%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	823

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,985,000	7,500	7,500	0%
2	3,020,000	15,100	22,600	1%
3	3,055,000	22,900	45,500	1%
4	3,090,000	30,900	76,400	2%
5	3,125,000	37,500	113,900	4%
6	3,160,000	44,200	158,100	5%
7	3,195,000	54,300	212,400	7%
8	3,230,000	64,600	277,000	9%
9	3,265,000	71,800	348,800	11%
10	3,300,000	79,200	428,000	13%
11	3,335,000	86,700	514,700	15%
12	3,370,000	101,100	615,800	18%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$10 Total Variable Admin. Cost	$102 Total Part. Measure Cost	$26 Total Part. Incentive
1	$900,000	$75,000	$765,000	$195,000
2	$850,000	$151,000	$1,540,200	$392,600
3	$850,000	$229,000	$2,335,800	$595,400
4	$850,000	$309,000	$3,151,800	$803,400
5	$850,000	$375,000	$3,825,000	$975,000
6	$850,000	$442,000	$4,508,400	$1,149,200
7	$850,000	$543,000	$5,538,600	$1,411,800
8	$850,000	$646,000	$6,589,200	$1,679,600
9	$850,000	$718,000	$7,323,600	$1,866,800
10	$850,000	$792,000	$8,078,400	$2,059,200
11	$850,000	$867,000	$8,843,400	$2,254,200
12	$850,000	$1,011,000	$10,312,200	$2,628,600

APPLIANCE REBATES PROGRAM

Overview

This program will promote efficient appliances using rebates and point-of-sale displays. Appliances will include high efficiency dishwashers, heat pump clothes dryers, clothes dryers with moisture sensors, horizontal axis clothes washers, high efficiency room air-conditioners, high efficiency freezers, high efficiency refrigerators, and high efficiency pool pumps.

Target Market

All residential customers in participating power distributor areas are targeted.

Implementation Strategy

Rebate coupons, point-of-sale displays, and appliance labeling are utilized to promote efficient appliances. Utility representatives will work with retail outlets to label applicable appliances and to distribute displays and coupons. Additionally, coupons will be distributed through other compatible DSM programs, power distributor offices, and upon phone request.

Incentives

Rebate coupons will be provided.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	15%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	60%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	181

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	573,500	13,800	13,800	2%
2	573,500	27,600	41,400	4%
3	573,500	55,200	96,600	6%
4	573,500	110,400	207,000	9%
5	573,500	110,400	317,400	11%
6	573,500	110,400	427,800	12%
7	573,500	110,400	538,200	13%
8	573,500	110,400	648,600	14%
9	573,500	110,400	759,000	15%
10	573,500	110,400	869,400	15%
11	573,500	110,400	979,800	16%
12	573,500	110,400	1,090,200	16%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
		$7	$90	$71
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$530,000	$96,600	$1,242,000	$979,800
2	$430,000	$193,200	$2,484,000	$1,959,600
3	$430,000	$386,400	$4,968,000	$3,919,200
4	$430,000	$772,800	$9,936,000	$7,838,400
5	$430,000	$772,800	$9,936,000	$7,838,400
6	$430,000	$772,800	$9,936,000	$7,838,400
7	$430,000	$772,800	$9,936,000	$7,838,400
8	$430,000	$772,800	$9,936,000	$7,838,400
9	$430,000	$772,800	$9,936,000	$7,838,400
10	$430,000	$772,800	$9,936,000	$7,838,400
11	$430,000	$772,800	$9,936,000	$7,838,400
12	$430,000	$772,800	$9,936,000	$7,838,400

Monitoring and Evaluation

Rebate coupons will provide initial information on replacement and usage patterns. A database will be completed from returned rebate coupons. Follow-up surveys of equipment installed and usage patterns will be conducted.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	Incentive ($)	Appliance Saturation Weighting	Long-Term Penetration Weighting
High-Efficiency dishwasher	130	20	20	41%	20%
High-Efficiency Pool Pump	281	39	39	4%	10%
Heat Pump Clothes Dryer	661	301	200	78%	2%
Best Current Freezer	152	68	68	48%	30%
Best Current Refrigerator	119	85	54	99%	30%
High-Efficiency Room A/C	414	142	142	40%	30%
Dryer with Moisture Sensor	122	75	56	78%	30%
Horizontal Axis Clothes Washer	450	350	200	85%	2%

Incentive based on incremental energy times average $/annual kWh, capped at full incremental cost, or capped at $200
Appliance saturation weighting based on TVA 1992 appliance survey.
Long-term penetration weighting based on information from BCI 08/03/94.

REFRIGERATOR TURN-IN AND RECYCLING PROGRAM

Overview

This is a second refrigerator and freezer pick-up program. The utility will remove unwanted refrigerators and freezers and ensure that they are disposed of properly in accordance with applicable environmental regulations. The appliance must be in working condition. The customer is given a $50 U.S. savings bond incentive for participation.

Target Market

All residential customers with second refrigerators or freezers are targeted.

Implementation Strategy

A turn-key contractor will administer and implement the program. The contractor sets up telephone lines to take customer phone calls. The call is screened to eliminate free ridership in the program. Then, an appointment is made to pick up the applicable device. The pick-up crew verifies that the equipment is operable and removes it, leaving the incentive with the customer. The equipment is taken to the contractor's warehouse/processing facility where the refrigerant is removed and recycled, and other components are disassembled and recycled.

The contractor handles administrative aspects of the program, providing monthly reports of removals, energy consumption of removed equipment and participants' names and addresses. Utility involvement is limited to contract administration and QA control over contract performance.

Incentives

A $50 U.S. savings bond is given to the customer when the operating appliance is picked up.

Monitoring and Evaluation

Reporting by turn-key contractor provides energy measurement and customer account information. Contractor performance and customer satisfaction data will be collected as part of a process evaluation.

Program Assumptions

Package Measure Life (Years)	7
Free-Rider Rate	34%
Free-Driver Rate	0%
Dropouts	25%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	60%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	929

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	298,500	12,900	12,900	1%
2	298,500	18,700	31,600	3%
3	298,500	30,200	61,800	6%
4	298,500	30,200	92,000	9%
5	298,500	24,400	116,400	11%
6	298,500	18,700	135,100	13%
7	298,500	18,700	153,800	15%
8	298,500	18,700	172,500	17%
9	298,500	18,700	191,200	19%
10	298,500	12,900	204,100	20%
11	298,500	12,900	217,000	21%
12	298,500	12,900	229,900	23%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$110 Total Part. Measure Cost	$25 Total Part. Incentive
1	$275,000	$0	$1,419,000	$322,500
2	$200,000	$0	$2,057,000	$467,500
3	$200,000	$0	$3,322,000	$755,000
4	$200,000	$0	$3,322,000	$755,000
5	$200,000	$0	$2,684,000	$610,000
6	$200,000	$0	$2,057,000	$467,500
7	$200,000	$0	$2,057,000	$467,500
8	$200,000	$0	$2,057,000	$467,500
9	$200,000	$0	$2,057,000	$467,500
10	$200,000	$0	$1,419,000	$322,500
11	$200,000	$0	$1,419,000	$322,500
12	$200,000	$0	$1,419,000	$322,500

STUDENT SELF-AUDIT—SCHOOLS ENVIRONMENTAL PROGRAM

Overview

This program builds upon the energy information materials TVA already provides to Valley teachers. In addition to general information, a self-audit package will be presented to students who will be required to conduct a home audit, fill out an audit form, and return it to school, where it will be analyzed by an audit software program. The software will analyze the audit form and recommend cost-effective environmental and energy efficiency measures that the students and their families can implement. Many materials recommended in the audit report will be available through the catalog mail program. Discount coupons for catalog materials may be provided to students. This audit report will also provide coordinated promotion of other TVA and distributor energy efficiency programs.

Target Market

High school students in participating power distributor areas are targeted.

Implementation Strategy

Lesson plans on energy and environment, audit forms, and a computer with audit analysis software will be provided to each school. TVA will provide training on all materials for teachers. Audit data collected by the students is entered on the computer and a custom audit report is generated. The survey data is also compiled for teacher and utility use.

Incentives

- TVA will pay for substitute teachers during the training.
- Class materials and audit materials will be provided.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	60%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	102

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	3,900	3,700	3,700	95%
2	32,500	30,900	34,600	95%
3	130,000	123,500	158,100	95%
4	130,000	123,500	281,600	95%
5	130,000	123,500	405,100	95%
6	130,000	123,500	528,600	95%
7	130,000	123,500	652,100	95%
8	130,000	123,500	775,600	95%
9	130,000	123,500	899,100	95%
10	130,000	123,500	1,022,600	95%
11	130,000	123,500	1,146,100	95%
12	130,000	123,500	1,269,600	95%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$5 Total Variable Admin. Cost	$19 Total Part. Measure Cost	$0 Total Part. Incentive
1	$1,432,000	$18,500	$70,300	$0
2	$982,000	$154,500	$587,100	$0
3	$796,400	$617,500	$2,346,500	$0
4	$796,400	$617,500	$2,346,500	$0
5	$796,400	$617,500	$2,346,500	$0
6	$796,400	$617,500	$2,346,500	$0
7	$796,400	$617,500	$2,346,500	$0
8	$796,400	$617,500	$2,346,500	$0
9	$796,400	$617,500	$2,346,500	$0
10	$796,400	$617,500	$2,346,500	$0
11	$796,400	$617,500	$2,346,500	$0
12	$796,400	$617,500	$2,346,500	$0

Monitoring and Evaluation

Follow-up phone surveys of students will determine which measures were installed and allow estimation of the energy savings attributable to the program. Savings for the first year of the program will be estimated as a small fraction of the measures expected to be recommended on the audit reports.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	Unitized Weighting	Weighted Energy (kWh/yr)	Weighted Cost ($)
NEW MH Motion Detectors—Outdoor Lighting	52.50	2.45	0.03	1.83	0.09
Existing AC/HP Maintenance	52.50	2.45	0.03	1.83	0.09
NEW MF Motion Detectors—Outdoor Lighting	60.00	2.80	0.03	2.09	0.10
NEW MH High Pressure Sodium (Outdoor)	60.00	2.80	0.03	2.09	0.10
Existing Ceiling Insulation (R11-R30)	130.02	20.00	0.03	4.50	0.69
Existing Reduced Duct Leakage	110.22	20.00	0.03	3.82	0.69
Existing Ceiling Insulation (R0-R19)	110.88	20.00	0.03	3.84	0.69
Existing DHW Heater Tank Insulation	77.56	20.00	0.03	2.69	0.69
NEW MH Efficient Incandescent	271.46	20.00	0.03	9.40	0.69
Existing Ceiling Fans	193.90	28.00	0.03	6.69	0.97
NEW MH Motion Detectors (Outdoor)	271.46	35.00	0.03	9.34	1.20
Existing MH High-Efficiency Dishwasher	477.45	105.88	0.03	15.90	3.53
Existing Ceiling Fans	1,119.10	105.88	0.03	37.26	3.53
Existing Programmable Thermostat (HP)	519.76	105.88	0.03	17.31	3.53
Existing Programmable Thermostat	1,011.26	105.88	0.03	33.67	3.53
Existing High-Efficiency Heat Pump	1,666.29	122.00	0.03	55.06	4.03
NEW MF Efficient Incandescent	1,272.99	122.00	0.03	42.07	4.03
Existing MF High-Efficiency Dishwasher	935.29	146.00	0.03	30.56	4.77
Existing Ground-Source Heat Pump	960.59	146.00	0.03	31.38	4.77
Existing SF High-Efficiency Dishwasher	1,905.06	275.00	0.03	58.40	8.43
NEW MF High Pressure Sodium (Outdoor)	1,133.22	275.00	0.03	34.74	8.43
NEW MF Efficient Incandescent	1,302.48	392.92	0.03	37.53	11.32
NEW MH High Pressure Sodium (Outdoor)	1,480.48	392.92	0.03	42.65	11.32
NEW MH Efficient Incandescent	1,623.30	392.92	0.03	46.77	11.32
NEW SF High Pressure Sodium (Outdoor)	1,842.03	392.92	0.03	53.07	11.32
NEW SF Motion Detectors for Outdoor Lighting	1,835.07	425.00	0.03	51.95	12.03
NEW MF Motion Detectors for Outdoor Lighting	3,488.64	590.00	0.03	89.77	15.18
NEW SF High Pressure Sodium (Outdoor)	1,366.27	650.32	0.02	33.87	16.12
Existing Low Flow Showerhead	4,655.83	650.32	0.02	115.42	16.12
Existing DHW Heat Trap	1,542.13	650.32	0.02	38.23	16.12
Existing DHW Pipe Insulation	4,069.82	650.32	0.02	100.89	16.12
Existing Reduced Duct Leakage	6,968.22	708.00	0.01	0.70	0.07
Wood Furnace w/Wood Cost	7,902.00	2,237.00	0.01	0.79	0.22
		Total	**1**	**1,016**	**192**

Same measure mix as Self-Audit Program, assumed 10 percent of homes will implement.

SELF-AUDIT PROGRAM

Overview

Customers will conduct home audits using materials provided by TVA. TVA will analyze the audits and provide recommendations for cost-effective energy and environmental conservation measures applicable to the customer's home.

Target Market

Residential customers in participating power distributor areas are targeted.

Implementation Strategy

Home audit forms and instructions will be available at mall kiosks and participating distributors' offices. Customers completing the audit form will take it to their distributor or mail it to TVA, and receive a customized computer-generated report recommending the implementation of specific environmental and energy efficiency measures. The custom printout will be coordinated with other programs and will provide referrals to other existing distributor DSM programs.

Incentives

No incentives will be provided.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	60%
Annual Energy Impact (kWh)	1,016

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	481,000	4,800	4,800	1%
2	478,600	19,100	23,900	5%
3	469,000	14,100	38,000	8%
4	462,000	11,100	49,100	11%
5	456,400	11,000	60,100	13%
6	451,000	10,800	70,900	16%
7	445,600	10,700	81,600	18%
8	440,200	10,600	92,200	21%
9	434,900	10,400	102,600	24%
10	429,700	10,300	112,900	26%
11	424,600	10,200	123,100	29%
12	419,500	10,100	133,200	32%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$5 Total Variable Admin. Cost	$192 Total Part. Measure Cost	$0 Total Part. Incentive
1	$437,500	$24,000	$921,600	$0
2	$187,500	$95,500	$3,667,200	$0
3	$187,500	$70,500	$2,707,200	$0
4	$187,500	$55,500	$2,131,200	$0
5	$187,500	$55,000	$2,112,000	$0
6	$187,500	$54,000	$2,073,600	$0
7	$187,500	$53,500	$2,054,400	$0
8	$187,500	$53,000	$2,035,200	$0
9	$187,500	$52,000	$1,996,800	$0
10	$187,500	$51,500	$1,977,600	$0
11	$187,500	$51,000	$1,958,400	$0
12	$187,500	$50,500	$1,939,200	$0

Monitoring and Evaluation

Follow-up phone surveys of participating customers will determine the number of installed measures, and allow estimation of the energy savings attributable to the program. Savings for the first year of the program will be estimated as a small fraction of the measures expected to be recommended on the audit reports.

Measure	Incremental Energy (kWh/yr)	Incremental Cost ($)	Unitized Weighting	Weighted Energy (kWh/yr)	Weighted Cost ($)
NEW MH Motion Detectors—Outdoor Lighting	52.50	2.45	0.03	1.83	0.09
Existing AC/HP Maintenance	52.50	2.45	0.03	1.83	0.09
NEW MF Motion Detectors—Outdoor Lighting	60.00	2.80	0.03	2.09	0.10
NEW MH High Pressure Sodium (Outdoor)	60.00	2.80	0.03	2.09	0.10
Existing Ceiling Insulation (R11-R30)	130.02	20.00	0.03	4.50	0.69
Existing Reduced Duct Leakage	110.22	20.00	0.03	3.82	0.69
Existing Ceiling Insulation (R0-R19)	110.88	20.00	0.03	3.84	0.69
Existing DHW Heater Tank Insulation	77.56	20.00	0.03	2.69	0.69
NEW MH Efficient Incandescent	271.46	20.00	0.03	9.40	0.69
Existing Ceiling Fans	193.90	28.00	0.03	6.69	0.97
NEW MH Motion Detectors (Outdoor)	271.46	35.00	0.03	9.34	1.20
Existing MH High-Efficiency Dishwasher	477.45	105.88	0.03	15.90	3.53
Existing Ceiling Fans	1,119.10	105.88	0.03	37.26	3.53
Existing Programmable Thermostat (HP)	519.76	105.88	0.03	17.31	3.53
Existing Programmable Thermostat	1,011.26	105.88	0.03	33.67	3.53
Existing High-Efficiency Heat Pump	1,666.29	122.00	0.03	55.06	4.03
NEW MF Efficient Incandescent	1,272.99	122.00	0.03	42.07	4.03
Existing MF High-Efficiency Dishwasher	935.29	146.00	0.03	30.56	4.77
Existing Ground-Source Heat Pump	960.59	146.00	0.03	31.38	4.77
Existing SF High-Efficiency Dishwasher	1,905.06	275.00	0.03	58.40	8.43
NEW MF High Pressure Sodium (Outdoor)	1,133.22	275.00	0.03	34.74	8.43
NEW MF Efficient Incandescent	1,302.48	392.92	0.03	37.53	11.32
NEW MH High Pressure Sodium (Outdoor)	1,480.48	392.92	0.03	42.65	11.32
NEW MH Efficient Incandescent	1,623.30	392.92	0.03	46.77	11.32
NEW SF High Pressure Sodium (Outdoor)	1,842.03	392.92	0.03	53.07	11.32
NEW SF Motion Detectors for Outdoor Lighting	1,835.07	425.00	0.03	51.95	12.03
NEW MF Motion Detectors for Outdoor Lighting	3,488.64	590.00	0.03	89.77	15.18
NEW SF High Pressure Sodium (Outdoor)	1,366.27	650.32	0.02	33.87	16.12
Existing Low Flow Showerhead	4,655.83	650.32	0.02	115.42	16.12
Existing DHW Heat Trap	1,542.13	650.32	0.02	38.23	16.12
Existing DHW Pipe Insulation	4,069.82	650.32	0.02	100.89	16.12
Existing Reduced Duct Leakage	6,968.22	708.00	0.01	0.70	0.07
Wood Furnace w/Wood Cost	7,902.00	2,237.00	0.01	0.79	0.22
		Total	**1**	**1,016**	**192**

LOAD MANAGEMENT PROGRAM—AIR CONDITIONERS

Overview

TVA presently has a radio control system that cycles water heaters and air-conditioning load to reduce power demand during hours of peak electrical usage. This program expands participation in the coverage area of the TVA-owned and -maintained radio control system.

Target Market

Residential customers with central air conditioners or heat pumps in participating power distributor areas are targeted.

Implementation Strategy

In participating power distributors' areas, the load management program will be promoted to encourage additional load management installations. Free maintenance of the load-controlled HVAC is used as an incentive. This provides multiple benefits including increased HVAC efficiency, increased QA inspections at no cost, and enhanced HVAC contractor buy-in to the program.

Incentives

TVA will pay the full cost of the switch and its installation. An incentive to the distributor is included and can be used to pay employees to sign up participants and/or part or all of the incentive can be passed on to participants. Free maintenance contracts are provided for central air conditioners and heat pumps participating in the program.

Monitoring and Evaluation

QA inspections of program switches and their operation are performed by the contractor during an annual maintenance inspection. Some spot checking of maintenance procedures and switch operation will be required.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	100%
Annual Energy Impact (kWh)	520

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	52,900	1,100	1,100	2%
2	52,900	3,200	4,300	8%
3	52,900	4,200	8,500	16%
4	52,900	5,300	13,800	26%
5	52,900	6,300	20,100	38%
6	52,900	6,300	26,400	50%
7	52,900	5,300	31,700	60%
8	52,900	4,200	35,900	68%
9	52,900	3,200	39,100	74%
10	52,900	500	39,600	75%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Annual Per Participant Incentive
Year	Fixed Administrative Cost	$225 Total Variable Admin. Cost	$0 Total Part. Measure Cost	$65 Total Part. Incentive
1	$100,000	$247,500	$0	$71,500
2	$100,000	$720,000	$0	$279,500
3	$100,000	$945,000	$0	$552,500
4	$100,000	$1,192,500	$0	$897,000
5	$100,000	$1,417,500	$0	$1,306,500
6	$100,000	$1,417,500	$0	$1,716,000
7	$100,000	$1,192,500	$0	$2,060,500
8	$100,000	$945,000	$0	$2,333,500
9	$100,000	$720,000	$0	$2,541,500
10	$100,000	$112,500	$0	$2,574,000

LOAD MANAGEMENT PROGRAM—WATER HEATERS

Overview

TVA presently has a radio control system that cycles water heaters and air-conditioning load to reduce power demand during hours of peak electrical usage. This program expands participation in the coverage area of the TVA-owned and -maintained radio control system.

Target Market

Residential customers with electric water heaters in participating power distributor areas are targeted.

Implementation Strategy

In participating power distributors' areas, the load management program will be promoted to encourage additional load management installations. For water heater control, direct incentives can be paid to the homeowner for participating in the program.

Incentives

TVA will pay the full cost of the switch and its installation. An incentive to the distributor is included, which can be used to pay employees to sign up participants and/or part or all of the incentive can be passed on to participants.

Monitoring and Evaluation

QA inspections of program switches and their operation are performed by the contractor during an annual maintenance inspection. Some spot checking of maintenance procedures and switch operation will be required.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	100%
Annual Energy Impact (kWh)	—

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	215,900	4,300	4,300	2%
2	215,900	13,000	17,300	8%
3	215,900	19,400	36,700	17%
4	215,900	25,900	62,600	29%
5	215,900	25,900	88,500	41%
6	215,900	25,900	114,400	53%
7	215,900	21,600	136,000	63%
8	215,900	17,300	153,300	71%
9	215,900	8,600	161,900	75%
10	215,900	—	161,900	75%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Annual Per Participant Incentive
		$554	$0	$24
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$100,000	$2,382,200	$0	$103,200
2	$100,000	$7,202,000	$0	$415,200
3	$100,000	$10,747,600	$0	$880,800
4	$100,000	$14,348,600	$0	$1,502,400
5	$100,000	$14,348,600	$0	$2,124,000
6	$100,000	$14,348,600	$0	$2,745,600
7	$100,000	$11,966,400	$0	$3,264,000
8	$100,000	$9,584,200	$0	$3,679,200
9	$100,000	$4,764,400	$0	$3,885,600
10	$100,000	$0	$0	$3,885,600

LOAD MANAGEMENT PROGRAM—STORAGE WATER HEATERS

Overview

TVA presently has a radio control system that cycles water heaters and air-conditioning load to reduce power demand during hours of peak electrical usage. This program prolongs cycling by using larger storage water heaters. Participation is limited to the coverage area of the TVA-owned and -maintained radio control system. The program also provides for a free water heater, installation, and free maintenance of the water heater as an incentive for program participation.

Target Market

Residential customers with electric water heaters in participating power distributor areas are targeted.

Implementation Strategy

In participating power distributors' areas, the load management program will be promoted to encourage additional load management installations. The homeowner will have a storage water heater installed free of charge, with free maintenance as an additional incentive. The storage water heater allows TVA to cycle the water heater for longer periods of time in order to minimize payback spikes at the end of a typical control period.

The specified storage water heater must meet specific efficiency requirements (Energy Factor) corresponding to the tank size. The water heater will be sized to accommodate the water heating needs of the home and to minimize hot water outages.

Repair and replacement work will be performed by local contractors. A local phone number with answering service will be available 24 hours per day, 365 days per year. The customer is guaranteed replacement or repair within 48 hours of the call.

Incentives

TVA will pay the full cost of the storage water heater, the control switch, and its installation. Also a free maintenance contract is provided for the storage water heater.

Monitoring and Evaluation

QA inspections of program switches and their operation are performed by the contractor during an annual maintenance inspection. Some spot checking of maintenance procedures and switch operation will be required.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	100%
Annual Energy Impact (kWh)	—

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	108,000	2,200	2,200	2%
2	108,000	6,500	8,700	8%
3	108,000	9,700	18,400	17%
4	108,000	10,800	29,200	27%
5	108,000	10,800	40,000	37%
6	108,000	10,800	50,800	47%
7	108,000	10,800	61,600	57%
8	108,000	8,600	70,200	65%
9	108,000	4,300	74,500	69%
10	108,000	2,200	76,700	71%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$600 Total Variable Admin. Cost	$400 Total Part. Measure Cost	$460 Total Part. Incentive
1	$350,000	$1,320,000	$880,000	$1,012,000
2	$350,000	$3,900,000	$2,600,000	$2,990,000
3	$350,000	$5,820,000	$3,880,000	$4,462,000
4	$350,000	$6,480,000	$4,320,000	$4,968,000
5	$350,000	$6,480,000	$4,320,000	$4,968,000
6	$350,000	$6,480,000	$4,320,000	$4,968,000
7	$350,000	$6,480,000	$4,320,000	$4,968,000
8	$350,000	$5,160,000	$3,440,000	$3,956,000
9	$350,000	$2,580,000	$1,720,000	$1,978,000
10	$350,000	$1,320,000	$880,000	$1,012,000

LOAD MANAGEMENT PROGRAM—DIRECT CONTROL WITH SCADA

Overview

Many TVA distributors presently have a Supervisory Control and Data Acquisition system. These SCADA systems can be upgraded to allow direct load control of water heaters in order to reduce power demand during hours of peak electrical usage. Through incentives, homeowners will be encouraged to have a load management device installed on their water heaters. This program expands load management participation from the coverage area of the TVA-owned and -maintained radio control system.

Target Market

Eligible residential customers have electric water heaters in participating power distributor areas that have SCADA systems and do not participate in the existing load management program using radio control.

Implementation Strategy

In participating power distributors' areas, the SCADA system will be upgraded to allow the direct load control of residential water heaters. Promotion of the load management program will encourage homeowners to have a load management device installed on their existing water heaters.

Incentives

TVA will pay the full cost of the switch and its installation. An incentive to the distributor is included and can be used to pay employees to sign up participants and/or part or all of the incentive can be passed on to participants.

Monitoring and Evaluation

QA inspections of program switches and their operation are performed by the contractor during an annual maintenance inspection. Some spot checking of maintenance procedures and switch operation will be required.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	100%
Annual Energy Impact (kWh)	—

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	793,000	7,900	7,900	1%
2	793,000	15,900	23,800	3%
3	793,000	23,800	47,600	6%
4	793,000	19,800	67,400	9%
5	793,000	—	67,400	9%
6	793,000	—	67,400	9%
7	793,000	—	67,400	9%
8	793,000	—	67,400	9%
9	793,000	—	67,400	9%
10	793,000	—	67,400	9%
11	793,000	—	67,400	9%
12	793,000	—	67,400	9%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Annual Per Participant Incentive
Year	**Fixed Administrative Cost**	**$125 Total Variable Admin. Cost**	**$0 Total Part. Measure Cost**	**$24 Total Part. Incentive**
1	$1,911,000	$987,500	$0	$189,600
2	$1,811,000	$1,987,500	$0	$571,200
3	$1,711,000	$2,975,000	$0	$1,142,400
4	$410,000	$2,475,000	$0	$1,617,600
5	$335,000	$0	$0	$1,617,600
6	$335,000	$0	$0	$1,617,600
7	$335,000	$0	$0	$1,617,600
8	$335,000	$0	$0	$1,617,600
9	$335,000	$0	$0	$1,617,600
10	$335,000	$0	$0	$1,617,600
11	$335,000	$0	$0	$1,617,600
12	$335,000	$0	$0	$1,617,600

LOAD MANAGEMENT PROGRAM—NEW TECHNOLOGY

Overview

This program utilizes a two-way communication network to provide a combination of benefits to the consumer, increased efficiency for utility operations, and possibly profitable side businesses. The main focus for the utility is direct load control of applicable residential appliances, and real-time-pricing or time-of-use pricing for the customer. The rate options provide for additional customer load management control of other appliances, and open the door for home automation and energy storage appliances.

Target Market

All residential customers in participating power distributor areas are targeted.

Implementation Strategy

The direct load control aspect of the information superhighway allows the utility to control air conditioners, water heaters, storage water heaters, and pool pumps when required. In return the customer receives a monthly or seasonal incentive for this control. Different control levels and incentive levels are available.

The utility can also improve operations through remote meter reading, remote connection and disconnection of electrical service, and easier bill payment methods.

The real-time-pricing and time-of-use rate options provide the customer with the ability to perform load management based on price signals from the utility. The customer maintains control and has the ability to lower costs.

The information superhighway or equivalent two-way communication network provides many benefits to the customer. They will be able to have competitive cable TV service, competitive telephone service, home security system monitoring, home automation, real-time electricity pricing, itemized utility bills, and remote bill payment, all from their home.

Incentives

- The real-time pricing provides a rate incentive to the customer.
- The time-of-use rate option is another rate incentive for the customer.
- For direct load control, a comparable incentive to the rate incentives can be provided to the customer in the form of a monthly incentive on their power bill.

Monitoring and Evaluation

The two-way communications network provides real-time feedback of loads shed and the impacts on their utility system.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	2%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	100%
Annual Energy Impact (kWh)	—

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	1,621,300	32,400	32,400	2%
2	1,621,300	64,900	97,300	6%
3	1,621,300	97,300	194,600	12%
4	1,621,300	81,100	275,700	17%
5	1,621,300	—	275,700	17%
6	1,621,300	—	275,700	17%
7	1,621,300	—	275,700	17%
8	1,621,300	—	275,700	17%
9	1,621,300	—	275,700	17%
10	1,621,300	—	275,700	17%
11	1,621,300	—	275,700	17%
12	1,621,300	—	275,700	17%

Year	Fixed Administrative Cost and New Business Revenue	Per Participant Variable Administrative Costs $25 Total Variable Admin. Cost	Per Participant Measure Cost $500 Total Part. Measure Cost	Per Participant Incentive $500 Total Part. Incentive
1	$150,056,000	$810,000	$16,200,000	$16,200,000
2	$146,795,000	$1,622,500	$32,450,000	$32,450,000
3	$143,633,000	$2,432,500	$48,650,000	$48,650,000
4	($12,095,000)	$2,027,500	$40,550,000	$40,550,000
5	($12,095,000)	$0	$0	$0
6	($12,095,000)	$0	$0	$0
7	($12,095,000)	$0	$0	$0
8	($12,095,000)	$0	$0	$0
9	($12,095,000)	$0	$0	$0
10	($12,095,000)	$0	$0	$0
11	($12,095,000)	$0	$0	$0
12	($12,095,000)	$0	$0	$0

COMMERCIAL AND INDUSTRIAL ENERGY EFFICIENCY OPTIONS

SUMMARY OF PROJECTED IMPACTS IN YEAR 2010

Option Name	2010 Winter MW	2010 Summer MW	GWh	Units Million (sq. ft)	¢kWh TRC
COMMERCIAL TECHNOLOGY REBATES					
Lighting Rebates	265	511	2,845	1,626	2.0
HVAC & Building Shell Rebates	255	223	670	630	7.7
Appliance Rebates	40	69	364	501	3.2
New Construction	124	188	762	360	4.4
New Construction—Renewables	30	40	159	30	7.4
SMALL COMMERCIAL SECTOR					
Retrofit - Direct Install	65	98	465	315	3.1
HVAC Maintenance Program	38	26	87	236	13.7
LARGE COMMERCIAL SECTOR					
Comprehensive Measures Financing	120	170	713	284	4.9
Comprehensive Measures Rebates	242	311	1,278	449	4.9
COMMERCIAL LOAD MANAGEMENT					
Commercial Cool Storage	0	120	13	59	453 [1]
Rooftop Cool Storage	0	93	3	44	167 [1]
Commercial Group Load Curtailment	244	242	227	2,240 [2]	169 [1]
INDUSTRIAL PROGRAMS					
Industrial Technology Rebates	21	24	167	2,100 [2]	3.2
Industrial Process EE—Distributor Served	149	169	1,057	11,226 [3]	4.1
Industrial Process EE—Direct Served	167	190	1,325	8,420 [3]	4.0
Energy-Efficient Rates (opt-out)	50	56	394	2,504 [3]	3.2

1 Cost in $/kW
2 Number of participants
3 Participant defined as industrial customer with one million kWh of energy use.

Values are the impacts occuring only in the year 2010 for the cumulative participation in the program to that date.

TVA developed commercial and industrial options for evaluation in Energy Vision 2020 with applications for all major uses of electricity and for all types of building. Some of the options are designed to promote specific technologies and some options address the financial, environmental, or productivity needs of end-use customers. Detailed descriptions of the options follow.

COMMERCIAL TECHNOLOGY REBATES—LIGHTING/HVAC & BUILDING SHELL/APPLIANCES

Overview

The installation of energy-efficient equipment can help commercial and industrial customers cut energy costs and enhance competitiveness and viability. Many energy-efficient technologies have widespread applicability in the commercial sector. This program provides pre-determined rebates to encourage installation of specified energy-efficient equipment.

Target Market

This program targets all commercial and industrial customers, representing over three billion square feet of floorspace in the Tennessee Valley region, interested in replacing or upgrading HVAC, lighting, water heating, or other electrical equipment. In addition to providing services for customers replacing a single technology, this program provides prescriptive rebates to customers who are not eligible for or for whom it would not be cost-effective to provide comprehensive design assistance or analysis.

Implementation Strategy

This program will be promoted to commercial and industrial customers through direct advertising, through trade allies, and at the point of purchase. The benefits of increased energy efficiency to a customer's operations will be promoted. By providing easily understandable information about these benefits, along with the rebates, customers are encouraged to select more efficient technologies. Technical assistance, such as lighting design assistance, will be available to ensure customer satisfaction and maximize the savings from the energy- efficient technologies.

Trade allies, such as equipment dealers, will receive incentives to stock and promote the energy efficient technologies included in the program to their commercial customers.

Incentives

This program targets customers at the time of natural equipment replacement and reflects a market-driven, lost opportunity resource. Once a customer has replaced equipment, the efficiency improvement may not be cost-effective until the end of the equipment's lifetime. Therefore, under this program, customers will be offered rebates equal to 75 percent of the incremental cost to achieve the desired level of participation and to make energy-efficient technologies more widely available across the Valley.

Commercial Technology Rebates—Lighting

Program Assumptions

Package Measure Life (Years)	12
Free-Rider Rate	15%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	1,650

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	271,040	54,210	54,210	20%
2	271,040	81,310	135,520	25%
3	271,040	108,420	243,940	30%
4	271,040	135,520	379,460	35%
5	271,040	135,520	514,980	38%
6	271,040	135,520	650,500	40%
7	271,040	135,520	786,020	41%
8	271,040	135,520	921,540	43%
9	271,040	135,520	1,057,060	43%
10	271,040	135,520	1,192,580	44%
11	271,040	135,520	1,328,100	49%
12	271,040	135,520	1,463,620	54%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$20 Total Variable Admin. Cost	$200 Total Part. Measure Cost	$150 Total Part. Incentive
1	$575,000	$1,084,200	$10,842,000	$8,131,500
2	$575,000	$1,626,200	$16,262,000	$12,196,500
3	$575,000	$2,168,400	$21,684,000	$16,263,000
4	$575,000	$2,710,400	$27,104,000	$20,328,000
5	$575,000	$2,710,400	$27,104,000	$20,328,000
6	$575,000	$2,710,400	$27,104,000	$20,328,000
7	$575,000	$2,710,400	$27,104,000	$20,328,000
8	$575,000	$2,710,400	$27,104,000	$20,328,000
9	$575,000	$2,710,400	$27,104,000	$20,328,000
10	$575,000	$2,710,400	$27,104,000	$20,328,000
11	$575,000	$2,710,400	$27,104,000	$20,328,000
12	$575,000	$2,710,400	$27,104,000	$20,328,000

Monitoring and Evaluation

Process evaluation will be conducted to compare the cost and effectiveness of the delivery strategy. Impact evaluation will be conducted to determine the program benefits.

COMMERCIAL TECHNOLOGY REBATES—LIGHTING

Per Participant Costs and Impacts Based on:

Efficient Measures	Base Measures	Annual Energy Impact	Cost ($)	Measure Penetration	Weighted Energy Impact	Weighted Cost ($)
T-8/Electronic Ballasts	4’ - 40W Fluor. Lamps/EE Ballasts	631	62	75%	473	47
Refl/Delamp: 4’ - 40W/Elec. Ballasts	4’ - 40W Fluor. Lamps/EE Ballasts	1,998	185	5%	100	9
Refl/Delamp 8’ - 75W/EE Ballasts	8’ - 75W Fluor. Lamps/EE Ballasts	1,442	103	2%	29	2
Compact Fluorescent	Incandescent Lamps	8,480	179	3%	254	5
Occupancy Sensors	All Interior Fluorescent Lighting	847	135	25%	212	34
Photoelectric Control	Existing Lighting - Outdoor	232	6	10%	23	1
Fluorescent Exit Signs	Incandescent Exit Signs	88	28	10%	9	3
LED Exit Signs	Incandescent Exit Signs	289	103	30%	87	31
Electroluminescent Exit Signs	Incandescent Exit Signs	342	118	10%	34	12
Daylighting Design	4’ - 40W Fluor. Lamps/EE Ballasts	1,760	250	10%	176	25
High Pressure Sodium	Mercury Vapor Fixtures	1,544	184	2%	31	4
High Pressure Sodium (35W)	Incandescent Lamps (150W)	11,967	1,559	2%	239	31
		Total			**1,667**	**204**

The penetration of a measure is based on its cost-effectiveness, potential net benefits, persistence of energy savings over time, technical feasibility, and the current penetration of the base and efficient technologies.

Commercial Technology Rebates—HVAC & Building Shell

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	950

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	101,640	20,330	20,330	20%
2	101,640	20,330	40,660	20%
3	101,640	20,330	60,990	20%
4	101,640	30,490	91,480	23%
5	101,640	30,490	121,970	24%
6	101,640	30,490	152,460	25%
7	101,640	40,660	193,120	27%
8	101,640	40,660	233,780	29%
9	101,640	40,660	274,440	30%
10	101,640	50,820	325,260	32%
11	101,640	50,820	376,080	34%
12	101,640	50,820	426,900	35%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$40 Total Variable Admin. Cost	$350 Total Part. Measure Cost	$265 Total Part. Incentive
1	$325,000	$813,200	$7,115,500	$5,387,450
2	$325,000	$813,200	$7,115,500	$5,387,450
3	$325,000	$813,200	$7,115,500	$5,387,450
4	$325,000	$1,219,600	$10,671,500	$8,079,850
5	$325,000	$1,219,600	$10,671,500	$8,079,850
6	$325,000	$1,219,600	$10,671,500	$8,079,850
7	$325,000	$1,626,400	$14,231,000	$10,774,900
8	$325,000	$1,626,400	$14,231,000	$10,774,900
9	$325,000	$1,626,400	$14,231,000	$10,774,900
10	$325,000	$2,032,800	$17,787,000	$13,467,300
11	$325,000	$2,032,800	$17,787,000	$13,467,300
12	$325,000	$2,032,800	$17,787,000	$13,467,300

COMMERCIAL TECHNOLOGY REBATES—HVAC

Per Participant Costs and Impacts Based on:

Efficient Measures	Base Measures	Annual Energy Impact	Cost ($)	Measure Penetration	Weighted Energy Impact	Weighted Cost ($)
High-Efficiency Chiller	Standard Eff. Chiller	28	12	60%	17	7
Speed Control for Cooling Tower	Standard Cooling Tower	70	6	60%	42	4
High-Efficiency A/C DX	Standard Eff. A/C DX	500	225	30%	150	68
High-Efficiency Room A/C	Standard Efficiency Room A/C	464	289	10%	46	29
High-Efficiency Heat Pump	Standard Eff. Heat Pump	300	464	20%	60	93
Ground-Source Heat Pump	Standard Eff. Heat Pump	1,167	2,680	1%	12	27
High-Efficiency Ventilation Motors	Stan. Eff. Constant Speed Motors	38	11	25%	10	3
ASD Ventilation Controls w/VAV	Stan. Eff. Constant Speed Motors	95	66	30%	29	20
Timer/Programmable Vent. Cont.	Stan. Eff. Constant Speed Motors	128	119	5%	6	6
Roof Insulation	All Heating, Cooling, Ventilation	2,458	228	15%	369	34
Wall Insulation	All Heating, Cooling, Ventilation	285	334	5%	14	17
Window Film	Standard Windows	570	65	15%	86	10
Leak-Free Ducts	All Heating, Cooling, Ventilation	256	127	15%	38	19
HVAC Air Duct/Water Pipe Insul.	All Heating, Cooling, Ventilation	173	79	15%	26	12
Temperature Setback/Setup	All Heating, Cooling, Ventilation	246	22	25%	62	6
		Total			**967**	**355**

- *High Efficiency Chillers and Speed Control for Cooling Towers Applicable in Large Office and Hospital Buildings*
- *ASD Ventilation Controls w/VAV Applicable in University Buildings*

The penetration of a measure is based on its cost-effectiveness, potential net benefits, persistence of energy savings over time, technical feasibility, and the current penetration of the base and efficient technologies.

Commercial Technology Rebates—Appliances

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	10%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	600

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	102,995	20,600	20,600	20%
2	102,995	20,600	41,200	20%
3	102,995	30,900	72,100	23%
4	102,995	30,900	103,000	25%
5	102,995	41,200	144,200	28%
6	102,995	41,200	185,400	30%
7	102,995	51,500	236,900	33%
8	102,995	51,500	288,400	35%
9	102,995	51,500	339,900	37%
10	102,995	51,500	391,400	38%
11	102,995	51,500	442,900	39%
12	102,995	51,500	494,400	40%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$15 Total Variable Admin. Cost	$100 Total Part. Measure Cost	$75 Total Part. Incentive
1	$165,000	$309,000	$2,060,000	$1,545,000
2	$165,000	$309,000	$2,060,000	$1,545,000
3	$165,000	$463,500	$3,090,000	$2,317,500
4	$165,000	$463,500	$3,090,000	$2,317,500
5	$165,000	$618,000	$4,120,000	$3,090,000
6	$165,000	$618,000	$4,120,000	$3,090,000
7	$165,000	$772,500	$5,150,000	$3,862,500
8	$165,000	$772,500	$5,150,000	$3,862,500
9	$165,000	$772,500	$5,150,000	$3,862,500
10	$165,000	$772,500	$5,150,000	$3,862,500
11	$165,000	$772,500	$5,150,000	$3,862,500
12	$165,000	$772,500	$5,150,000	$3,862,500

COMMERCIAL TECHNOLOGY REBATES—APPLIANCES

Per Participant Costs and Impacts Based on:

Efficient Measures	Base Measures	Annual Energy Impact	Cost ($)	Measure Penetration	Weighted Energy Impact	Weighted Cost ($)
WATER HEATING						
Heat Pump Water Heater	Electric Water Heater—Standard	494	81	50%	247	40
Heat Recovery Water Heaters	Electric Water Heater—Standard	247	19	35%	86	6
Solar Water Heaters	Electric Water Heater—Standard	638	520	5%	32	26
Low Flow Showerheads	Electric Water Heater—Standard	148	1	15%	22	1
DHW Heat Trap/Pipe Insulation	Electric Water Heater—Standard	99	1	10%	10	1
DHW Heater Insulation	Electric Water Heater—Standard	49	1	5%	3	1
DWH Recirculation Pumps	Electric Water Heater—Standard	592	4	5%	30	1
		Water Heating Total			**430**	**76**
REFRIGERATION						
Ref./Ambient Subcooling	Conv. Ref./No Subcooling	22	17	20%	4	3
High R-Value Glass Doors	Conventional Refrigeration System	283	20	40%	113	8
Anti-Condensate Heater Control	Conventional Refrigeration System	47	3	25%	12	1
Dual-Path Ref. System	Conventional Refrigeration System	68	10	20%	14	2
		Refrigeration Total			**143**	**14**
COOKING						
Energy-Efficient Electric Fryers	Standard Eff. Electric Fryers	52	5	40%	21	2
Electric Forced Convection Oven	Electric Nat. Convection Oven	47	16	20%	9	3
		Cooking Total			**30**	**5**
		Total			**603**	**95**

- *Ref./Ambient Subcooling Applicable in Restaurant, Grocery, Warehouse, and Hospital Buildings.*
- *High-R Value Glass Doors and Anti-Condensate Heater Controls Applicable in Restaurant, Retail, Grocery, School, College, Hospital, and Lodging Buildings*
- *Dual-Path Supermarket Air Conditioning Applicable in Grocery Buildings*
- *Energy-Efficient Fryers and Forced Convection Ovens Applicable in Restaurant, Grocery, School, Hospital, and Lodging Buildings*

The penetration of a measure is based on its cost-effectiveness, potential net benefits, persistence of energy savings over time, technical feasibility, and the current penetration of the base and efficient technologies.

COMMERCIAL NEW CONSTRUCTION/COMMERCIAL NEW CONSTRUCTION – RENEWABLES

Overview

This program will encourage the design and construction of energy-efficient new commercial buildings that exceed existing energy and building codes. Buildings undergoing major renovations would also be eligible to participate in this program. The program will have the goal of increasing the market acceptance of energy-efficient and renewable building technologies. This program will offer both a prescriptive path and a comprehensive path. For those customers choosing the comprehensive path, TVA will provide technical assistance to builders, architects, developers, and building owners from the early planning and design stages to the commissioning of the finished building. The prescriptive path would apply to smaller buildings or buildings too far along in their construction to participate in the comprehensive path.

Target Market

This program targets owners and developers of new commercial buildings and building undergoing major renovation. The forecast estimates that Valley commercial floorspace will grow by approximately 60 million square feet per year through 2010.

Implementation Strategy

The Commercial New Construction option will provide design assistance through provision of education and incentives to architects and engineers. Incentives provided to architects and engineers will be based on the energy efficiency performance of the building. The goal will be to make the design of energy-efficient electric buildings standard practice in the Valley. Additional design assistance will be provided to participants choosing the New Construction—Renewables option, which calls for the adoption of passive solar design.

Building commissioning services will be offered to ensure that installed efficiency measures operate as designed. Building commissioning includes balancing HVAC systems, setting controls on energy management systems, and fine tuning other equipment. Contractors will be trained to install equipment properly and building commissioning will enhance the reliability and cost-effectiveness of energy efficiency measures.

TVA will partner with trade allies in the design community in marketing the Commercial New Construction Program. Coordination with architects, engineers, and others will result in the most rapid adoption and acceptance of more energy efficient building design and construction.

Monitoring and Evaluation

Process evaluation will be conducted to compare the cost and the effectiveness of the different delivery strategies. Impact evaluation will be conducted to determine the program benefits.

Commercial New Construction

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	2,050

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	46,650	9,330	9,330	20%
2	46,650	13,995	23,325	25%
3	46,650	18,660	41,985	30%
4	46,650	23,325	65,310	35%
5	46,650	23,325	88,635	38%
6	48,450	24,225	112,860	40%
7	48,450	24,225	137,085	42%
8	48,450	24,225	161,310	43%
9	48,450	24,225	185,535	43%
10	48,450	24,225	209,760	44%
11	49,350	24,675	234,435	45%
12	49,350	24,675	259,110	45%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$75 Total Variable Admin. Cost	$500 Total Part. Measure Cost	$375 Total Part. Incentive
1	$475,000	$699,750	$4,665,000	$3,498,750
2	$475,000	$1,049,625	$6,997,500	$5,248,125
3	$475,000	$1,399,500	$9,330,000	$6,997,500
4	$475,000	$1,749,375	$11,662,500	$8,746,875
5	$475,000	$1,749,375	$11,662,500	$8,746,875
6	$475,000	$1,816,875	$12,112,500	$9,084,375
7	$475,000	$1,816,875	$12,112,500	$9,084,375
8	$475,000	$1,816,875	$12,112,500	$9,084,375
9	$475,000	$1,816,875	$12,112,500	$9,084,375
10	$475,000	$1,816,875	$12,112,500	$9,084,375
11	$475,000	$1,850,625	$12,337,500	$9,253,125
12	$475,000	$1,850,625	$12,337,500	$9,253,125

Incentives

This sector is the classic example of the lost opportunity efficiency investment. It is most cost-effective to include energy efficiency measures in the design and the initial construction of a new building. To achieve the desired participation level and the market transformation goals of the program, incentives will be offered to building owners and developers. Building owners and developers will be offered rebates to cover 75 percent of the incremental cost of design and of the energy-efficient technologies specified for the new or renovated building.

COMMERCIAL NEW CONSTRUCTION

Per Participant Costs and Impacts Based on:

Efficient Measures	Base Measures	Annual Energy Impact	Cost ($)	Measure Penetration	Weighted Energy Impact	Weighted Cost ($)
LIGHTING						
T-8/Electronic Ballasts	4' - 40W Fluor. Lamps/EE Ballasts	631	62	70%	442	43
Daylighting Design	4' - 40W Fluor. Lamps/EE Ballasts	1,760	250	25%	440	63
Occupancy Sensors	All Interior Fluorescent Lighting	847	135	25%	212	34
Photoelectric Controls	Existing Lighting—Outdoor	232	6	25%	58	2
LED Exit Lights	Incandescent Exit Signs	289	103	50%	144	51
		Lighting Total			**1,296**	**193**
HVAC						
High-Efficiency Chiller	Standard Eff. Chiller	93	41	50%	46	21
Speed Control for Cooling Tower	Standard Cooling Tower	234	22	50%	117	11
High-Efficiency A/C DX	Standard Eff. A/C DX	500	225	20%	100	45
High-Efficiency Heat Pump	Standard Eff. Heat Pump	300	464	15%	45	70
Spectrally Selective Windows	Standard Windows	324	294	15%	49	44
Roof Insulation	Standard Roof Insulation	317	156	15%	48	23
Wall Insulation	All Heating, Cooling, Ventilation	395	313	15%	59	47
		HVAC Total			**464**	**261**
WATER HEATING						
Heat Pump Water Heater	Electric Water Heater—Standard	494	81	40%	198	32
Heat Recovery Water Heater	Electric Water Heater—Standard	247	19	35%	86	7
Low Flow Showerheads	Electric Water Heater—Standard	148	1	25%	37	0
		Water Heating Total			**321**	**39**
		Total			**2,081**	**493**

The penetration of a measure is based on its cost-effectiveness, potential net benefits, persistence of energy savings over time, technical feasibility, and the current penetration of the base and efficient technologies.

Commercial New Construction—Renewables

Program Assumptions

Package Measure Life (Years)	30
Free-Rider Rate	10%
Free-Driver Rate	5%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	4,900

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	46,650	933	933	2%
2	46,650	933	1,866	2%
3	46,650	933	2,799	2%
4	46,650	1,400	4,199	2%
5	46,650	1,400	5,599	2%
6	48,450	1,454	7,053	3%
7	48,450	1,938	8,991	3%
8	48,450	1,938	10,929	3%
9	48,450	1,938	12,867	3%
10	48,450	2,423	15,290	3%
11	49,350	2,468	17,758	3%
12	49,350	2,468	20,226	4%

		Per Participant Variable Administrative <u>Costs</u>	Per Participant Measure <u>Cost</u>	Per Participant <u>Incentive</u>
Year	**Fixed Administrative Cost**	**$150 Total Variable Admin. Cost**	**$2,150 Total Part. Measure Cost**	**$1,500 Total Part. Incentive**
1	$225,000	$139,950	$2,005,950	$1,399,500
2	$225,000	$139,950	$2,005,950	$1,399,500
3	$225,000	$139,950	$2,005,950	$1,399,500
4	$225,000	$210,000	$3,010,000	$2,100,000
5	$225,000	$210,000	$3,010,000	$2,100,000
6	$225,000	$218,100	$3,126,100	$2,181,000
7	$225,000	$290,700	$4,166,700	$2,907,000
8	$225,000	$290,700	$4,166,700	$2,907,000
9	$225,000	$290,700	$4,166,700	$2,907,000
10	$225,000	$363,450	$5,209,450	$3,634,500
11	$225,000	$370,200	$5,306,200	$3,702,000
12	$225,000	$370,200	$5,306,200	$3,702,000

COMMERCIAL NEW CONSTRUCTION—RENEWABLES

Per Participant Costs and Impacts Based on:

Efficient Measures	Base Measures	Annual Energy Impact	Cost ($)	Measure Penetration	Weighted Energy Impact	Weighted Cost ($)
LIGHTING						
Daylighting Design	4' - 40W Fluor. Lamps/EE Ballasts	1,760	250	100%	1,760	250
HVAC						
Passive Solar Design	All Heating, Cooling, Ventilation	2,500	1,350	100%	2,500	1,350
WATER HEATING						
Solar Water Heaters	Electric Water Heater—Standard	638	544	100%	638	544
		Total			**4,898**	**2,144**

The penetration of a measure is based on its cost-effectiveness, potential net benefits, persistence of energy savings over time, technical feasibility, and the current penetration of the base and efficient technologies.

SMALL COMMERCIAL RETROFIT—DIRECT INSTALL

Overview

The installation of energy-efficient equipment can assist small commercial and industrial customers in reducing operating costs and enhancing their competitiveness and viability. This program will focus on promoting energy efficiency and renewable technologies that benefit the local business community, the utility, and the customer by reducing costs, improving reliability, and enhancing customer satisfaction.

Target Market

This program is most applicable to existing and new small commercial and industrial companies with less than 50 kilowatts of demand. These customers, occupying about one-half of the commercial floorspace in the Valley, often do not have the staff or the capital to analyze or invest in energy efficiency improvements. This program utilizes a very aggressive delivery strategy to address the needs of these customers who are considered the most difficult commercial and industrial customers to reach.

Implementation Strategy

The Small Commercial Retrofit Program would provide participants with an on-site audit. At the time of the audit, the auditor installs cost-effective lighting, water heating, and weatherization measures. The auditor will also identify and recommend any additional cost-effective energy-efficient opportunities that may exist in the customer's facility. The auditor will refer the customer to other programs offered by TVA and/or the distributors that offer rebates or financing for energy-efficient measures that cannot be installed by the auditor (e.g., HVAC system upgrade). Customers may be asked to pay a nominal charge for this service to minimize free-ridership and program dropouts.

Incentives

Direct installation of measures at the time of site visit and audit, as well as rebates or financing for other measures installed by the customer based on audit recommendations.

Program Assumptions

Package Measure Life (Years)	7
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	10%
Free-Rider Market Barrier Costs Eliminated	60%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	1,500

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	1,500,000	30,000	30,000	2%
2	1,500,000	45,000	75,000	5%
3	1,500,000	60,000	135,000	9%
4	1,500,000	60,000	195,000	13%
5	1,500,000	60,000	255,000	17%
6	1,500,000	60,000	315,000	21%
7	1,500,000	60,000	375,000	25%
8	1,500,000	60,000	435,000	29%
9	1,500,000	60,000	495,000	33%
10	1,500,000	45,000	540,000	36%
11	1,500,000	45,000	585,000	39%
12	1,500,000	45,000	630,000	42%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$40 Total Variable Admin. Cost	$280 Total Part. Measure Cost	$250 Total Part. Incentive
1	$375,000	$1,200,000	$8,400,000	$7,500,000
2	$375,000	$1,800,000	$12,600,000	$11,250,000
3	$375,000	$2,400,000	$16,800,000	$15,000,000
4	$375,000	$2,400,000	$16,800,000	$15,000,000
5	$375,000	$2,400,000	$16,800,000	$15,000,000
6	$375,000	$2,400,000	$16,800,000	$15,000,000
7	$375,000	$2,400,000	$16,800,000	$15,000,000
8	$375,000	$2,400,000	$16,800,000	$15,000,000
9	$375,000	$2,400,000	$16,800,000	$15,000,000
10	$375,000	$1,800,000	$12,600,000	$11,250,000
11	$375,000	$1,800,000	$12,600,000	$11,250,000
12	$375,000	$1,800,000	$12,600,000	$11,250,000

Monitoring and Evaluation

Process evaluation will be conducted to compare the cost and the effectiveness of different delivery strategies. Impact evaluation will be conducted to determine the program benefits.

SMALL COMMERCIAL RETROFIT—DIRECT INSTALL

Per Participant Costs and Impacts Based on:

Efficient Measures	Base Measures	Annual Energy Impact	Cost ($)	Measure Penetration	Weighted Energy Impact	Weighted Cost ($)
LIGHTING						
Compact Fluorescent Lighting	Incandescent Lighting	8,600	1,280	10%	860	128
LED Exit Lights	Incandescent Lighting	289	135	50%	145	68
T-8/Electronic Ballasts	4’ - 40W Fluor. Lamps/EE Ballasts	1,234	230	25%	308	57
	Lighting Total				**1,313**	**253**
HVAC						
Temperature Setup/Setback	All Heating, Cooling, Ventilation	246	22	25%	61	5
Window Film	Standard Windows	570	65	10%	57	7
Leak-Free Ducts	All Heating, Cooling, Ventilation	256	127	10%	26	13
	HVAC Total				**144**	**25**
WATER HEATING						
DHW Heater Insulation	Electric Water Heater—Standard	50	5	50%	25	3
DHW Heat Trap/Pipe Insulation	Electric Water Heater—Standard	99	5	20%	20	1
	Water Heating Total				**45**	**4**
	Total				**1,502**	**282**

The penetration of a measure is based on its cost-effectiveness, potential net benefits, persistence of energy savings over time, technical feasibility, and the current penetration of the base and efficient technologies.

COMMMERCIAL HVAC MAINTENANCE PROGRAM

Overview

This program offers commercial customers maintenance contracts for their HVAC systems. A monthly charge, included on the customer's electricity bill, covers regular maintenance of the customer's HVAC equipment by TVA or a contractor. The contract also provides repairs at a reduced cost in case of failure of the HVAC system. The proper maintenance of the system will result in energy savings and improved performance for the customer.

Target Market

This program targets small to medium commercial customers without building maintenance staffs.

Implementation Strategy

TVA would contract with local dealers to provide this service to the small commercial and industrial customers. The program will be promoted directly by TVA and through its trade allies. Approved TVA contractors would be enlisted to promote this program to their commercial and industrial customers. The cost of providing this service to customers would be recovered through a small charge on the customer's monthly bill. However, the customer should see a net reduction in the total bill as a result of the energy savings realized.

This program will build TVA's long-term relationship with its customers, as well as provide an opportunity to promote other TVA programs to the customer.

Incentives

The customer receives HVAC maintenance services for a fee. The maintenance contract may provide a performance guarantee or insurance coverage to protect the customer in the case of equipment failure.

Monitoring and Evaluation

Standard monitoring and evaluation will be conducted to determine program costs and benefits. Process evaluation will be conducted to assess the value of this service to customers.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	70%
Annual Energy Impact (kWh)	350

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,250,000	5,625	5,625	0%
2	2,250,000	5,625	11,250	1%
3	2,250,000	5,625	16,875	1%
4	2,250,000	11,250	28,125	1%
5	2,250,000	11,250	39,375	2%
6	2,250,000	11,250	50,625	2%
7	2,250,000	16,875	67,500	3%
8	2,250,000	16,875	84,375	4%
9	2,250,000	16,875	101,250	5%
10	2,250,000	22,500	123,750	6%
11	2,250,000	22,500	146,250	7%
12	2,250,000	22,500	168,750	8%

		Per Participant Annual Variable Administrative Costs	Per Participant Annual Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$40 Total Variable Admin. Cost	$50 Total Part. Measure Cost	$0 Total Part. Incentive
1	$160,000	$225,000	$281,250	$0
2	$160,000	$450,000	$562,500	$0
3	$160,000	$675,000	$843,750	$0
4	$160,000	$1,125,000	$1,406,250	$0
5	$160,000	$1,575,000	$1,968,750	$0
6	$160,000	$2,025,000	$2,531,250	$0
7	$160,000	$2,700,000	$3,375,000	$0
8	$160,000	$3,375,000	$4,218,750	$0
9	$160,000	$4,050,000	$5,062,500	$0
10	$160,000	$4,950,000	$6,187,500	$0
11	$160,000	$5,850,000	$7,312,500	$0
12	$160,000	$6,750,000	$8,437,500	$0

COMPREHENSIVE MEASURES PROGRAM—FINANCING/REBATES

Overview

This program targets large commercial customers to encourage the installation of a comprehensive set of energy efficiency measures. Technical assistance is provided to program participants to encourage them to install a combination of lighting, HVAC, water heating, and other measures in order to achieve the maximum energy savings at the lowest cost. This program will also pursue retrofits in conjunction with market-driven investments in commercial chiller and packaged HVAC unit overhauls. The program would encourage installation of high-efficiency lighting and other cooling load reductions, such as HVAC system optimization measures that allow installation of new high-efficiency, properly sized HVAC units.

Target Market

This program targets commercial customers with a demand greater than 50 kilowatts. Customer research estimates that this reflects one-third of the approximately 3 billion square feet of commercial floor space in the Tennessee Valley.

Implementation Strategy

This program provides technical assistance, low-interest financing, and rebates to customers to encourage the installation of a comprehensive set of energy efficiency measures. This program will encourage the application of energy efficient technologies to meet customers' financial, environmental, and productivity needs. TVA will employ account representatives to promote this program to its largest customers. TVA will establish partnerships with trade allies to identify industry-specific opportunities to promote energy efficiency. TVA will work with customers to assess their needs and evaluate technology-based solutions.

Incentives

Under this program, customers will be offered low interest financing to encourage installation of energy-efficient measures. Low interest financing of the full cost of the energy-efficient investment assists customers in overcoming the initial capital expenditure barrier to investing in energy efficiency, while having a minimal effect on rates. In a more aggressive scenario, customers would be offered a rebate equal to 50 percent of the cost of energy-efficient technologies. These rebates would be offered to encourage greater participation, as well as higher energy and demand savings.

Comprehensive Measures Program—Financing

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	5%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	5%
Free-Rider Market Barrier Costs Eliminated	40%
Non-Free-Rider Market Barrier Costs Eliminated	60%
Annual Energy Impact (kWh)	2,400

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	945,923	9,460	9,460	1%
2	945,923	9,460	18,920	2%
3	945,923	9,460	28,380	3%
4	945,923	14,190	42,570	5%
5	945,923	14,190	56,760	6%
6	945,923	14,190	70,950	8%
7	945,923	18,920	89,870	10%
8	945,923	18,920	108,790	12%
9	945,923	18,920	127,710	14%
10	945,923	23,650	151,360	16%
11	945,923	23,650	175,010	19%
12	945,923	23,650	198,660	21%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$60 Total Variable Admin. Cost	$600 Total Part. Measure Cost	$75 Total Part. Incentive
1	$400,000	$567,600	$5,676,000	$709,500
2	$400,000	$567,600	$5,676,000	$709,500
3	$400,000	$567,600	$5,676,000	$709,500
4	$400,000	$851,400	$8,514,000	$1,064,250
5	$400,000	$851,400	$8,514,000	$1,064,250
6	$400,000	$851,400	$8,514,000	$1,064,250
7	$400,000	$1,135,200	$11,352,000	$1,419,000
8	$400,000	$1,135,200	$11,352,000	$1,419,000
9	$400,000	$1,135,200	$11,352,000	$1,419,000
10	$400,000	$1,419,000	$14,190,000	$1,773,750
11	$400,000	$1,419,000	$14,190,000	$1,773,750
12	$400,000	$1,419,000	$14,190,000	$1,773,750

Applicable Measures

A comprehensive set of customized measures will be identified for each participant. The measures will be selected to achieve the maximum level of energy savings at the lowest cost. While several technologies have been identified for promotion in this program, the program also allows for the identification of customized applications of energy-efficient technologies that are cost-effective on a site-specific basis.

COMPREHENSIVE MEASURES PROGRAM—FINANCING

Per Participant Costs and Impacts Based on:

Efficient Measures	Base Measures	Annual Energy Impact	Cost ($)	Measure Penetration	Weighted Energy Impact	Weighted Cost ($)
LIGHTING						
T-8/Electronic Ballasts	4' - 40W Fluor. Lamps/EE Ballasts	1,234	230	70%	864	161
Refl/Delamp: 4' - 40W/Elec. Ballast	4' - 40W Fluor. Lamps/EE Ballasts	2,184	321	10%	218	32
LED Exit Lights	Incandescent Exit Signs	289	135	50%	144	67
Occupancy Sensors	All Interior Fluorescent Lighting	911	135	25%	228	34
		Lighting Total			**1,454**	**294**
HVAC						
High-Efficiency Chiller	Standard Eff. Chiller	93	41	50%	46	21
Speed Control for Cooling Tower	Standard Cooling Tower	234	22	50%	117	11
High-Efficiency A/C DX	Standard Eff. A/C DX	500	225	20%	100	45
Chiller Downsizing						
High-Efficiency Heat Pump	Standard Eff. Heat Pump	150	232	20%	30	46
Roof Insulation	All Heating, Cooling, Ventilation	2,458	228	10%	246	23
Window Film	Standard Windows	570	65	10%	57	7
ASD Ventilation Controls w/VAV	Stan. Eff. Constant Speed Motors	690	930	10%	69	93
Leak-Free Ducts	All Heating, Cooling, Ventilation	256	127	10%	26	13
		HVAC Total			**691**	**257**
WATER HEATING						
Heat Pump Water Heater	Electric Water Heater—Standard	494	104	35%	173	36
Heat Recovery Water Heater	Electric Water Heater—Standard	247	43	30%	74	13
Low Flow Showerheads	Electric Water Heater—Standard	148	1	15%	22	0
		Water Heating Total			**269**	**49**
		Total			**2,415**	**602**

The penetration of a measure is based on its cost-effectiveness, potential net benefits, persistence of energy savings over time, technical feasibility, and the current penetration of the base and efficient technologies.

Comprehensive Measures Program—Rebates

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	8%
Free-Rider Market Barrier Costs Eliminated	45%
Non-Free-Rider Market Barrier Costs Eliminated	65%
Annual Energy Impact (kWh)	2,700

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	945,923	14,190	14,190	2%
2	945,923	14,190	28,380	3%
3	945,923	18,920	47,300	5%
4	945,923	18,920	66,220	7%
5	945,923	23,650	89,870	10%
6	945,923	23,650	113,520	12%
7	945,923	28,380	141,900	15%
8	945,923	28,380	170,280	18%
9	945,923	33,110	203,390	22%
10	945,923	33,110	236,500	25%
11	945,923	37,840	274,340	29%
12	945,923	37,840	312,180	33%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$50 Total Variable Admin. Cost	$700 Total Part. Measure Cost	$350 Total Part. Incentive
1	$500,000	$709,500	$9,933,300	$4,966,500
2	$500,000	$709,500	$9,933,300	$4,966,500
3	$500,000	$946,000	$13,244,000	$6,622,000
4	$500,000	$946,000	$13,244,000	$6,622,000
5	$500,000	$1,182,500	$16,555,000	$8,277,500
6	$500,000	$1,182,500	$16,555,000	$8,277,500
7	$500,000	$1,419,000	$19,866,000	$9,933,000
8	$500,000	$1,419,000	$19,866,000	$9,933,000
9	$500,000	$1,655,500	$23,177,000	$11,588,500
10	$500,000	$1,655,500	$23,177,000	$11,588,500
11	$500,000	$1,892,000	$26,488,000	$13,244,000
12	$500,000	$1,892,000	$26,488,000	$13,244,000

COMPREHENSIVE MEASURES PROGRAM—REBATES

Per Participant Costs and Impacts Based on:

Efficient Measures	Base Measures	Annual Energy Impact	Cost ($)	Measure Penetration	Weighted Energy Impact	Weighted Cost ($)
LIGHTING						
T-8/Electronic Ballasts	4' - 40W Fluor. Lamps/EE Ballasts	1,234	230	75%	925	173
Refl/Delamp: 4' - 40W/Elec. Ballast	4' - 40W Fluor. Lamps/EE Ballasts	2,184	321	10%	218	32
LED Exit Lights	Incandescent Exit Signs	289	135	40%	116	54
Electroluminescent Exit Signs	Incandescent Exit Signs	342	150	10%	34	15
Occupancy Sensors	All Interior Fluorescent Lighting	911	135	25%	228	34
		Lighting Total			**1,521**	**308**
HVAC						
High Efficiency Chiller	Standard Eff. Chiller	93	41	50%	46	20
Speed Control for Cooling Tower	Standard Cooling Tower	234	22	50%	117	11
High Efficiency A/C DX	Standard Eff. A/C DX	500	225	20%	100	45
Chiller Downsizing						
High Efficiency Heat Pump	Standard Eff. Heat Pump	150	232	20%	30	46
Roof Insulation	All Heating, Cooling, Ventilation	2,458	228	15%	369	34
Window Film	Standard Windows	570	65	15%	86	10
ASD Ventilation Controls w/VAV	Stan. Eff. Constant Speed Motors	690	930	15%	104	140
Leak Free Ducts	All Heating, Cooling, Ventilation	256	127	15%	38	19
		HVAC Total			**890**	**325**
WATER HEATING						
Heat Pump Water Heater	Electric Water Heater—Standard	494	104	40%	198	42
Heat Recovery Water Heater	Electric Water Heater—Standard	247	43	30%	74	13
Solar Water Heaters	Electric Water Heater—Standard	638	544	5%	32	27
Low Flow Showerheads	Electric Water Heater—Standard	148	1	15%	22	0
		Water Heating Total			**326**	**82**
		Total			**2,737**	**715**

The penetration of a measure is based on its cost-effectiveness, potential net benefits, persistence of energy savings over time, technical feasibility, and the current penetration of the base and efficient technologies.

COMMERCIAL LOAD MANAGEMENT—COOL STORAGE/ ROOFTOP COOL STORAGE

Overview

This program offers customers incentives to encourage the adoption of cool storage technologies to reduce the customer's peak billing demand and thus reduce the TVA system peak demand. By encouraging customers to utilize cool storage technologies, TVA's load factor is enhanced by shifting on-peak cooling demand to off-peak periods, which lowers generating costs. The program will also promote rooftop cool storage, an emerging technology that provides efficiency and load management opportunities for small commercial customers.

Target Markets

This program is targeted at large commercial customers, particularly large offices and hospitals, with significant year-round cooling loads. The program will also be targeted to the large percentage of commercial customers using rooftop cooling equipment. The program is open both to new and existing customers able to incorporate cool storage into their building design.

Implementation Strategy

The cool storage technology will be promoted through TVA field staff technical assistance and through trade allies, particularly HVAC contractors. Customers will be offered assistance in designing the cool storage systems and incentives to cover the additional cost of installing them.

Incentives

This program offers customers a rebate of 150 percent of the incremental cost of the cool storage equipment, or offers customers a technology-specific rate option, in order to encourage adoption of cool storage technologies and to cover increased operating costs. HVAC contractors will be offered incentives to promote cool storage technology to commercial customers.

Customers are offered an incentive of 50 percent of the incremental cost of rooftop cool storage units which offer efficiency benefits. A technology specific rate for cool storage could be offered as alternative incentive to customers.

Monitoring and Evaluation

The cool storage system will be demand-metered in order to determine the demand savings to the TVA system. Bill analyses will be conducted to determine the impact on customers.

Applicable Technologies

- Thermal Storage Systems - Ice or Water
- Rooftop Cool Storage Units

Commercial Load Management—Cool Storage

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	(100)
Average Demand Impacts (kW)	2

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	342,000	1,710	1,710	1%
2	342,000	1,710	3,420	1%
3	342,000	1,710	5,130	2%
4	342,000	1,710	6,840	2%
5	342,000	3,420	10,260	3%
6	342,000	3,420	13,680	4%
7	342,000	3,420	17,100	5%
8	342,000	3,420	20,520	6%
9	342,000	3,420	23,940	7%
10	342,000	3,420	27,360	8%
11	342,000	3,420	30,780	9%
12	342,000	3,420	34,200	10%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
		$40	$300	$450
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$175,000	$68,400	$513,000	$769,500
2	$175,000	$68,400	$513,000	$769,500
3	$175,000	$68,400	$513,000	$769,500
4	$175,000	$68,400	$513,000	$769,500
5	$175,000	$136,800	$1,026,000	$1,539,000
6	$175,000	$136,800	$1,026,000	$1,539,000
7	$175,000	$136,800	$1,026,000	$1,539,000
8	$175,000	$136,800	$1,026,000	$1,539,000
9	$175,000	$136,800	$1,026,000	$1,539,000
10	$175,000	$136,800	$1,026,000	$1,539,000
11	$175,000	$136,800	$1,026,000	$1,539,000
12	$175,000	$136,800	$1,026,000	$1,539,000

Commercial Load Management—Rooftop Cool Storage

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	50
Average Demand Impact (kW)	2

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	1,500,000	2,050	2,050	0%
2	1,500,000	2,050	4,010	0%
3	1,500,000	3,050	7,150	1%
4	1,500,000	3,050	10,200	1%
5	1,500,000	3,050	13,250	1%
6	1,500,000	3,050	16,300	1%
7	1,500,000	4,070	20,370	1%
8	1,500,000	4,070	24,440	2%
9	1,500,000	5,080	29,520	2%
10	1,500,000	5,080	34,600	2%
11	1,500,000	5,080	39,680	3%
12	1,500,000	5,080	44,760	3%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	**Fixed Administrative Cost**	**$25 Total Variable Admin. Cost**	**$1,000 Total Part. Measure Cost**	**$500 Total Part. Incentive**
1	$131,250	$51,250	$2,050,000	$1,025,000
2	$131,250	$51,250	$2,050,000	$1,025,000
3	$131,250	$76,250	$3,050,000	$1,525,000
4	$131,250	$76,250	$3,050,000	$1,525,000
5	$131,250	$76,250	$3,050,000	$1,525,000
6	$131,250	$76,250	$3,050,000	$1,525,000
7	$131,250	$101,750	$4,070,000	$2,035,000
8	$131,250	$101,750	$4,070,000	$2,035,000
9	$131,250	$127,000	$5,080,000	$2,540,000
10	$131,250	$127,000	$5,080,000	$2,540,000
11	$131,250	$127,000	$5,080,000	$2,540,000
12	$131,250	$127,000	$5,080,000	$2,540,000

COMMERCIAL GROUP LOAD CURTAILMENT

Overview

This program is designed to reduce the electricity demand of commercial customers at the time of the system peak. Commercial customers would band together to shed 100 kilowatts blocks from the system peak. Commercial customers would select their own load reduction strategy. Customers would receive bill credits as an incentive to reduce load at the system peak.

Target Market

This program targets large commercial customers, or groups of customers that can reduce electricity demand by at least 100 kilowatts at the time of the system peak.

Implementation Strategy

TVA would employ account representatives to promote this program directly to customers. The program would provide technical assistance to customers helping them to choose the most beneficial load reduction strategy. The utility would select the method and timing for notifying the customer of the need to reduce load.

Customers will select the load reduction strategy. The utility will advise customers on appropriate technologies for accomplishing load reductions.

Incentives

Participants will be offered financial incentives or bill credits based on the level of their load reduction. The amount of the incentive or bill credit will vary based on the length and frequency of interruption and the amount of notice the participating customer(s) is given.

Monitoring and Evaluation

Monitoring and evaluation will be conducted to determine program impacts, costs, and benefits. Process evaluation will monitor customers' compliance with the terms and conditions of the load reduction contract.

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	20%
Non-Free-Rider Market Barrier Costs Eliminated	30%
Annual Energy Impact (kWh)	4,000
Average Demand Impact (kW)	100

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	32,039	80	80	0%
2	32,039	80	160	1%
3	32,039	80	240	1%
4	32,039	80	320	1%
5	32,039	160	480	2%
6	32,039	160	640	2%
7	32,039	160	800	3%
8	32,039	160	960	3%
9	32,039	240	1,200	4%
10	32,039	240	1,440	5%
11	32,039	160	1,600	5%
12	32,039	160	1,760	6%

		Annual Per Participant Variable Administrative Costs	Annual Per Participant Measure Cost	Annual Per Participant Incentive
		$250	$4,500	$4,500
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$200,000	$20,000	$360,000	$360,000
2	$200,000	$40,000	$720,000	$720,000
3	$200,000	$60,000	$1,080,000	$1,080,000
4	$200,000	$80,000	$1,440,000	$1,440,000
5	$200,000	$120,000	$2,160,000	$2,160,000
6	$200,000	$160,000	$2,880,000	$2,880,000
7	$200,000	$200,000	$3,600,000	$3,600,000
8	$200,000	$240,000	$4,320,000	$4,320,000
9	$200,000	$300,000	$5,400,000	$5,400,000
10	$200,000	$360,000	$6,480,000	$6,480,000
11	$200,000	$400,000	$7,200,000	$7,200,000
12	$200,000	$440,000	$7,920,000	$7,920,000

INDUSTRIAL TECHNOLOGY REBATES—HIGH-EFFICIENCY MOTORS/ADJUSTABLE SPEED DRIVES/ COMPRESSED AIR EFFICIENCY

Overview

More than 70 percent of the electricity consumed by TVA's industrial customers is used to power electric motors. To save energy and money, standard motors can be replaced with energy-efficient motors. Energy-efficient motors use less electricity, run cooler, often last longer, and outperform standard motors of the same size. This program would encourage the use of properly sized high-efficiency motors and variable speed motor drives in cost-effective applications. This program also promotes energy-efficient compressors and the proper maintenance of compressed air systems to reduce leaks.

Target Market

This program targets industrial customers using standard efficiency equipment in process or manufacturing applications.

Implementation Strategy

This program will address the delivery and availability of energy-efficient motors. Energy-efficient motors are very cost-effective and usually meet the strict payback requirements of commercial and industrial customers. However, customers' motor replacement patterns often prevent selection of such high-efficiency motors. Motors are most often replaced when they fail. The replacement motor comes out of the existing stock at the customer's site or from the motor distributor. The customer generally cannot wait several weeks to receive an efficient motor to replace a failed motor. In order to change current motor replacement practices, customers need education about the significant cost savings potential of high-efficiency motors. The program will work to create market acceptance and demand for high-efficiency motors through incentives. TVA will also partner with motor distributors in promoting high-efficiency motors. Motor distributors will be offered incentives to stock them and make them available to customers.

Incentives

Financial incentives will be offered, in addition to education and technical assistance, to help customers adopt the practice of replacing standard motors with high-efficiency motors, and using adjustable speed drives. Rebates will be offered to program participants to offset the incremental cost of the energy-efficient measures. In addition, incentives will be directed to motor dealers to enhance the availability of high-efficiency motors in the Tennessee Valley region. Incentives would be based on the size and efficiency of the replacement motor.

Monitoring and Evaluation

Standard monitoring and evaluation will be conducted to determine program costs and benefits. Process evaluation will be conducted to assess the market transformation effects of the program.

Industrial Technology Rebates—High-Efficiency Motors

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	20%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	40,000

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,369	36	36	2%
2	2,369	71	107	5%
3	2,369	107	214	9%
4	2,369	142	356	15%
5	2,369	142	498	21%
6	2,369	142	640	27%
7	2,369	142	782	33%
8	2,369	142	924	39%
9	2,369	142	1,066	45%
10	2,369	142	1,208	51%
11	2,369	142	1,350	57%
12	2,369	142	1,492	63%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$100 Total Variable Admin. Cost	$2,000 Total Part. Measure Cost	$1,500 Total Part. Incentive
1	$225,000	$3,600	$72,000	$54,000
2	$225,000	$7,100	$142,000	$106,500
3	$225,000	$10,700	$214,000	$160,500
4	$225,000	$14,200	$284,000	$213,500
5	$225,000	$14,200	$284,000	$213,500
6	$225,000	$14,200	$284,000	$213,500
7	$225,000	$14,200	$284,000	$213,500
8	$225,000	$14,200	$284,000	$213,500
9	$225,000	$14,200	$284,000	$213,500
10	$225,000	$14,200	$284,000	$213,500
11	$225,000	$14,200	$284,000	$213,500
12	$225,000	$14,200	$284,000	$213,500

Industrial Technology Rebate—Adjustable Speed Drives

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	40,000

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,369	24	24	1%
2	2,369	36	60	3%
3	2,369	47	107	5%
4	2,369	59	166	7%
5	2,369	59	225	10%
6	2,369	59	284	12%
7	2,369	59	343	15%
8	2,369	59	402	17%
9	2,369	59	461	20%
10	2,369	59	520	22%
11	2,369	59	579	25%
12	2,369	59	638	27%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$125 Total Variable Admin. Cost	$5,000 Total Part. Measure Cost	$3,750 Total Part. Incentive
1	$100,000	$3,000	$120,000	$90,000
2	$100,000	$4,500	$180,000	$135,000
3	$100,000	$5,875	$236,000	$176,250
4	$100,000	$7,375	$295,000	$221,250
5	$100,000	$7,375	$295,000	$221,250
6	$100,000	$7,375	$295,000	$221,250
7	$100,000	$7,375	$295,000	$221,250
8	$100,000	$7,375	$295,000	$221,250
9	$100,000	$7,375	$295,000	$221,250
10	$100,000	$7,375	$295,000	$221,250
11	$100,000	$7,375	$295,000	$221,250
12	$100,000	$7,375	$295,000	$221,250

Industrial Technology Rebate—Compressed Air Efficiency

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	75,000

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,369	12	12	1%
2	2,369	18	30	1%
3	2,369	18	48	2%
4	2,369	24	72	3%
5	2,369	24	95	4%
6	2,369	24	120	5%
7	2,369	30	150	6%
8	2,369	30	180	8%
9	2,369	30	210	9%
10	2,369	36	246	10%
11	2,369	36	282	12%
12	2,369	36	318	13%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$400 Total Variable Admin. Cost	$25,000 Total Part. Measure Cost	$18,750 Total Part. Incentive
1	$100,000	$4,800	$300,000	$225,000
2	$100,000	$7,200	$450,000	$337,500
3	$100,000	$7,200	$450,000	$337,500
4	$100,000	$9,600	$600,000	$450,000
5	$100,000	$9,600	$600,000	$450,000
6	$100,000	$9,600	$600,000	$450,000
7	$100,000	$12,000	$750,000	$562,500
8	$100,000	$12,000	$750,000	$562,500
9	$100,000	$12,000	$750,000	$562,500
10	$100,000	$14,400	$900,000	$675,000
11	$100,000	$14,400	$900,000	$675,000
12	$100,000	$14,400	$900,000	$675,000

INDUSTRIAL PROCESS ENERGY EFFICIENCY PROGRAM—DISTRIBUTOR SERVED/DIRECT SERVED

Overview

This program is designed to promote energy-efficient technologies to the industrial customers served by TVA and the distributors of TVA power. The program provides technical assistance to identify opportunities for energy efficiency improvements in industrial processes. This program will encourage applications of energy-efficient technologies to address customers' financial, environmental, and productivity needs.

Target Market

This program targets large industrial customers served by TVA and the distributors of TVA power.

Implementation Strategy

TVA will employ account representatives to promote this program directly to customers. The program would enlist trade allies and technical specialists to identify energy and demand savings opportunities. This program will help to build long-term relationships with this vulnerable customer group and establish a partnership to promote future economic development.

Incentives

Customers will be encouraged to participate with financial incentives, cost savings, and productivity improvements.

Monitoring and Evaluation

Monitoring and evaluation will be conducted to determine program impacts, costs, and benefits.

Applicable Measures

Customized energy-efficient technology applications will be identified for each participant.

Industrial Process Energy Efficiency Program— Distributor Served

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	150,000

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	14,625	219	219	2%
2	15,000	225	444	3%
3	15,375	308	752	5%
4	15,750	315	1,067	7%
5	16,125	403	1,470	9%
6	16,500	413	1,883	11%
7	16,875	506	2,389	14%
8	17,250	518	2,907	17%
9	17,625	617	3,524	20%
10	18,000	630	4,154	23%
11	18,375	735	4,889	27%
12	18,750	750	5,639	30%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$500 Total Variable Admin. Cost	$33,000 Total Part. Measure Cost	$16,500 Total Part. Incentive
1	$187,500	$109,500	$7,227,000	$3,613,500
2	$187,500	$112,500	$7,425,000	$3,712,500
3	$187,500	$154,000	$10,164,000	$5,082,000
4	$187,500	$157,500	$10,395,000	$5,197,500
5	$187,500	$201,500	$13,299,000	$6,649,500
6	$187,500	$206,500	$13,629,000	$6,814,500
7	$187,500	$253,000	$16,698,000	$8,349,000
8	$187,500	$259,000	$17,094,000	$8,547,000
9	$187,500	$308,500	$20,361,000	$10,180,500
10	$187,500	$315,000	$20,790,000	$10,395,000
11	$187,500	$367,500	$24,255,000	$12,127,500
12	$187,500	$375,000	$24,750,000	$12,375,000

*Industrial Process Energy Efficiency Program—
Direct Served*

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	100,000

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	19,500	293	293	2%
2	20,000	300	593	3%
3	20,500	410	1,003	5%
4	21,000	420	1,423	7%
5	21,500	538	1,961	9%
6	22,000	550	2,511	11%
7	22,500	675	3,186	14%
8	23,000	690	3,876	17%
9	23,500	823	4,699	20%
10	24,000	840	5,539	23%
11	24,500	980	6,519	27%
12	25,000	1,000	7,519	30%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$500 Total Variable Admin. Cost	$22,500 Total Part. Measure Cost	$11,250 Total Part. Incentive
1	$187,500	$146,500	$6,592,500	$3,296,250
2	$187,500	$150,000	$6,750,000	$3,375,000
3	$187,500	$205,000	$9,225,000	$4,612,500
4	$187,500	$210,000	$9,450,000	$4,725,000
5	$187,500	$269,000	$12,105,000	$6,052,500
6	$187,500	$275,000	$12,375,000	$6,187,500
7	$187,500	$337,500	$15,187,500	$7,593,750
8	$187,500	$345,000	$15,525,000	$7,762,500
9	$187,500	$411,500	$18,517,500	$9,258,750
10	$187,500	$420,000	$18,900,000	$9,450,000
11	$187,500	$490,000	$22,050,000	$11,025,000
12	$187,500	$500,000	$22,500,000	$11,250,000

ENERGY-EFFICIENT RATES (OPT OUT)

Overview

Customers who have made investments in energy-efficient measures and who, therefore, cannot participate in the programs offered by TVA and its distributors would be eligible for the Energy-Efficient Rate. This program rewards customers who have taken action to use energy wisely and protect the environment. These customers are granted a rate discount for five years. The rate discount is put into effect after the customers demonstrate that they have made all cost-effective energy efficiency investments to their facilities.

In addition to the rate discount, customers will be provided with cooperative advertising materials that they can use to promote themselves as an energy-efficient supplier of goods and services. The promotional materials will emphasize the environmental benefits of energy efficiency and the wise use of resources by customers who have made investments in energy-efficient measures and processes.

This program provides in effect an opt-out option for customers who chose to make investments in energy-efficient measures themselves, without financial assistance from the utility. To qualify for the Energy-Efficient Rate, the customer must agree to a co-funded audit of its facilities. If the auditor identifies any remaining opportunities for cost-effective energy efficiency investments, the customer must agree to adopt the auditor's recommendations that meet a mutually agreed upon investment hurdle rate.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	150,000

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	14,625	293	293	2%
2	15,000	300	593	4%
3	15,375	308	901	6%
4	15,750	236	1,137	7%
5	16,125	242	1,379	9%
6	16,500	248	1,627	10%
7	16,875	169	1,796	11%
8	17,250	173	1,969	11%
9	17,625	176	2,145	12%
10	18,000	90	2,235	12%
11	18,375	92	2,327	13%
12	18,750	94	2,421	13%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Annual Per Participant Incentive
Year	Fixed Administrative Cost	$2,000 Total Variable Admin. Cost	$35,000 Total Part. Measure Cost	$2,000 Total Part. Incentive
1	$100,000	$586,000	$10,255,000	$586,000
2	$100,000	$600,000	$10,500,000	$1,186,000
3	$100,000	$616,000	$10,780,000	$1,802,000
4	$100,000	$472,000	$8,260,000	$2,274,000
5	$100,000	$484,000	$8,470,000	$2,758,000
6	$100,000	$496,000	$8,680,000	$3,254,000
7	$100,000	$338,000	$5,915,000	$3,592,000
8	$100,000	$345,000	$6,055,000	$3,938,000
9	$100,000	$352,000	$6,160,000	$4,290,000
10	$100,000	$180,000	$3,150,000	$4,470,000
11	$100,000	$184,000	$3,220,000	$4,654,000
12	$100,000	$188,000	$3,290,000	$4,842,000

RENEWABLE/SELF-GENERATION CUSTOMER SERVICE OPTIONS

SUMMARY OF PROJECTED IMPACTS IN YEAR 2010

Option Name	2010 Winter MW	2010 Summer MW	GWh	Units (# part.)	¢/kWh TRC
RENEWABLE GENERATION PROGRAMS					
Landfill Gas/Fuel Cells	74	74	585	36	6.0
Small Head Hydro	5	5	29	5	5.9
Biomass/Wood Waste	54	54	374	62	3.6
Photovoltaics	1	1.5	5	1,975	33.0
Photovoltaics/Technology Advancement.	3	3.3	11	4,600	19.0
SELF-GENERATION					
Existing Cogeneration—Commercial	95	95	118	416	7.7
New Cogeneration—Commercial	18	18	51	84	12.1
New Cogeneration—Industrial	30	30	17	208	8.8

Values are the impacts occuring only in the year 2010 for the cumulative participation in the program to date.

TVA developed eight self-generation options, including cogeneration and options utilizing renewable fuels. The greatest potential for self-generation is from land-fill gas, wood wastes and existing commercial cogeneration. Detailed descriptions of the self-generation options follow.

RENEWABLE ENERGY GENERATION: LANDFILL GAS/FUEL CELLS, SMALL-HEAD HYDRO, BIOMASS/WOOD WASTE, PHOTOVOLTAICS, PHOTOVOLTAICS/TECHNOLOGY ADVANCEMENT

Overview

This program will encourage the development of customer-owned renewable generation resources. Renewable energy resources include generation from wood waste, biogas derived from anaerobic digestion of animal waste, and methane recovered from landfills. These fuels can be used with a number of generating technologies and fuel cells. Other renewable energy resources with cost-effective potential include small-head hydro systems and the use of photovoltaics in remote locations. This program provides annual incentives to customers to develop renewable resources to provide energy for their own use and for the benefit of the TVA system.

Target Market

This program targets customers with access to or in close proximity of renewable energy resources.

Implementation Strategy

Customers with access to renewable energy sources would be provided assistance to develop those resources. In addition to technical assistance, financial incentives would be provided to customers to improve the cost-effectiveness of renewable energy.

Incentives

Customers would be offered incentives of 2¢/kilowatt-hour for energy produced by combustion-based renewable resources. For non-combustion-based renewable resources, such as hydro resources and photovoltaics, customers would be offered an incentive of 3¢/kilowatt-hour. The incentives cover the higher costs and higher uncertainties associated with energy produced from renewable resources and reflect the environmental benefits of renewable and non-combustion-based resources. These incentives are for energy produced for the customer's own use which defers the need for TVA to add to its system resources. Excess energy produced could be sold to the TVA system at a market price.

Monitoring and Evaluation

Monitoring and evaluation will be conducted to determine program costs and benefits. Information on the cost and performance of renewable resources will be gathered and documented.

Renewable Energy Generation—Landfill Gas/Fuel Cells

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	15,768,600
Average Demand Impact (kW)	2000

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	—	—	—	n/a
2	—	1	1	n/a
3	—	1	2	n/a
4	—	2	4	n/a
5	—	2	6	n/a
6	—	2	8	n/a
7	—	2	10	n/a
8	—	2	12	n/a
9	—	3	15	n/a
10	—	3	18	n/a
11	—	3	21	n/a
12	—	3	24	n/a

Year	Fixed Administrative Cost	Per Participant Variable Administrative Costs $1,000 Total Variable Admin. Cost	Per Participant Measure Cost $3,360,000 Total Part. Measure Cost	Annual Per Participant Incentive $160/kW Total Part. Incentive
1	$50,000	$0	$0	$0
2	$50,000	$1,000	$3,360,000	$320,000
3	$50,000	$1,000	$3,360,000	$640,000
4	$50,000	$2,000	$6,720,000	$1,280,000
5	$50,000	$2,000	$6,720,000	$1,920,000
6	$50,000	$2,000	$6,720,000	$2,560,000
7	$50,000	$2,000	$6,720,000	$3,200,000
8	$50,000	$2,000	$6,720,000	$3,840,000
9	$50,000	$3,000	$10,080,000	$4,800,000
10	$50,000	$3,000	$10,080,000	$5,760,000
11	$50,000	$3,000	$10,080,000	$6,720,000
12	$50,000	$3,000	$10,080,000	$7,680,000

Renewable Energy Generation—Small-Head Hydro

Program Assumptions

Package Measure Life (Years)	30
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	1,000,000
Average Demand Impact (kW)	163

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	—	—	—	n/a
2	—	10	10	n/a
3	—	—	10	n/a
4	—	1	10	n/a
5	—	—	10	n/a
6	—	5	15	n/a
7	—	—	15	n/a
8	—	9	25	n/a
9	—	—	25	n/a
10	—	4	29	n/a
11	—	—	29	n/a
12	—	—	29	n/a

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Annual Per Participant Incentive
		$0	Varies	$185/kW
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$50,000	$0	$0	$0
2	$50,000	$0	$3,162,587	$295,519
3	$50,000	$0	$0	$295,519
4	$50,000	$0	$216,056	$313,612
5	$50,000	$0	$0	$313,612
6	$50,000	$0	$1,957,192	$461,372
7	$50,000	$0	$0	$461,372
8	$50,000	$0	$5,407,107	$738,798
9	$50,000	$0	$0	$738,798
10	$50,000	$0	$2,481,976	$862,433
11	$50,000	$0	$0	$862,433
12	$50,000	$0	$0	$862,433

Renewable Energy Generation—Biomass/Wood Waste

Program Assumptions

Package Measure Life (Years)	30
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	5,550,000
Average Demand Impact (kW)	800

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	—	3	3	n/a
2	—	3	6	n/a
3	—	3	9	n/a
4	—	4	13	n/a
5	—	4	17	n/a
6	—	5	22	n/a
7	—	5	27	n/a
8	—	4	31	n/a
9	—	4	35	n/a
10	—	3	38	n/a
11	—	3	41	n/a
12	—	3	44	n/a

		Participant Variable Administrative Costs	Per Participant Measure Cost	Per Annual Per Participant Incentive
		$0	$1,200,000	$140/kW
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$75,000	$3,000	$3,600,000	$336,000
2	$75,000	$3,000	$3,600,000	$672,000
3	$75,000	$3,000	$3,600,000	$1,008,000
4	$75,000	$4,000	$4,800,000	$1,456,000
5	$75,000	$4,000	$4,800,000	$1,904,000
6	$75,000	$5,000	$6,000,000	$2,464,000
7	$75,000	$5,000	$6,000,000	$3,024,000
8	$75,000	$4,000	$4,800,000	$3,472,000
9	$75,000	$4,000	$4,800,000	$3,920,000
10	$75,000	$3,000	$3,600,000	$4,256,000
11	$75,000	$3,000	$3,600,000	$4,592,000
12	$75,000	$3,000	$3,600,000	$4,928,000

Renewable Energy Generation—Photovoltaics

Program Assumptions

Package Measure Life (Years)	30
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	2,230
Average Demand Impact (kW)	1

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	—	50	50	n/a
2	—	50	100	n/a
3	—	75	175	n/a
4	—	100	275	n/a
5	—	100	375	n/a
6	—	125	500	n/a
7	—	125	625	n/a
8	—	150	775	n/a
9	—	150	925	n/a
10	—	150	1,075	n/a
11	—	150	1,225	n/a
12	—	150	1,375	n/a

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Annual Per Participant Incentive
		$10	$5,000	$100/kW
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$50,000	$500	$250,000	$5,000
2	$50,000	$500	$250,000	$10,000
3	$50,000	$750	$375,000	$17,500
4	$50,000	$1,000	$500,000	$27,500
5	$50,000	$1,000	$500,000	$37,500
6	$50,000	$1,250	$625,000	$50,000
7	$50,000	$1,250	$625,000	$62,500
8	$50,000	$1,500	$750,000	$77,500
9	$50,000	$1,500	$750,000	$92,500
10	$50,000	$1,500	$750,000	$107,500
11	$50,000	$1,500	$750,000	$122,500
12	$50,000	$1,500	$750,000	$137,500

Renewable Energy Generation—Photovoltaics/Technology Advancement

Program Assumptions

Package Measure Life (Years)	30
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	2,230
Average Demand Impact (kW)	1

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	—	150	150	n/a
2	—	150	300	n/a
3	—	200	500	n/a
4	—	200	700	n/a
5	—	250	950	n/a
6	—	250	1,200	n/a
7	—	300	1,500	n/a
8	—	300	1,800	n/a
9	—	350	2,150	n/a
10	—	350	2,500	n/a
11	—	350	2,850	n/a
12	—	350	3,200	n/a

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Annual Per Participant Incentive
		$10	$3,000	$100/kW
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$50,000	$1,500	$450,000	$15,000
2	$50,000	$1,500	$450,000	$30,000
3	$50,000	$2,000	$600,000	$50,000
4	$50,000	$2,000	$600,000	$70,000
5	$50,000	$2,500	$750,000	$95,000
6	$50,000	$2,500	$750,000	$120,000
7	$50,000	$3,000	$900,000	$150,000
8	$50,000	$3,000	$900,000	$180,000
9	$50,000	$3,500	$1,050,000	$215,000
10	$50,000	$3,500	$1,050,000	$250,000
11	$50,000	$3,500	$1,050,000	$285,000
12	$50,000	$3,500	$1,050,000	$320,000

EXISTING COGENERATION—COMMERCIAL

Overview

The program will promote the use of existing 150-kilowatt to 20-megawatt cogeneration installations in the commercial market sector as a means of load reduction.

Target Market

SIC codes most likely to be operating existing cogeneration systems are targeted SICs 40 - 49 (transportation), SIC 54 (supermarkets), SIC 58 (restaurants), SICs 60 - 67 (finance, insurance), SIC 70 (hotels/motels), SIC 805 (hospitals), and SIC 806 (nursing homes).

Implementation Strategy

TVA will work with commercial decision-makers in the above-mentioned SIC classifications to ensure comprehensive coverage of the market. Business decision-makers will receive information, technical studies, and/or financial incentives to promote the installation of new cogeneration technologies. The technologies are targeted to be in the 150-kilowatt to 20- megawatt range and will supply power to the business for all or part of their total load during TVA system peak loads.

Incentives

TVA will pay the customer for on-peak load reductions, acheived through self-generation, at a cost range averaging $25 per kilwatt. Excess energy produced could be sold to the TVA system at a market price.

Monitoring and Evaluation

TVA engineers will work with the on-site personnel and the vendor to ensure proper installation and synchronization with local distribution systems and the facility. Contracted payments to the company will be paid based on actual peak load demand reductions.

Applicable Technologies

- Reciprocating Engine Systems
- Gas Turbine Systems
- Coal-Fired Steam Turbine Systems

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	3,423,382
Average Demand Impact (kW)	615

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	803	3	3	n/a
2	803	6	9	n/a
3	803	12	21	n/a
4	803	18	39	n/a
5	803	21	60	n/a
6	803	18	78	n/a
7	803	12	90	n/a
8	803	12	102	n/a
9	803	9	111	n/a
10	803	7	118	n/a

Year	Fixed Administrative Cost	Per Participant Variable Administrative Costs $5,000 Total Variable Admin. Cost	Per Participant Measure Cost $0 Total Part. Measure Cost	Annual Per Participant Incentive $25/kW Total Part. Incentive
1	$76,000	$15,000	$0	$46,125
2	$76,000	$30,000	$0	$138,375
3	$76,000	$60,000	$0	$322,875
4	$76,000	$90,000	$0	$599,625
5	$76,000	$105,000	$0	$922,500
6	$76,000	$90,000	$0	$1,199,250
7	$76,000	$60,000	$0	$1,383,750
8	$76,000	$60,000	$0	$1,568,250
9	$76,000	$45,000	$0	$1,706,625
10	$76,000	$35,000	$0	$1,814,250

NEW COGENERATION—COMMERCIAL

Overview

The program will promote new 150-kilowatt to 20-megawatt cogeneration installations in the commercial market sector as a means of load reduction.

Target Market

SIC codes most receptive to adding new cogeneration systems are targeted SICs 40 - 49 (transportation), SIC 54 (supermarkets), SIC 58 (restaurants), SICs 60 - 67 (finance, insurance), SIC 70 (hotels/motels).

Implementation Strategy

TVA will work with commercial decision-makers in the above-mentioned SIC classifications to ensure comprehensive coverage of the market. Industry decision-makers will receive information, technical studies, and/or financial incentives to promote the installation of new cogeneration technologies. The technologies are targeted to be in the 150-kilowatt to 20- megawatt range and will supply power to the business for all or part of their total load during TVA system peak loads.

Incentives

TVA will pay the customer for on-peak load reductions, acheived through self-generation, at a cost range averaging $40 per kilowatt. Excess energy produced could be sold to the TVA system at a market price.

Monitoring and Evaluation

TVA engineers will work with on-site personnel and the vendor to ensure proper installation and synchronization with local distribution systems and the facility. Contracted payments to the company will be paid based on actual peak load demand reductions.

Applicable Technologies

- Reciprocating Engine Systems
- Gas Turbine Systems
- Coal-Fired Steam Turbine Systems

Program Assumption

Package Measure Life (Years)	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	1,614,455
Average Demand Impact (kW)	328

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	12,800	1	1	n/a
2	12,800	3	4	n/a
3	12,800	5	9	n/a
4	12,800	8	17	n/a
5	12,800	9	26	n/a
6	12,800	8	34	n/a
7	12,800	5	39	n/a
8	12,800	5	44	n/a
9	12,800	4	48	n/a
10	12,800	3	51	n/a

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Annual Per Participant Incentive
Year	Fixed Administrative Cost	$7,200 Total Variable Admin. Cost	$595,320 Total Part. Measure Cost	$40/kW Total Part. Incentive
1	$76,000	$7,200	$595,320	$13,120
2	$76,000	$21,600	$1,785,960	$52,480
3	$76,000	$36,000	$2,976,600	$118,080
4	$76,000	$57,600	$4,762,560	$223,040
5	$76,000	$64,800	$5,357,880	$341,120
6	$76,000	$57,600	$4,762,560	$446,080
7	$76,000	$36,000	$2,976,600	$511,680
8	$76,000	$36,000	$2,976,600	$577,280
9	$76,000	$28,800	$2,381,280	$629,760
10	$76,000	$21,600	$1,785,960	$669,120

NEW COGENERATION—INDUSTRIAL MARKET SECTOR

Overview

The program will promote new 150-kilowatt to 20-megawatt cogeneration installations in the industrial manufacturing sectors in SIC codes 20 through 39, as a means of achieving peak load reduction.

Target Market

The SIC codes in the industrial sector that are most receptive to cogeneration are the food industry (SIC 20), the wood industry (SIC 24), the pulp and paper industry (SIC 26), and the chemical industry (SIC 28). These SIC codes are targeted.

Implementation Strategy

TVA will work with industry decision-makers in the above-mentioned SIC classifications to ensure comprehensive coverage of the market. Industry decision-makers will receive information, technical studies, and/or financial incentives to promote the installation of new cogeneration technologies. The technologies are targeted to be in the 150-kilowatt to 20- megawatt range and will supply power to the plant for all or part of their total load during times of TVA system peak load.

Incentives

TVA will pay the customer for on-peak load reductions, acheived through self-generation, at a cost range averaging $35 per kilowatt. Excess energy produced could be sold to the TVA system at a market price.

Monitoring and Evaluation

TVA engineers will work with on-site plant personnel and the vendor to ensure proper installation and synchronization with local distribution systems and the facility. Contracted payments to the company will be paid based on actual peak load demand reductions.

Applicable Technologies

- Reciprocating Engine Systems
- Gas Turbine Systems
- Coal-Fired Steam Turbine Systems

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	70%
Non-Free-Rider Market Barrier Costs Eliminated	80%
Annual Energy Impact (kWh)	11,126,814
Average Demand Impact (kW)	1600

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	1,600	1	1	n/a
2	1,600	2	3	n/a
3	1,600	4	7	n/a
4	1,600	5	12	n/a
5	1,600	6	18	n/a
6	1,600	5	23	n/a
7	1,600	4	27	n/a
8	1,600	4	31	n/a
9	1,600	3	34	n/a
10	1,600	1	35	n/a

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	**Fixed Administrative Cost**	**$10,000 Total Variable Admin. Cost**	**$2,640,000 Total Part. Measure Cost**	**$35/kW Total Part. Incentive**
1	$76,000	$10,000	$2,640,000	$56,000
2	$76,000	$20,000	$5,280,000	$168,000
3	$76,000	$40,000	$10,560,000	$392,000
4	$76,000	$50,000	$13,200,000	$672,000
5	$76,000	$60,000	$15,840,000	$1,008,000
6	$76,000	$50,000	$13,200,000	$1,288,000
7	$76,000	$40,000	$10,560,000	$1,512,000
8	$76,000	$40,000	$10,560,000	$1,736,000
9	$76,000	$30,000	$7,920,000	$1,904,000
10	$76,000	$10,000	$2,640,000	$1,960,000

BENEFICIAL ELECTRIFICATION OPTIONS

SUMMARY OF PROJECTED IMPACTS IN YEAR 2010

Option Name	MW	GWh	Units
INDUSTRIAL SECTOR			
Process Heating and Melting	-87	-609	228
Process Melting	-79	-549	29
Curing and Drying	-18	-123	425
Electrotechnologies/Food Processing	-53	-368	29
Electrotechnologies/Textiles	-3	-19	64
Electrotechnologies/Chemicals & Metals	-5	-37	49
Environmental Technologies	-33	-227	140
COMMERCIAL SECTOR			
Space Conditioning and Water Heating	-21	-294	30,300
Cooking and Security Lighting	-25	-112	10,917
RESIDENTIAL SECTOR			
HVAC and Water Heating	119	-374	101,256
Security Lighting and Lawn Mowers	0	-51	236,407
TRANSPORTATION			
Electric Buses	0	-9	259
Fleet Vehicles	0	-4	503
Electric Autos	0	-6	1,774

Values are the impacts occuring only in the year 2010 for the cumulative participation in the program to that date.

TVA developed 14 beneficial electrification options for evaluation in Energy Vision 2020 with applications in all customer sectors. The industrial sector options have the most impact. Commercial space conditioning and residential heating and cooling are also significant. Detailed descriptions of the beneficial electrification options follow.

INDUSTRIAL PROCESS HEATING AND MELTING

Overview

The Process Heating and Melting programs promote select electrotechnologies (induction, resistance, arc, plasma, and infrared) to assist industrial customers in optimizing their energy efficiency needs within process heat application. These electrotechnologies also allow customers to maintain and even enhance their competitiveness by lowering operating and maintenance costs, increasing productivity, allowing for increased operating flexibility, and by helping them to position their facilities for long-term environmental compliance.

Within this program, the customer is provided with a complete menu of technologies from which to select in order to determine the most appropriate solution. This program concept has applicability to a large part of the industrial sector, but will focus initially on key industrial segments with extensive process heating and melting requirements. A pilot program is recommended to gain experience and to allow market research to be conducted to refine estimates of market potential and cost-effectiveness.

Target Markets

Target markets for the initial pilot will include: Primary Metals (SIC 33); Fabricated Metals (SIC 34); Transportation Equipment (SIC 37); Industrial Machinery (SIC 35); Electronic Equipment (SIC 36); Stone, Clay, Glass & Concrete (SIC 32); Rubber and Plastics (SIC 30).

Implementation Strategy

TVA does not plan to use any prescriptive or customized rebates for the program. Each electrotechnology should be promoted based on its potential to offer practical solutions to each customer's problems. The program is application-specific and is targeted to large industrial customers and all industrial customers perceived at risk with regard to customer retention. The process heating and melting program should be marketed to enhance customer competitiveness. Understanding the customer's need for favorable paybacks on capital outlays, two additional offerings are considered: a customized rate and customer financing.

The program will be delivered jointly by TVA and participating power distributors. TVA will supply industrial specialists to assist distributor served industrial customers. The success of the program will depend upon TVA's ability to identify and target the most appropriate markets for this program. This effort will require open, two-way communication with distributors and trade allies.

Industrial Process Heating

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	20%
Annual Energy Impact (kWh)	(2,532,323)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	139	—	—	0%
2	139	1	1	0%
3	555	6	7	1%
4	1,106	17	24	1%
5	1,092	27	51	2%
6	1,070	27	78	2%
7	1,049	26	104	2%
8	1,028	26	130	2%
9	1,007	25	155	2%
10	987	25	180	2%
11	967	24	204	2%
12	948	24	228	2%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$368,000 Total Part. Measure Cost	$0 Total Part. Incentive
1	$138,125	$0	$0	$0
2	$138,125	$0	$368,000	$0
3	$138,125	$0	$2,208,000	$0
4	$138,125	$0	$6,256,000	$0
5	$175,938	$0	$9,936,000	$0
6	$175,938	$0	$9,936,000	$0
7	$175,938	$0	$9,568,000	$0
8	$175,938	$0	$9,568,000	$0
9	$175,938	$0	$9,200,000	$0
10	$175,938	$0	$9,200,000	$0
11	$175,938	$0	$8,932,000	$0
12	$175,938	$0	$8,832,000	$0

Promotional Strategies

The program will be marketed via a program brochure and personalized one-on-one marketing visits with potential program participants. Where possible, TVA should establish customer showcases that would allow other customers the opportunity to witness successful electrotechnology applications in operation. Technical seminars and training will be provided to promote the virtues of electrotechnologies for heating and melting applications.

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-1A	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$200,000	$1,963,000	$0
1996	1	1	$208,000	$2,041,520	$2,249,520
1997	6	7	$216,320	$2,123,181	$16,160,187
1998	17	24	$224,973	$2,208,108	$56,819,133
1999	27	51	$233,972	$2,296,432	$123,435,276
2000	27	78	$243,331	$2,388,290	$192,856,557
2001	26	104	$253,064	$2,483,821	$264,897,048
2002	26	130	$263,186	$2,583,174	$342,655,456
2003	25	155	$273,714	$2,686,501	$423,250,505
2004	25	180	$284,662	$2,793,961	$510,029,530
2005	24	204	$296,049	$2,905,720	$599,872,056
2006	24	228	$307,891	$3,021,948	$696,393,528

One-Time Environmental Savings	*$200,000*
Annual Productivity, O&M, Fuel Savings	*$1,963,000*
Escalation Rate	*4%*

Industrial Process Melting

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	30%
Annual Energy Impact (kWh)	(17,950,000)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	19	—	—	0%
2	37	1	1	1%
3	74	1	2	1%
4	147	3	5	2%
5	145	3	8	2%
6	142	3	11	2%
7	141	3	14	2%
8	138	3	17	2%
9	136	3	20	2%
10	134	3	23	2%
11	132	3	26	2%
12	130	3	29	2%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	**Fixed Administrative Cost**	**$0 Total Variable Admin. Cost**	**$1,490,000 Total Part. Measure Cost**	**$0 Total Part. Incentive**
1	$138,125	$0	$0	$0
2	$138,125	$0	$1,490,000	$0
3	$138,125	$0	$1,490,000	$0
4	$138,125	$0	$4,470,000	$0
5	$138,125	$0	$4,470,000	$0
6	$138,125	$0	$4,470,000	$0
7	$138,125	$0	$4,470,000	$0
8	$138,125	$0	$4,470,000	$0
9	$138,125	$0	$4,470,000	$0
10	$138,125	$0	$4,470,000	$0
11	$138,125	$0	$4,470,000	$0
12	$138,125	$0	$4,470,000	$0

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-1B	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$900,000	$1,748,000	$0
1996	1	1	$936,000	$1,817,920	$2,753,920
1997	1	2	$973,440	$1,890,637	$4,754,714
1998	3	5	$1,012,378	$1,966,262	$12,868,444
1999	3	8	$1,052,873	$2,044,913	$19,517,923
2000	3	11	$1,094,988	$2,126,709	$26,678,763
2001	3	14	$1,138,787	$2,211,778	$34,381,253
2002	3	17	$1,184,339	$2,300,249	$42,657,250
2003	3	20	$1,231,712	$2,392,259	$51,540,316
2004	3	23	$1,280,981	$2,487,949	$61,065,770
2005	3	26	$1,332,220	$2,587,467	$71,270,802
2006	3	29	$1,385,509	$2,690,966	$82,194,541

One-Time Environmental Savings	*$900,000*
Annual Productivity, O&M, Fuel Savings	*$1,748,000*
Escalation Rate	*4%*

INDUSTRIAL CURING AND DRYING

Overview

The Process Curing and Drying program promotes select electrotechnologies (infrared, radio-frequency, microwave, ultraviolet, and electron beam) to assist industrial customers to optimize their energy efficiency needs within curing and drying applications. These electrotechnologies also allow customers to maintain and even enhance their competitiveness by lowering operating and maintenance costs, increasing productivity, allowing for increased operating flexibility, and by helping them to position their facilities for long-term environmental compliance.

Within this program, customers are provided a complete menu of technologies from which to select in determining the most appropriate solution to meet their needs. This program concept is applicable to a large part of the industrial sector, but will focus initially on key industrial segments with extensive process curing and drying requirements. A pilot program is recommended to gain experience and to allow market research to be conducted to refine estimates of market potential and cost-effectiveness.

Target Markets

Target markets for the initial pilot will include: Food and Kindred Products (SIC 20); Textiles (SIC 22); Lumber and Wood Products (SIC 24); Paper and Allied Products (SIC 26); Printing and Publishing (SIC 27); Chemicals and Allied Products (SIC 28); Rubber and Plastics (SIC 30); Fabricated Metals (SIC 34); and Transportation (SIC 37).

Implementation Strategy

TVA does not plan to use any prescriptive or customized rebates for the program. Each electrotechnology will be promoted based on its potential to offer practical solutions to each customer's problems. The Process Curing and Drying program should be marketed to enhance customer competitiveness. Understanding the customer's need for favorable paybacks on capital outlays, two additional offerings are considered: a customized rate and customer financing.

The program would be delivered jointly by TVA and participating power distributors. TVA would supply industrial specialists to assist distributor served industrial customers. The success of the program will depend upon TVA's ability to identify and target the most appropriate markets for this program. This effort will require open, two-way communication with distributors and trade allies.

Program Assumptions

Package Measure Life (Years)	12
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	10%
Annual Energy Impact (kWh)	(273,122)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	141	—	—	0%
2	141	3	3	1%
3	562	11	14	2%
4	1,115	33	47	2%
5	1,088	54	101	3%
6	1,045	52	153	4%
7	1,003	50	203	4%
8	963	48	251	4%
9	925	46	297	4%
10	887	44	341	4%
11	852	43	394	4%
12	818	41	425	4%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$200,000 Total Part. Measure Cost	$0 Total Part. Incentive
1	$276,250	$0	$0	$0
2	$276,250	$0	$600,000	$0
3	$276,250	$0	$2,200,000	$0
4	$276,250	$0	$6,600,000	$0
5	$351,875	$0	$10,800,000	$0
6	$351,875	$0	$10,400,000	$0
7	$351,875	$0	$10,000,000	$0
8	$351,875	$0	$9,600,000	$0
9	$351,875	$0	$9,200,000	$0
10	$351,875	$0	$8,800,000	$0
11	$351,875	$0	$8,600,000	$0
12	$351,875	$0	$8,200,000	$0

Promotional Strategies

The program will be marketed via a program brochure and personalized one-on-one marketing visits with potential program participants. Where possible, TVA should establish customer showcases that would allow other customers the opportunity to witness successful electrotechnology applications in operation. Technical seminars and training will be provided to promote the virtues of electrotechnologies for heating and melting applications.

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-2	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$100,000	$2,303,000	$0
1996	3	3	$104,000	$2,395,120	$7,497,360
1997	11	14	$108,160	$2,490,925	$36,062,710
1998	33	47	$112,486	$2,590,562	$125,468,452
1999	54	101	$116,986	$2,694,184	$278,429,828
2000	52	153	$121,665	$2,801,952	$435,025,236
2001	50	203	$126,532	$2,914,030	$597,874,690
2002	48	251	$131,593	$3,030,591	$766,994,805
2003	46	297	$136,857	$3,151,815	$942,384,477
2004	44	341	$142,331	$3,277,887	$1,124,022,031
2005	43	384	$148,024	$3,409,003	$1,315,422,184
2006	41	425	$153,945	$3,545,363	$1,513,091,020

One-Time Environmental Savings	*$100,000*
Annual Productivity, O&M, Fuel Savings	*$2,303,000*
Escalation Rate	*4%*

INDUSTRIAL ELECTROTECHNOLOGIES

Overview

The Process-Specific Electrification program promotes select electrotechnologies (freeze concentration, reverse osmosis, vacuum slot heating and drying, and electrolytics) that represent niche opportunities for beneficial electrification. These electrotechnologies also allow customers to maintain and even enhance their competitiveness by lowering operating and maintenance costs, increasing productivity, allowing for increased operating flexibility, and by helping them to position their facilities for long-term environmental compliance.

Within this program, the customer is provided a complete menu of technologies to select from when determining the most appropriate solution to meet their needs. This program concept has applicability to a large part of the industrial sector, but will focus initially on key industrial segments with extensive process-specific electrification requirements. A pilot program is recommended to gain experience and to conduct market research in order to refine estimates of market potential and cost-effectiveness.

Target Markets

Target markets with corresponding niche opportunities for electrotechnologies include: Food and Kindred Products (SIC 20), Freeze Concentration and Reverse Osmosis Textiles (SIC 22), Vacuum Slot Heating and Drying Chemicals (SIC 28), Primary Metals (SIC 33), and Fabricated Metals (SIC 34) for electrolytics.

Implementation Strategy

TVA does not plan to use any prescriptive or customized rebates for the program. Each electrotechnology will be promoted based on its potential to offer practical solutions to each customer's problems. The Process-Specific Electrification program should be marketed to enhance customer competitiveness. The introduction of niche technologies that allow incremental gains in overall productivity assumes an extensive screening for opportunities. Understanding the customer's need for favorable paybacks on capital outlays, TVA will consider offering a customized rate and customer financing.

The program would be delivered jointly by TVA and participating power distributors. TVA will supply industrial specialists to assist distributor served industrial customers. The success of the program will depend upon TVA's ability to identify and target the most appropriate markets for this program and will require open, two-way communication with distributors and trade allies.

Promotional Strategies

The program will be marketed via a program brochure and personalized one-on-one marketing visits with potential program participants. Where possible, TVA will establish customer showcases that allow other customers the opportunity to witness successful electrotechnology applications in operation. Technical seminars and training will be provided to promote the virtues of electrotechnologies for heating and melting applications. Presentations should be made at industry trade organizations and to trade allies to promote program awareness.

Industrial Electrotechnologies/Food Processing

Program Assumptions

Package Measure Life (Years)	18
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	50%
Annual Energy Impact (kWh)	(12,044,480)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	35	—	—	0%
2	35	1	1	1%
3	88	1	2	1%
4	175	3	5	2%
5	173	3	8	2%
6	171	3	11	2%
7	170	3	14	2%
8	168	3	17	2%
9	166	3	20	2%
10	165	3	23	2%
11	163	3	26	2%
12	161	3	29	2%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$4,730,000 Total Part. Measure Cost	$0 Total Part. Incentive
1	$102,500	$0	$0	$0
2	$102,500	$0	$4,730,000	$0
3	$102,500	$0	$4,730,000	$0
4	$102,500	$0	$14,190,000	$0
5	$102,500	$0	$14,190,000	$0
6	$102,500	$0	$14,190,000	$0
7	$102,500	$0	$14,190,000	$0
8	$102,500	$0	$14,190,000	$0
9	$102,500	$0	$14,190,000	$0
10	$102,500	$0	$14,190,000	$0
11	$102,500	$0	$14,190,000	$0
12	$102,500	$0	$14,190,000	$0

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-3A	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$2,400,000	$8,410,000	$0
1996	1	1	$2,496,000	$8,746,400	$11,242,400
1997	1	2	$2,595,840	$9,096,256	$20,788,352
1998	3	5	$2,699,674	$9,460,106	$55,399,552
1999	3	8	$2,807,661	$9,838,510	$87,131,063
2000	3	11	$2,919,967	$10,232,051	$121,312,462
2001	3	14	$3,036,766	$10,641,333	$158,088,960
2002	3	17	$3,158,236	$11,066,986	$197,613,470
2003	3	20	$3,284,566	$11,509,666	$240,047,018
2004	3	23	$3,415,948	$11,970,052	$285,559,040
2005	3	26	$3,552,586	$12,448,854	$334,327,962
2006	3	29	$3,694,690	$12,946,809	$386,541,531

One-Time Environmental Savings	*$2,400,000*
Annual Productivity, O&M, Fuel Savings	*$8,410,000*
Escalation Rate	*4%*

Industrial Electrotechnologies/Textiles

Program Assumptions

Package Measure Life	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	25%
Annual Energy Impact (kWh)	(280,000)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	23	—	—	0%
2	23	0	0	1%
3	92	2	2	1%
4	183	3	5	2%
5	181	6	11	2%
6	176	9	20	3%
7	169	8	28	3%
8	162	8	36	4%
9	156	8	44	4%
10	150	7	51	4%
11	144	7	58	4%
12	138	7	65	4%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$76,000 Total Part. Measure Cost	$0 Total Part. Incentive
1	$102,500	$0	$0	$0
2	$102,500	$0	$0	$0
3	$102,500	$0	$152,000	$0
4	$102,500	$0	$228,000	$0
5	$102,500	$0	$456,000	$0
6	$102,500	$0	$684,000	$0
7	$102,500	$0	$608,000	$0
8	$102,500	$0	$608,000	$0
9	$102,500	$0	$608,000	$0
10	$102,500	$0	$532,000	$0
11	$102,500	$0	$532,000	$0
12	$102,500	$0	$532,000	$0

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-3B	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$38,000	$607,000	$0
1996	0	0	$39,520	$631,280	$0
1997	2	2	$41,101	$656,531	$1,395,264
1998	3	5	$42,745	$682,792	$3,413,960
1999	6	11	$44,455	$710,104	$7,811,144
2000	9	20	$46,233	$738,508	$15,186,257
2001	8	28	$48,082	$768,049	$21,505,372
2002	8	36	$50,005	$798,771	$28,753,596
2003	8	44	$52,006	$830,721	$36,551,724
2004	7	51	$54,086	$863,950	$44,061,450
2005	7	58	$56,249	$898,508	$52,113,464
2006	7	65	$58,499	$934,449	$61,148,678

One-Time Environmental Savings	*$38,000*
Annual Productivity, O&M, Fuel Savings	*$607,000*
Escalation Rate	*4%*

Industrial Electrotechnologies/Chemicals and Metals

Program Assumptions

Package Measure Life	20
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	25%
Annual Energy Impact (kWh)	(705,536)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	60	—	—	0%
2	60	1	1	1%
3	150	2	3	1%
4	300	4	7	1%
5	298	4	11	1%
6	295	4	15	1%
7	293	5	20	1%
8	291	6	26	2%
9	288	6	32	2%
10	285	6	38	2%
11	282	6	44	2%
12	279	6	50	2%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$328,000 Total Part. Measure Cost	$0 Total Part. Incentive
1	$102,500	$0	$0	$0
2	$102,500	$0	$328,000	$0
3	$102,500	$0	$656,000	$0
4	$102,500	$0	$1,312,000	$0
5	$102,500	$0	$1,312,000	$0
6	$102,500	$0	$1,312,000	$0
7	$102,500	$0	$1,640,000	$0
8	$102,500	$0	$1,968,000	$0
9	$102,500	$0	$1,968,000	$0
10	$102,500	$0	$1,968,000	$0
11	$102,500	$0	$1,968,000	$0
12	$102,500	$0	$1,968,000	$0

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-3C	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$328,299	$2,011,000	$0
1996	1	1	$341,431	$2,091,440	$2,432,871
1997	2	3	$355,088	$2,175,098	$7,235,470
1998	4	7	$369,292	$2,262,102	$17,311,882
1999	4	11	$384,063	$2,352,586	$27,414,698
2000	4	15	$399,426	$2,446,689	$38,298,039
2001	5	20	$415,403	$2,544,557	$52,968,155
2002	6	26	$432,019	$2,646,339	$68,804,814
2003	6	32	$449,300	$2,752,192	$90,765,944
2004	6	38	$467,272	$2,862,280	$111,570,272
2005	6	44	$485,963	$2,976,771	$133,893,702
2006	6	50	$505,401	$3,095,842	$157,824,506

One-Time Environmental Savings	*$328,299*
Annual Productivity, O&M, Fuel Savings	*$2,011,000*
Escalation Rate	*4%*

ENVIRONMENTAL TECHNOLOGIES

Overview

The Environmental Technology Solutions program will promote select environmental compliance technologies (ultrafiltration, nanofiltration, ozonation, and reverse osmosis) to assist industrial and commercial customers to address air and water regulation and by helping them to position their facilities for long-term environmental compliance. These electrotechnologies also allow customers to maintain and even enhance their competitiveness by reducing operating and maintenance costs and by enhancing product quality.

Within this program, the customer is provided a complete menu of technologies from which to chose in determining the most appropriate solution to meet its needs. This option concept is applicable to a large part of the industrial sector, but will focus initially on key industrial segments with extensive environmental problems. A pilot program is recommended to gain experience and to conduct market research in order to refine estimates of market potential and cost effectiveness.

Target Markets

Target markets for the initial pilot will include: Municipal Waste Water Treatment Facilities (SIC 49); Select Commercial Institutions, Food and Kindred Products (SIC 20); Textiles (SIC 22); Chemicals (SIC 28); Primary Metals (SIC 33); Fabricated Metals (SIC 34); and Electronic Equipment (SIC 36).

Implementation Strategy

TVA does not plan to use any prescriptive or customized rebates for the program. Each environmental electrotechnology will be promoted on its own merits, in terms of improving product quality and addressing long-term environmental compliance. Each technology should offer a practical long-term solution to an individual customer's problems.

It is suggested that TVA consider financing options to assist in the purchase of these technologies. TVA should also consider tailored collaboration projects with EPRI to secure leveraging of federal funds for process improvement projects.

The program would be delivered jointly by TVA and participating power distributors. TVA would supply industrial specialists to assist distributor served industrial customers. The success of the program will depend upon TVA's ability to identify and target the most appropriate markets for this program. This effort will require open, two-way communication with distributors and trade allies.

Program Assumptions

Package Measure Life (Years)	14
Free-Rider Rate	0%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	50%
Annual Energy Impact (kWh)	(1,537,918)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	144	—	—	0%
2	144	1	1	1%
3	432	6	7	1%
4	860	13	20	1%
5	852	13	33	1%
6	844	13	46	1%
7	837	13	59	1%
8	829	16	75	2%
9	820	17	92	2%
10	809	16	108	2%
11	800	16	124	2%
12	790	16	140	2%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$1,560,000 Total Part. Measure Cost	$0 Total Part. Incentive
1	$295,000	$0	$0	$0
2	$295,000	$0	$1,560,000	$0
3	$295,000	$0	$9,360,000	$0
4	$295,000	$0	$20,280,000	$0
5	$342,500	$0	$20,280,000	$0
6	$342,500	$0	$20,280,000	$0
7	$342,500	$0	$20,280,000	$0
8	$342,500	$0	$24,960,000	$0
9	$342,500	$0	$26,520,000	$0
10	$342,500	$0	$24,960,000	$0
11	$342,500	$0	$24,960,000	$0
12	$342,500	$0	$24,960,000	$0

Promotional Strategies

The program will be promoted via brochures outlining state-specific regulations/compliance issues, as well as technology solutions. TVA will take into consideration each state's specific regulations. Technical seminars and training will be provided to promote electrotechnology solutions to environmental problems.

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-4	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$3,100,000	$1,904,000	$0
1996	1	1	$3,224,000	$1,980,160	$5,204,160
1997	6	7	$3,352,960	$2,059,366	$34,533,322
1998	13	20	$3,487,078	$2,141,741	$88,166,834
1999	13	33	$3,626,562	$2,227,411	$120,649,869
2000	13	46	$3,771,624	$2,316,507	$155,590,434
2001	13	59	$3,922,489	$2,409,167	$193,133,210
2002	16	75	$4,079,389	$2,505,534	$259,770,197
2003	17	92	$4,242,564	$2,605,755	$307,610,484
2004	16	108	$4,412,267	$2,709,986	$363,274,760
2005	16	124	$4,588,757	$2,818,385	$422,899,852
2006	16	140	$4,772,308	$2,931,121	$486,713,868

One-Time Environmental Savings	*$3,100,000*
Annual Productivity, O&M, Fuel Savings	*$1,904,000*
Escalation Rate	*4%*

COMMERCIAL SPACE CONDITIONING AND WATER HEATING

Overview

Beneficial water heating and space conditioning electrotechnologies will be promoted to new and existing commercial customers. The Commercial Space Conditioning and Water Heating option would promote technologies which overlap with measures being offered in the commercial energy efficiency options (heat pump water heaters [15kBtuh, 50kBtuh, &100kBtuh], air-source heat pumps, and dual-fuel heat pumps). In addition, the program will promote new water chillers designed to comply with ozone depletion regulations.

The Commercial Space Conditioning and Water Heating option will be designed to avoid overt load building. For example, it would be promoted through trade allies, thereby targeting customers already considering an equipment purchase, rather than actively encouraging customers to switch fuels to electricity. In addition, this option will only promote high-efficiency equipment using the same efficiency standards as the commercial energy efficiency options.

Target Market

The program will target customers replacing failed non-electric water heaters, space conditioning equipment, and/or adding air conditioning. Some technologies will be targeted to specific business types. For example, chillers will be targeted to large office buildings, schools/colleges, hospitals, and government facilities. Heat pumps will be targeted to small office buildings, restaurants, and retail establishments.

Implementation Strategy

The program will be offered in participating distributor service areas. It will be delivered through architects and engineers, and HVAC/plumbing contractors. TVA should provide trade allies with technical materials that inform potential purchasers of the benefit of replacing non-electric equipment with high-efficiency electric alternatives. To encourage contractors to educate customers, TVA will provide incentive payments to dealers. Heat pump incentives would match those of the energy efficiency options. For chillers, TVA would also provide analysis/design incentives that would reimburse owners for the cost of economic/feasibility studies.

TVA will maintain a flexible posture concerning the level of aggressiveness with which it promotes the program. Changes in market or resource conditions may warrant revising some elements of the program or terminating it completely.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	(8,329)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	25,252	2,525	2,525	10%
2	25,252	2,525	5,050	10%
3	25,252	2,525	7,575	10%
4	25,252	2,525	10,100	10%
5	25,252	2,525	12,625	10%
6	25,252	2,525	15,150	10%
7	25,252	2,525	17,675	10%
8	25,252	2,525	20,200	10%
9	25,252	2,525	22,725	10%
10	25,252	2,525	25,250	10%
11	25,252	2,525	27,775	10%
12	25,252	2,525	30,300	10%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$1,525 Total Variable Admin. Cost	$7,920 Total Part. Measure Cost	$70 Total Part. Incentive
1	$624,000	$3,850,625	$19,998,000	$176,750
2	$624,000	$3,850,625	$19,998,000	$176,750
3	$624,000	$3,850,625	$19,998,000	$176,750
4	$624,000	$3,850,625	$19,998,000	$176,750
5	$624,000	$3,850,625	$19,998,000	$176,750
6	$624,000	$3,850,625	$19,998,000	$176,750
7	$624,000	$3,850,625	$19,998,000	$176,750
8	$624,000	$3,850,625	$19,998,000	$176,750
9	$624,000	$3,850,625	$19,998,000	$176,750
10	$624,000	$3,850,625	$19,998,000	$176,750
11	$624,000	$3,850,625	$19,998,000	$176,750
12	$624,000	$3,850,625	$19,998,000	$176,750

Promotional Strategies

Promotional efforts will emphasize personal contact between TVA and key equipment installers/decision-makers. The program should also be promoted through presentations and seminars to professional organizations such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. Technical seminars and training would be provided to educate trade allies and explain program operating detail. In addition, the program should feature cooperative advertising and point-of-purchase information and displays.

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-5	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	2,525	2,525	$0	$3,000	$7,575,000
1996	2,525	5,050	$0	$3,120	$15,756,000
1997	2,525	7,575	$0	$3,245	$24,580,875
1998	2,525	10,100	$0	$3,375	$34,087,500
1999	2,525	12,625	$0	$3,510	$44,313,750
2000	2,525	15,150	$0	$3,650	$55,297,500
2001	2,525	17,675	$0	$3,796	$67,094,300
2002	2,525	20,200	$0	$3,948	$79,749,600
2003	2,525	22,725	$0	$4,106	$93,308,850
2004	2,525	25,250	$0	$4,270	$107,817,500
2005	2,525	27,775	$0	$4,441	$123,348,775
2006	2,525	30,300	$0	$4,618	$139,925,400

One-Time Environmental Savings	*$0*
Annual Productivity, O&M, Fuel Savings	*$3,000*
Escalation Rate	*4%*

COMMERCIAL COOKING AND SECURITY LIGHTING

Overview

Beneficial electrotechnologies addressing security lighting will be promoted among customers where appropriate. In this program the following technologies would be promoted:

- High pressure sodium (HPS) security lighting
- Cooking—convection oven
- Cooking—high-efficiency fryer

Target Markets

These technologies will be promoted among a narrow range of customers. Security lighting will be promoted among retail customers and restaurants, where the technology can provide high value to customers by improving safety in walkways and parking lots. Cooking would be promoted among restaurants and hotels. Convection ovens provide value and efficiency by distributing heat more evenly in less time. High-efficiency fryers with their better insulation reduce heat loss through the bottom of the fry pot.

Delivery Strategy

Security lighting and cooking will be delivered differently. TVA, in conjunction with power distributors, will purchase HPS lamps. Power distributors would install them in targeted geographical areas and recover costs through a leasing arrangement.

Cooking technologies would be delivered through retail vendors such as restaurant supply outlets. TVA will develop a list of qualifying equipment manufacturers and recruit vendors to participate in the program. Vendors will procure approved equipment through their own distribution channels. To encourage customers to purchase electric equipment, TVA will offer customer financing. Vendors will be expected to perform the following functions:

- Promote equipment via promotional material developed by TVA
- Maintain record of equipment sales (both electric and gas) to track participation and penetration

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	0%
Free-Driver Rate	10%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	25%
Annual Energy Impact (kWh)	(9,470)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	109,238	550	550	1%
2	109,228	550	1,100	1%
3	109,218	550	1,650	2%
4	109,208	550	2,200	2%
5	109,198	1,100	3,300	3%
6	109,188	1,100	4,400	4%
7	109,178	1,100	5,500	5%
8	109,168	1,100	6,600	6%
9	109,158	1,100	7,700	7%
10	109,148	1,100	8,800	8%
11	109,139	1,100	9,900	9%
12	109,129	1,100	11,000	10%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$13 Total Variable Admin. Cost	$2,292 Total Part. Measure Cost	$0 Total Part. Incentive
1	$410,000	$7,150	$1,260,600	$0
2	$375,000	$7,150	$1,260,600	$0
3	$350,000	$7,150	$1,260,600	$0
4	$350,000	$7,150	$1,260,600	$0
5	$350,000	$14,300	$2,521,200	$0
6	$350,000	$14,300	$2,521,200	$0
7	$350,000	$14,300	$2,521,200	$0
8	$350,000	$14,300	$2,521,200	$0
9	$350,000	$14,300	$2,521,200	$0
10	$350,000	$14,300	$2,521,200	$0
11	$350,000	$14,300	$2,521,200	$0
12	$350,000	$14,300	$2,521,200	$0

Promotional Strategies

For security lighting, TVA and power distributors will emphasize direct mail, telemarketing, and face-to-face contact in targeted areas. In addition, TVA will make presentations and provide displays to regional retail chains and to local chambers of commerce, security organizations, etc. Promotional materials would illustrate how lighting can improve customer security. Materials will also discuss the low operating costs of HPS lamps.

Cooking equipment will be marketed through direct contact with restaurants and hotels. In addition, cooking supply outlets will be provided with information and encouraged to promote electric technologies among their customers. Sample equipment used to demonstrate the quality of electric cooked food should be made available to large vendors and at trade shows. TVA will develop point-of-purchase information and displays for participating vendors.

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-6	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	550	550	$0	$3,000	$1,650,000
1996	550	1,100	$0	$3,120	$3,432,000
1997	550	1,650	$0	$3,245	$5,354,250
1998	550	2,200	$0	$3,375	$7,425,000
1999	1,100	3,300	$0	$3,510	$11,583,000
2000	1,100	4,400	$0	$3,650	$16,060,000
2001	1,100	5,500	$0	$3,796	$20,878,000
2002	1,100	6,600	$0	$3,948	$26,056,800
2003	1,100	7,700	$0	$4,106	$31,616,200
2004	1,100	8,800	$0	$4,270	$37,576,000
2005	1,100	9,900	$0	$4,441	$43,965,900
2006	1,100	11,000	$0	$4,618	$50,798,000

One-Time Environmental Savings	*$0*
Annual Productivity, O&M, Fuel Savings	*$3,000*
Escalation Rate	*4%*

RESIDENTIAL HVAC AND WATER HEATING

Overview

This option promotes beneficial water heating and space conditioning electrotechnologies to new and existing residential customers. The Residential HVAC and Water Heating option promotes the following energy-efficient technologies: heat pump water heaters; air-source heat pumps with heat recovery; ground-source heat pumps with heat recovery; and dual-fuel heat pumps with heat recovery

Program features would be similar to the residential energy efficiency option. However, participation and impact levels would be tracked separately. Installations through this option would represent added load. Impacts among participants without air conditioning may represent the full requirements of a SEER 12 air-source heat pump. Impacts for participants that previously had air conditioning but no electric heat would represent the winter heat pump load requirements. In contrast, the energy efficiency option impacts would represent the energy and demand savings achieved by installing the high-efficiency measure rather than the standard efficiency replacement.

The Residential HVAC and Water Heating option is designed to avoid overt load building. For example, it would be promoted through trade allies to customers already considering an equipment purchase, rather than actively encouraging customers to switch from another fuel to electricity. The program will use the same efficiency standards as the related energy efficiency option, and both options will offer similar services and incentives.

Target Markets

The program would target customers replacing failed nonelectric water heaters, space conditioning equipment, and/or adding air conditioning.

Delivery Strategy

The program would be delivered through HVAC/plumbing contractors. TVA should provide trade allies with technical/educational materials that inform potential purchasers of the benefits of replacing non-electric equipment with high-efficiency electric alternatives. To encourage contractors to educate customers, TVA would provide incentive payments to dealers. Heat pump incentives will match those provided under the energy efficiency options. In addition, incentives will be provided to encourage dealers to promote heat pump water heaters.

TVA will maintain a flexible posture concerning the level of aggressiveness with which it promotes this option. Changes in market or resource conditions may warrant revising some elements of the program or terminating it completely.

Program Assumptions

Package Measure Life (Years)	15
Free-Rider Rate	10%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	50%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	(2,935)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	84,376	8,440	8,440	10%
2	84,376	8,440	16,880	10%
3	84,376	8,440	25,320	10%
4	84,376	8,440	33,760	10%
5	84,376	8,440	42,200	10%
6	84,376	8,440	50,640	10%
7	84,376	8,440	59,080	10%
8	84,376	8,440	67,520	10%
9	84,376	8,440	75,960	10%
10	84,376	8,440	84,400	10%
11	84,376	8,440	92,840	10%
12	84,376	8,440	101,280	10%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
		$25	$2,900	$230
Year	Fixed Administrative Cost	Total Variable Admin. Cost	Total Part. Measure Cost	Total Part. Incentive
1	$624,000	$211,000	$24,476,000	$1,914,200
2	$624,000	$211,000	$24,476,000	$1,914,200
3	$624,000	$211,000	$24,476,000	$1,914,200
4	$624,000	$211,000	$24,476,000	$1,914,200
5	$624,000	$211,000	$24,476,000	$1,914,200
6	$624,000	$211,000	$24,476,000	$1,914,200
7	$624,000	$211,000	$24,476,000	$1,914,200
8	$624,000	$211,000	$24,476,000	$1,914,200
9	$624,000	$211,000	$24,476,000	$1,914,200
10	$624,000	$211,000	$24,476,000	$1,914,200
11	$624,000	$211,000	$24,476,000	$1,914,200
12	$624,000	$211,000	$24,476,000	$1,914,200

Promotional Strategies

Trade allies represent a key source of program promotion. The program will feature cooperative advertising and point-of-purchase display materials. In addition, training will be provided to educate trade allies and explain program operating details.

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-7	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	8,440	8,440	$0	$1,000	$8,440,000
1996	8,440	16,880	$0	$1,040	$17,555,200
1997	8,440	25,320	$0	$1,082	$27,376,240
1998	8,440	33,760	$0	$1,125	$37,980,000
1999	8,440	42,200	$0	$1,170	$49,374,000
2000	8,440	50,640	$0	$1,217	$61,628,880
2001	8,440	59,080	$0	$1,265	$74,736,200
2002	8,440	67,520	$0	$1,316	$88,856,320
2003	8,440	75,960	$0	$1,369	$103,989,240
2004	8,440	84,400	$0	$1,423	$120,101,200
2005	8,440	92,840	$0	$1,480	$137,403,200
2006	8,440	101,280	$0	$1,539	$155,869,920

One-Time Environmental Savings	*$0*
Annual Productivity, O&M, Fuel Savings	*$1,000*
Escalation Rate	*4%*

RESIDENTIAL SECURITY LIGHTING AND LAWN MOWERS

Overview

Beneficial electrification technologies addressing security lighting and lawn maintenance would be promoted among customers where appropriate. The following technologies would be promoted in this program: high pressure sodium (HPS) security lighting, cordless electric lawn mowers, and electric cord lawn mowers.

These technologies can provide high value to certain customers. Security lighting meets a growing concern for safety, and does it in a highly efficient manner. In the past, customers wanting to receive the benefits of security lighting had to pay relatively high operating costs associated with mercury vapor lamps.

Lawn mowing with traditional gasoline-powered engines has recently been identified by the U.S. Environmental Protection Agency as a major source of air pollution. While significant improvements have been made in reducing automobile emissions, lawn mowers remain a totally uncontrolled source.

Target Markets

These technologies would be promoted among a relatively narrow range of customers. Security lighting would be promoted in rural and high crime areas. Lawn mowers would be promoted among urban and suburban customers in the market to replace existing equipment.

Delivery Strategy

Program delivery would be handled differently for security lighting and lawn mowers. TVA and/or power distributors would purchase HPS lamps. Power distributors would install them in geographically targeted areas. Distributors would recover costs through a leasing arrangement with the customer.

The lawn mowing component would be delivered through retail vendors such as Home Depot, Sears, hardware stores, etc. TVA would provide vendors with point-of-purchase educational materials designed to persuade the customer to purchase the electric mower rather than a gasoline-powered mower. TVA should develop a list of qualifying equipment manufacturers and recruit vendors to participate in the program. Vendors will use the list to procure equipment through their own distribution channels.

Program Assumptions

Package Measure Life (Years)	8
Free-Rider Rate	0%
Free-Driver Rate	10%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	(196)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,955,150	14,775	14,775	1%
2	2,955,140	14,775	29,550	1%
3	2,955,130	14,775	44,325	2%
4	2,955,120	14,775	59,100	2%
5	2,955,110	29,550	88,650	3%
6	2,955,101	29,550	118,200	4%
7	2,955,091	29,550	147,750	5%
8	2,955,081	29,550	177,300	6%
9	2,955,071	29,550	206,850	7%
10	2,955,061	29,550	236,400	8%
11	2,955,051	29,550	265,950	9%
12	2,955,041	29,550	295,500	10%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$13 Total Variable Admin. Cost	$220 Total Part. Measure Cost	$0 Total Part. Incentive
1	$410,000	$192,075	$3,250,500	$0
2	$375,000	$192,075	$3,250,500	$0
3	$350,000	$192,075	$3,250,500	$0
4	$350,000	$192,075	$3,250,500	$0
5	$350,000	$384,150	$6,501,000	$0
6	$350,000	$384,150	$6,501,000	$0
7	$350,000	$384,150	$6,501,000	$0
8	$350,000	$384,150	$6,501,000	$0
9	$350,000	$384,150	$6,501,000	$0
10	$350,000	$384,150	$6,501,000	$0
11	$350,000	$384,150	$6,501,000	$0
12	$350,000	$384,150	$6,501,000	$0

Promotional Strategies

Security lighting will be promoted through direct mail, telemarketing, and face-to-face contact. Promotional materials will illustrate how lights improve customer security. Vendors will be the key source of promotion for lawn mowers. This component of the program would feature cooperative advertising and point-of-purchase information developed by TVA. In addition, educational materials will be developed to discuss the environmental and other benefits of electric lawn mowers.

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-8	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	14,775	14,775	$0	$0	$0
1996	14,775	29,550	$0	$0	$0
1997	14,775	44,325	$0	$0	$0
1998	14,775	59,100	$0	$0	$0
1999	29,550	88,650	$0	$0	$0
2000	29,550	118,200	$0	$0	$0
2001	29,550	147,750	$0	$0	$0
2002	29,550	177,300	$0	$0	$0
2003	29,550	206,850	$0	$0	$0
2004	29,550	236,400	$0	$0	$0
2005	29,550	265,950	$0	$0	$0
2006	29,550	295,500	$0	$0	$0

One-Time Environmental Savings	*$0*
Annual Productivity, O&M, Fuel Savings	*$0*
Escalation Rate	*4%*

ELECTRIC TRANSPORTATION

Overview

The Electric Transportation option promotes select technologies (electric bus, electric fleet van, and electric cars) to assist all customer segments in reducing emissions and improving the environment in the TVA region. These technologies offer participating customers reduced operating and maintenance costs.

There are several market barriers related to this option that must be considered. This option represents a "cutting edge" strategy in promoting and accelerating the commercialization of this technology. The electric vehicle technology has not advanced to a high confidence level; in fact, it currently has reached a plateau and a technology breakthrough is required to instill enthusiasm and confidence into the marketplace.

Within the option, customers are offered a select menu of electrotechnologies from which to choose in determining the most appropriate solution to meet their needs. Electric buses and vans will target commercial, industrial, and municipal customers. Electric cars will target residential customers in select areas. A pilot program is recommended to gain experience in administering such a program. In addition, a pilot offers minimal risks to TVA and allows the evaluation of specific technologies and development of the optimal program delivery mechanisms.

Target Markets

Target markets pursued in the initial pilot include select geographic areas and markets within the industrial, commercial, residential, and municipal sectors.

Delivery Strategy

TVA does not plan to offer rebates as part of the program. The program and its technology options will be marketed as an innovative technology. TVA may consider financing or a technology-specific rate to stimulate consumer interest.

Program delivery will be administered through TVA marketing representatives and specific in-house technical staff working with power distributors and various trade allies/professionals. TVA should hire/develop an industry expert (transportation) for technical support of the program. TVA should also consider teaming up with trade professionals (equipment sales engineers and representatives) to assist in customer education and awareness. Coordination with the listed trade professionals from initial program design through program roll-out is essential to program success.

Electric Transportation/Electric Buses

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	20%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	(32,500)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	100	—	—	0%
2	500	5	5	1%
3	995	20	25	3%
4	975	29	54	6%
5	946	29	83	9%
6	917	27	110	12%
7	890	27	137	15%
8	863	26	163	19%
9	837	25	188	22%
10	812	24	212	26%
11	788	24	236	30%
12	764	23	259	34%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
		$0	$200,000	$0
Year	**Fixed Administrative Cost**	**Total Variable Admin. Cost**	**Total Part. Measure Cost**	**Total Part. Incentive**
1	$88,333	$0	$0	$0
2	$88,333	$0	$1,000,000	$0
3	$88,333	$0	$4,000,000	$0
4	$88,333	$0	$5,800,000	$0
5	$117,500	$0	$5,800,000	$0
6	$117,500	$0	$5,400,000	$0
7	$117,500	$0	$5,400,000	$0
8	$117,500	$0	$5,200,000	$0
9	$117,500	$0	$5,000,000	$0
10	$117,500	$0	$4,800,000	$0
11	$117,500	$0	$4,800,000	$0
12	$117,500	$0	$4,600,000	$0

Promotional Strategies

The program will be promoted via program brochures and marketing materials to permit widespread awareness of the program and its electric technologies. Technical seminars and training will be provided to educate potential customers concerning the virtues of electric vehicles and corresponding customer benefits. Presentations will be made at various industry and general public meetings to further promote this option.

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-9A	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$0	$6,000	$0
1996	5	5	$0	$6,240	$31,200
1997	20	25	$0	$6,490	$162,250
1998	29	54	$0	$6,749	$364,446
1999	29	83	$0	$7,019	$582,577
2000	26	110	$0	$7,300	$803,000
2001	27	137	$0	$7,592	$1,040,104
2002	26	163	$0	$7,896	$1,287,048
2003	25	188	$0	$8,211	$1,543,688
2004	24	212	$0	$8,540	$1,810,480
2005	24	236	$0	$8,881	$2,095,916
2006	23	259	$0	$9,237	$2,392,383

One-Time Environmental Savings	*$0*
Annual Productivity, O&M, Fuel Savings	*$6,000*
Escalation Rate	*4%*

Electric Transportation/Fleet Vehicles

Program Assumptions

Package Measure Life (Years)	20
Free-Rider Rate	20%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	40%
Annual Energy Impact (kWh)	(7,800)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	500	—	—	0%
2	500	5	5	1%
3	1,998	30	35	2%
4	3,972	60	95	2%
5	3,924	82	177	5%
6	3,858	62	239	6%
7	3,809	61	300	8%
8	3,760	41	341	9%
9	3,727	41	382	10%
10	3,694	41	423	11%
11	3,662	40	463	13%
12	3,630	40	503	14%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$18,000 Total Part. Measure Cost	$0 Total Part. Incentive
1	$88,333	$0	$0	$0
2	$88,333	$0	$90,000	$0
3	$88,333	$0	$540,000	$0
4	$88,333	$0	$1,080,000	$0
5	$117,500	$0	$1,476,000	$0
6	$117,500	$0	$1,116,000	$0
7	$117,500	$0	$1,098,000	$0
8	$117,500	$0	$738,000	$0
9	$117,500	$0	$738,000	$0
10	$117,500	$0	$738,000	$0
11	$117,500	$0	$720,000	$0
12	$117,500	$0	$720,000	$0

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-9B	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$0	$200	$0
1996	5	5	$0	$208	$1,040
1997	30	35	$0	$216	$7,560
1998	60	95	$0	$225	$21,375
1999	82	177	$0	$234	$41,418
2000	62	239	$0	$243	$58,077
2001	61	300	$0	$253	$75,900
2002	41	341	$0	$263	$89,683
2003	41	382	$0	$274	$104,688
2004	41	423	$0	$285	$120,555
2005	40	463	$0	$296	$137,048
2006	40	503	$0	$308	$154,924

One-Time Environmental Savings	*$0*
Annual Productivity, O&M, Fuel Savings	*$200*
Escalation Rate	*4%*

Electric Transportation/Electric Autos

Program Assumptions

Package Measure Life (Years)	10
Free-Rider Rate	30%
Free-Driver Rate	0%
Dropouts	0%
Take-Back Percentage	0%
Free-Rider Market Barrier Costs Eliminated	0%
Non-Free-Rider Market Barrier Costs Eliminated	75%
Annual Energy Impact (kWh)	(3,000)

Year	Annual Eligible Population	New Participants	Total Participants	Cumulative Participation Rate
1	2,000	—	—	0%
2	2,000	10	10	1%
3	9,995	50	60	1%
4	19,940	199	259	1%
5	19,741	197	457	2%
6	19,543	195	652	3%
7	19,348	193	845	4%
8	19,154	192	1,037	5%
9	18,963	190	1,227	6%
10	18,773	188	1,415	8%
11	18,585	186	1,600	9%
12	18,400	184	1,784	10%

		Per Participant Variable Administrative Costs	Per Participant Measure Cost	Per Participant Incentive
Year	Fixed Administrative Cost	$0 Total Variable Admin. Cost	$25,000 Total Part. Measure Cost	$0 Total Part. Incentive
1	$88,333	$0	$0	$0
2	$88,333	$0	$250,000	$0
3	$88,333	$0	$1,250,000	$0
4	$88,333	$0	$4,975,000	$0
5	$117,500	$0	$4,925,000	$0
6	$117,500	$0	$4,875,000	$0
7	$117,500	$0	$4,825,000	$0
8	$117,500	$0	$4,800,000	$0
9	$117,500	$0	$4,750,000	$0
10	$117,500	$0	$4,700,000	$0
11	$117,500	$0	$4,650,000	$0
12	$117,500	$0	$4,600,000	$0

QUALITY GAIN ESTIMATES FOR DSMANAGER VALUE TEST

BE-9C	New Participants	Cumulative Penetration	One-Time Benefit/ Participant	Annual Benefit/ Participant	Quality Gain
1995	0	0	$0	$700	$0
1996	10	10	$0	$728	$7,280
1997	50	60	$0	$757	$45,427
1998	199	259	$0	$787	$203,938
1999	197	457	$0	$819	$374,283
2000	195	652	$0	$852	$555,504
2001	193	845	$0	$886	$748,670
2002	192	1,037	$0	$921	$955,077
2003	190	1,227	$0	$958	$1,175,466
2004	188	1,415	$0	$996	$1,409,340
2005	186	1,600	$0	$1,036	$1,657,874
2006	184	1,784	$0	$1,078	$1,922,470

One-Time Environmental Savings	*$0*
Annual Productivity, O&M, Fuel Savings	*$700*
Escalation Rate	*4%*

TECHNOLOGY INFORMATION

DESCRIPTION OF TECHNOLOGY DATABASE

TVA developed a technology database that includes information on energy efficiency, load management, beneficial electrification, and self/generation and renewable technologies. The data used to develop the technology database included information from several primary and secondary data sources. Hourly simulations for all building types provided data for the weather-dependent technologies.

Development of the database began with a list of technologies that was reviewed for diversity and completeness by two leading DSM consultants. TVA worked with Synergic Resources Corporation (SRC) to develop the energy efficiency portions of the database for the residential, commercial, and industrial sectors. Barakat & Chamberlin, Inc. (BCI) provided information for renewable and beneficial electrification technologies. For some technologies, estimates of costs and impacts were obtained from more than one source. Technology information on small cogeneration systems was provided by Schiller Associates and UNIMAR Group, Ltd.

Technology costs and energy and demand impacts were included for both existing structures and new construction to provide estimates for retrofit and new construction options. Technologies were matched with appropriate base technologies for each market. Base technology energy use and shares were taken from detailed forecast information contained in TVA's files for REEPS (EPRI's Residential End-Use Energy Planning System software) and COMMEND (EPRI's Commercial End-Use Planning System software). Historical residential UECs (Unit Energy Consumption, kWh/yr) are based on conditional demand models using TVA survey and billing data. Some appliance data are based on manufacturers and EPRI estimates, along with other sources. The use of REEPS and COMMEND energy use and shares helped to ensure that technology estimates were consistent with load forecast assumptions. Forecast market shares were based on residential, commercial, and industrial surveys performed by TVA.

Additions and corrections to the database were made based on comments from TVA staff and reviews by the following organizations:

- National Renewable Energy Laboratory (NREL), Golden, Colorado
- TELLUS Institute, Boston, Massachusetts
- E Source, Boulder, Colorado
- TVA Energy Vision 2020 Review Group members and their consultants:
  —Resource Insight, Inc., Middlebury, Vermont
  —Xenergy, Allendale, New Jersey
  —Vermont Energy Investment Corporation, Burlington, Vermont

RESIDENTIAL

Primary data sources included existing saturation surveys, energy audits, end-use load forecasts, and institutional data. Hourly building simulations of prototypical buildings were developed using DOE-2 and TMY (Typical Meteorological Year) weather for Nashville, Tennessee, to estimate energy and demand impacts of HVAC technologies and building shell improvements. DOE-2 is public domain software developed with funding from the U.S. Department of Energy and used internationally to calculate the hourly energy use of buildings and their life cycle costs of operation, given information on building location, construction, operation, and heating and air conditioning systems.

Secondary data sources included Competitek, EPRI reports, energy journals, case studies, other utility filings, ESOURCE reports, manufacturers' literature, and previous work done by SRC and BCI. ESOURCE, formerly known as Competitek, is a proprietary information service and a subsidiary of Rocky Mountain Institute.

As much as possible, the energy impacts have been adjusted to be consistent with TVA's residential end-use forecast.

The residential technologies include electric conservation, load shifting, peak clipping, and beneficial electrification (load building) measures. A summary listing of the DSM technologies is shown in *Figure T7-5*.

The technologies were grouped by end use. The primary end-use catagories considered for the residential sector were: Space Conditioning, Water Heating, Appliance, and Lighting. For each end use, the technologies were mapped to an appropriate base technology and building type. In the residential market, three building types were included: single-family, multi-family, and manufactured homes. Following are descriptions of the technologies considered for each end use.

FIGURE T7-5. Residential Technologies

End-Use	Demand-Side Measure
Space Conditioning Cooling	High-Efficiency Room Air Conditioner
	High-Efficiency Central Air Conditioner (CAC)
	Two-Speed Central Air Conditioner
	Whole-House Fan
	Ceiling Fans
	Servicing Central Air Conditioner
	Central Air Conditioner Cycling or Direct Load Control
Space Conditioning Cool/Heat	High-Efficiency Heat Pump
	Standard Heat Pump
	Two-Speed Heat Pump
	Ground-Source Heat Pump
	Dual-Fuel Heat Pump
	Standard Add-On Heat Pump
	High-Efficiency Add-On Heat Pump
	Electric Heat Direct Load Control
	Insider Heat Pump
	Servicing Heat Pump
Space Conditioning Ducting & Controls	Ducts in Conditioned Spaces
	Reduced Duct Leakage
	Reduced Duct Heat Transfer
	Programmable Thermostat
Space Conditioning Building Shell	Wall Insulation
	Weather Stripping/Caulking
	Window Film/Reflective Glass
	Low-E Glass
	Window Shade Screens
	Reflective Roof Coating
	Attic Radiant Barrier
	Landscape Shading
	Ceiling Insulation
Water Heating	High-Efficiency Electric Resistance
	Integral Heat Pump Water Heater
	Add-On Heat Pump Water Heater
	Maintenance of Heat Pump Water Heater
	Solar Water Heater
	Heat Recovery Water Heater (Desuperheater)
	Instantaneous (Tankless) Electric Water Heater
	Water Heater Tank Wrap
	Water Heater Heat Trap
	Hot Water Pipe Insulation
	Low Flow Showerhead
	Direct Load Control of Electric Resistance
	Bottom Boards
	Standard Efficiency Gas Water Heater
	High-Efficiency Gas Water Heater
Appliances	Best Current Frost-Free Refrigerator
	Remove Second Refrigerator
	Best Current Frost-Free Freezer
	Remove Second Freezer
	Servicing Refrigerator or Freezer (Clean Coils)
	Microwave Clothes Dryer
	Electric Dryer with Moisture Sensor
	Heat Pump Clothes Dryer
	Horizontal-Axis Clothes Dryer
	High-Efficiency Dishwasher
	Induction Cooktop
	Electric Cordless Lawn Mower
	Electric Cord Lawn Mower
	Smart House (Home Automation & Real-Time Pricing)
	High-Efficiency Pool Pumps or Spa Pumps
	Downsized Pool Pumps with Oversized Piping
	Direct Load Control of Pool Pumps
	Pool Pump Timer
Lighting	Compact Fluorescent
	Efficient Incandescent
	Security Lighting
	High Pressure Sodium (Outdoor)
	Halogen Lamp (Outdoor)
	Halogen Lamp (Indoor)
	Motion Detectors for Outdoor Lighting

Residential Space Conditioning

Six prototypical buildings were simulated in DOE-2 with Nashville TMY weather data to develop some of the energy impacts for space conditioning technologies. Energy impacts from simulations of a building with and without a particular technology were combined with REEPS UECs to develop average kWh and kW demand impacts.

In the short descriptions of space conditioning technologies that follow, some abbreviations are used for ratings of equipment. The common rating terms are:

- COP—Coefficient of Performance
- HSPF—Heating Season Performance Factor
- SEER—Seasonal Energy Efficiency Ratio
- R-Value—Insulation Value

Cooling

High-Efficiency Room Air Conditioner—A high-efficiency unit with an Energy Efficiency Ratio (EER) of 11.0 replaces a standard unit with an EER of 8.8.

High-Efficiency Central Air Conditioner—A high-efficiency unit with a SEER of 13.0 and a Coefficient of Performance (COP) of 3.437 replaces a standard unit with a SEER of 10.0 and a COP of 2.570.

Two-Speed Central Air Conditioner—A two-speed unit with a SEER of 14.8 and a COP of 3.074 replaces a standard unit with a SEER of 10.0 and a COP of 2.570. The two-speed unit has better performance than the high-efficiency unit at part load, but has a lower performance at design conditions.

Whole-House Fan—A whole-house fan is installed in new and existing single-family dwellings to reduce cooling energy use. The fan will be sized to provide 20 air changes per hour and will operate when the outdoor air temperature is above 72° F and below 83° F, and when relative humidity is 60 percent or less. When the fan is running, the air conditioning system is turned off.

Ceiling Fans—Ceiling fans will allow cooling thermostat settings to be increased by 2° F in single-family and multi-family dwellings. A ceiling fan will be installed for each 250 square feet of floor area.

Servicing Central Air Conditioner—Annual air conditioner maintenance reduces cooling energy use by 10 percent.

Central Air Conditioner Cycling or Direct Load Control — This measure involves the use of remote transmitters to control residential space cooling systems to reduce peak load by load shedding (turning units off at the time of the utility peak) or cycling (periodically turning units off).

Cool/Heat

High-Efficiency Heat Pump—A high-efficiency air-source heat pump with SEER 13.0 and HSPF 8.1 replaces a standard efficiency heat pump with SEER 10.0 and HSPF 6.8 in new and existing construction. The standard unit has a cooling COP of 2.570 and a heating COP of 2.978. The high-efficiency unit has a cooling COP of 3.437 and a heating COP of 3.540.

Standard Heat Pump—The standard air-source heat pump has a SEER of 10.0 and a HSPF of 6.8 in new and existing construction. The standard unit has a cooling COP of 2.570 and a heating COP of 2.978.

Two-Speed Heat Pump—A heat pump with a two-speed compressor, a SEER of 14.8 and a HSPF of 8.45 replaces a standard heat pump. The heat pump has a cooling COP of 3.074 and a heating COP of 3.430. The primary advantage of the two-speed heat pump is better performance at part load. Part load is between no load and full load. At design conditions (full load), this heat pump is somewhat less efficient than a high-efficiency unit.

Ground-Source Heat Pump—A ground-source heat pump exchanges heat with water in thermal contact with the ground. Ground-source heat pumps can be closed-loop, where water is continuously circulated (while the heat pump is running) between the heat pump and pipes buried in the ground, or they can be open-loop, where water is extracted from a well or lake and dumped after use. A ground-source heat pump replaces a standard efficiency heat pump. For this analysis, only closed-loop systems were considered.

Dual-Fuel Heat Pump—A dual-fuel heat pump is an air-source heat pump with a fossil fuel burner system for back-up heating rather than resistance coils. Estimates were included for a SEER 12 unit.

Standard Add-On Heat Pump—This measure is promoted to households that currently have central air conditioning and gas heat and are approaching the time of replacement of their central air conditioners. In addition to providing cooling, an add-on heat pump would provide heating during the moderate heating season and gas heat would be used as a back-up. The cooling efficiency of the Central Air Conditioner (CAC) and heat pump is SEER 10.0. The gas heating efficiency is 78 percent Annual Fuel Utilization Efficiency (AFUE), and the heat pump heating efficiency is HSPF 6.8.

High-Efficiency Add-On Heat Pump—This measure is similar to the standard add-on heat pump, except a high-efficiency heat pump is promoted, having a SEER 13 and HSPF 8.1. This measure provides heating electrification and cooling conservation.

Electric Heat Direct Load Control—This measure involves the use of remote transmitters to control residential space heat-

ing systems to reduce peak load by load shedding (turning units off at the time of the utility peak) or cycling (periodically turning units off). This measure was only considered for utilities that already have load control programs, meaning the cost of the central transmitter is not included in the estimates.

Insider Heat Pump—Estimates for this particular heat pump were included for manufactured housing.

Servicing Heat Pump—Annual heat pump maintenance reduces cooling energy use by 10 percent and heating energy use by 9.2 percent.

Ducting and Controls

Ducts in Conditioned Spaces—It is common in single-family detached dwellings to have space conditioning ductwork located in unconditioned spaces (primarily the attic). For this measure, the ductwork in new single-family detached dwellings will be located in the conditioned space to eliminate losses associated with duct leakage and duct heat gain/loss.

Reduced Duct Leakage—This measure involves the sealing of space conditioning ducts to eliminate the loss of conditioned air and/or the introduction of attic air into the duct system. An equivalent conditioning system efficiency change was used in DOE-2 to simulate a 70 percent reduction in duct air losses. One-third of this improvement was on the supply-side ducts and two-thirds were on the return side ducts.

Reduced Duct Heat Transfer—This measure involves the addition of insulation to ducting in new single-family detached dwellings. For this measure, it is assumed that additional insulation would be added to increase the duct total insulation level to R-12 from R-6 required by the energy code.

Programmable Thermostat—The programmable thermostat sets the thermostat up 5° F from 9:00 AM to 5:00 PM during weekdays in the cooling season and sets the thermostat down 5° F from 11:00 PM to 6:00 AM for all days during the heating season. The thermostat is assumed to have energy management recovery that allows for early recovery from a setup and involves the automatic calculation of when to begin raising (or lowering) the space temperature to reach the programmed temperature at a preset time.

Building Shell

Wall Insulation—For this measure, wall insulation in existing frame dwellings is increased from R-0 to R-11. This measure only applies to dwellings with no wall insulation.

Weather Stripping/Caulking—Caulking and weather stripping of existing dwellings reduces air infiltration by 10 percent on average. This measure only applies to existing dwellings, as it is assumed that new construction is adequately sealed in accordance with the new construction building code.

Window Film/Reflective Glass—In existing dwellings, a reflective window film is applied to the interior surface of single-pane windows. Double-pane reflective glass is substituted for clear double-pane glass in new construction. This measure is applied to windows facing east and west because the solar gain is highest from these directions.

Low-Emissivity Glass—To represent this class of windows, double-pane glass with an argon gas fill and a low-emissivity coating on the inner surface of the outer pane replaces single- and double-pane clear glass windows. This measure reduces heat transmission through the windows.

Window Shade Screens—For this measure, shade screens that block solar gain are installed on single- and double-pane clear windows in existing and new construction. This measure is applied to windows facing east and west because solar gain is highest from these directions.

Reflective Roof Coating—This measure will involve the application of a reflective coating with an absorptivity of 0.30 to a standard roof with an absorptivity of 0.80 to reduce the cooling loads associated with roof solar gain.

Attic Radiant Barrier—This measure involves the installation of a reflective surface on the bottom of roof joists in new single-family detached construction to reduce solar gain through the roof. The reflective surface will have an emissivity of 0.08 on each side and result in an effective increase in the roof insulation of approximately R-7.

Landscape Shading—This measure involves the planting of six trees, three each on the east and west sides of new and existing single family dwellings, to provide external shading during the cooling season.

Ceiling Insulation (new construction)—This measure involves adding more ceiling insulation (from R-30 to R-38) to new dwellings.

Ceiling Insulation (R-0 to R-19)—In existing dwellings with no ceiling insulation, R-19 would be added.

Ceiling Insulation (R-11 to R-30)—In existing dwellings with R-11 ceiling insulation, R-19 would be added to achieve a total of R-30.

Ceiling Insulation (R-19 to R-30)—In existing dwellings with R-19 ceiling insulation, R-11 would be added to achieve a total of R-30.

Ceiling Insulation (R-30 to R-38)—In existing dwellings with R-30 ceiling insulation, R-8 would be added to achieve a total of R-38.

Residential Water Heating

There are four general types of electric water heating equipment for the residential market:

- Electric resistance water heater
- Heat pump water heater
- Heat recovery water heater (desuperheater)
- Solar water heater

Each type has unique operating and consumption characteristics. The UEC for electric water heating is a combination (weighted average) of these four heating types for each building type. Individual UECs for each technology type were derived by disaggregating the weighted-average UEC (from REEPS) using the relative efficiencies and shares for each technology type. Efficiencies, saturations, and UECs for water heating are shown in *Figures T7-6, T7-7,* and *T7-8.*

Brief descriptions of the residential water heating technologies follow.

High-Efficiency Electric Resistance—Electric resistance water heaters with Efficiency Factors of 0.96 are compared to models that meet federal appliance standards (EF=0.90).

Integral Heat Pump Water Heater—Heat pump water heaters could be installed either to replace electric resistance water heaters or gas water heaters. When an electric resistance water heater is replaced, the electricity used for water heating is reduced by approximately half

FIGURE T7-6. **Electric Water Heating Technologies: Relative Efficiencies**

Water Heater System Type	Annual COP	Normalized COP	Daily Use (kWh)	Percent Savings
Resistance Water Heaters	0.82	1	9.60	0%
Heat Pump Water Heaters	1.53	1.87	5.13	47%
Heat Recovery Water Heaters	1.1	1.34	7.16	25%
Solar Water Heaters	2.35	2.87	3.34	65%

SOURCE: FSEC, 1990. Florida Solar Energy Center, "Electrical Use, Efficiency, and Peak Demand of Electric Resistance, Heat Pump, Desuperheater, and Solar Hot Water Systems."

FIGURE T7-7. **Electric Water Heating: Saturations**

	EXISTING			NEW		
	Single-Family	Multi-Family	Manufactured Home	Single-Family	Multi-Family	Manufactured Home
All Electric Water Heaters [1]	75.54	78.40	84.68	75.54	78.40	84.68
Resistance Water Heaters [2]	96.00	97.00	100.00	96.00	97.00	100.00
Heat Pump Water Heaters [2]	2.00	2.00	0.00	2.00	2.00	0.00
Heat Recovery Water Heaters [2]	1.00	0.00	0.00	1.00	0.00	0.00
Solar Water Heaters	1.00	1.00	0.00	1.00	1.00	0.00

1 Electric water heat saturations for existing households are taken directly from 1993 Residential Sales Profile. Saturations for new households are assumed to be the same as existing.

2 Based on SRC assumptions of the distribution of electric water heating technologies.

FIGURE T7-8. **Electric Water Heating: Unit Energy Consumptions (UECs)**

	EXISTING			NEW		
	Single-Family	Multi-Family	Manufactured Home	Single-Family	Multi-Family	Manufactured Home
All Electric Water Heaters [1]	4,178	3,304	3,200	3,807	3,011	2,916
Resistance Water Heaters - STOCK [2]	4,256	3,357	3,200	3,878	3,059	2,916
Heat Pump Water Heaters [2]	2,276	1,795	1,711	2,074	1,636	1,559
Heat Recovery Water Heaters [2]	3,176	2,505	2,388	2,894	2,283	2,176
Solar Water Heaters [2]	1,483	1,170	1,115	1,351	1,066	1,016
Resistance Water Heaters- STANDARD [3]	3,878	3,059	2,916	3,878	3,059	2,916

1 All electric water heat UEC values for existing households are directly from 1993 Residential Sales Profile and exclude energy used in conjunction with major hot water using appliances. All electric water heat UECs for new households are calculated based on the adjustment factor used for Stock to Standard.

2 Calculated based on the shares and relative efficiencies such that the weighted average is consistent with the All Electric Water Heater UEC.

3 Calculated based on the adjustment of STOCK consumption to account for natural increases in efficiency due to replacements . Efficiency of STOCK water heaters estimated to be EF=0.82 (average efficiency in 1986) and of STANDARD water heaters to be EF=0.90 (based on 1990 Federal Standards).

(as well as providing reduced cooling loads in some cases). A heat pump water heater utilizes a vapor compressor refrigerator cycle similar to that of an air conditioner to draw heat from the surrounding air to heat water. The heat pump water heater condenser rejects heat to the domestic water supply. An integral unit includes both the water tank and the heat pump water heater located on top of the tank.

Add-On Heat Pump Water Heater—An add-on heat pump water heater supplements the existing electric resistance hot water system at the supply to the water heater.

Maintenance of Heat Pump Water Heater—Maintenance includes replacing filters, cleaning coils, checking refrigerant charge, checking plumbing connections, and checking plumbing insulation to maintain efficiency of the heat pump water heater.

Solar Water Heater—The solar water heating system actually assists rather than replaces an electric resistance water heater. When solar radiation is available, it is absorbed by collector panels and then transferred to the domestic hot water supply. Some systems heat water directly by circulating potable water through the solar loop. Others recirculate the same absorption fluid through the collectors and transfer the heat via a heat exchanger to the potable water supply.

Heat Recovery Water Heater—Estimates for the replacement of an electric resistance water heater with a heat recovery water heater show the majority of the savings occur during summer months. These units recover superheat from the compressor discharge gas of a central air conditioner or heat pump for the purpose of heating or preheating water.

Instantaneous (Tankless) Electric Water Heater—Energy savings result primarily from the elimination of tank losses. Demand increases may result in the winter because larger heating elements are used and hot water is frequently used during winter peak times.

Water Heater Tank Wrap—This measure includes the installation of R-11 external insulation blanket onto electric resistance water heater tanks.

Water Heater Heat Trap—This measure includes the installation of external heat traps on both the inlets and outlets of electric water heaters.

Hot Water Pipe Insulation—This measure includes the installation of pipe insulation to all accessible domestic hot water piping (assumed to be 70 feet of pipe in new homes, but only 20 feet in existing homes).

Low Flow Showerhead—This measure replaces existing showerheads (3-5 gallons per minute or gpm) with high quality low flow showerheads (2-2.5 gpm). Water savings, as well as energy to heat the water, result for each shower of equivalent quality. Estimates are per household.

Direct Load Control of Electric Resistance Water Heaters — Utility-controlled radio switches installed on residential electric water heaters could shut off 100 percent of participating water heaters during utility system peak periods.

Bottom Boards—This measure involves placing a 2-inch polystyrene (R-10) board under an electric resistance water heater. Savings measurements of 53 to 75 kWh/year have been recorded. Savings of 75 kWh/year were assumed for single-families, savings and 60 kWh/year savings were assumed for multi-family and manufactured housing.

Standard Efficiency Gas Water Heater—This measure includes replacing an existing electric water heater (assumed EF=0.82) with a standard efficiency gas water heater (EF=0.54 for 40-gallon heater and 0.56 for 30-gallon heater).

High-Efficiency Gas Water Heater—This measure includes replacing an existing electric water heater (assumed EF=0.82) with a high-efficiency gas water heater (EF=0.65 for 40-gallon and EF=0.63 for 30-gallon).

Residential Appliances

The 1993 UECs and saturations (or shares) from REEPS were the basis for evaluating new appliances and are shown in *Figure T7-9* and *T7-10*.

Brief descriptions of residential appliance technologies follow.

Best Current Frost-Free Refrigerator—Estimates were included for frost-free refrigerators with efficiencies at least 16 percent better than those required by federal appliance efficiency standards.

Remove Second Refrigerator—Customers with second, older, and less efficient, yet still operating refrigerators could be encouraged to remove them. The utility would be responsible for picking up and disposing of the refrigerators.

Best Current Frost-Free Freezer—Estimates were included for frost-free freezers with efficiencies at least 22 percent better than those required by federal appliance efficiency standards.

Remove Second Freezer—Customers with second, older, and less efficient, yet still operating freezers could be encouraged to remove them. The utility would be responsible for picking up and disposing of the freezers.

Servicing Refrigerator or Freezer (Primarily Clean Coils)— This measure was included for direct-install type options (programs).

Microwave Clothes Dryer—Successful prototypes that vaporize the water in clothes rather than heating them may now have a solution to the metal button problem. Preliminary tests with a lower frequency magnetron have been successful. Energy, drying times, and drying temperatures are all reduced with this technology.

FIGURE T7-9. **Appliances: Unit Energy Consumptions (UECs)**

	EXISTING			NEW		
Appliance	**Single-Family**	**Multi-Family**	**Manufactured Home**	**Single-Family**	**Multi-Family**	**Manufactured Home**
Refrigerator - 1st	1,088	989	990	1,088	989	990
Refrigerator - 2nd	949	757	941	949	757	941
Refrigerator - Average	1,066	980	988	1,066	980	988
Freezer	989	800	815	989	800	815
Clothes Dryer	1,017	957	906	1,017	957	906
Clothes Washer	195	134	113	195	134	113
Dishwasher	394	336	334	394	336	334
Electric Cooking	994	845	746	994	845	746
Pool Pumps (from FEO)	3,117	3,117	3,117	3,117	3,117	3,117

From Tennessee Valley Authority 1993 Residential Sales Profile
FEO = Florida Energy Office

FIGURE T7-10. **Appliances: Saturations**

	EXISTING			NEW		
Appliance	**Single-Family**	**Multi-Family**	**Manufactured Home**	**Single-Family**	**Multi-Family**	**Manufactured Home**
Refrigerator - 1st	100	100	100	100	100	100
Refrigerator - 2nd	19	4	4	19	4	4
Freezer	57	16	36	57	16	36
Clothes Dryer	72	48	59	72	48	59
Clothes Washer	90	47	70	90	47	70
Dishwasher	53	51	29	53	51	29
Electric Cooking	87	89	85	87	89	85
Pool Pumps	NA	NA	NA	NA	NA	NA

From Tennessee Valley Authority 1993 Residential Sales Profile

Electric Dryer with Moisture Sensor—Most dryers utilize a temperature sensor to control the operation of the dryer. A moisture sensor in the exhaust provides more precise control for automatic shutoff of the dryer when the clothes are mostly dry.

Heat Pump Clothes Dryer—The heat pump clothes dryer (not yet commercially available) uses a refrigerant cycle to remove moisture from exhaust air. This dehumidified exhaust air is then rewarmed and recirculated into the dryer. Because the exhaust is recirculated, a vent is not needed. However, a condensate drain would be required.

Horizontal-Axis Clothes Washer—Horizontal-axis clothes washers, available overseas, use less water, energy, and detergent per cycle compared to the vertical-axis clothes washer common in the United States. Only the energy savings (from the use of less hot water) were estimated.

High-Efficiency Dishwasher—In 1994 U.S. energy efficiency standards for dishwashers improved the efficiency of dishwashers being purchased in the United States. However, models are available in the U.S. that surpass this standard by about 30 percent. Their savings may be attributed to booster water heaters, lower water use, more efficient motors, and air-drying features.

Induction Cooktop—This technology (gaining acceptance in the commercial market and available but limited for the residential market) consists of a high frequency electric coil located beneath a smooth cooking surface. The coil creates an alternating magnetic field that induces a current in ferrous metal pots, thus causing heating in the pot rather than the cooking surface. Induction cooktops have efficiency gains of 20 to 40 percent over electric resistance cooktops.

Electric Cordless Lawn Mower—A cordless lawn mower uses a rechargeable battery and an electric motor. Estimates are based on Black & Decker's 18-inch model with a 12-volt lead/acid battery.

Electric Cord Lawn Mower—Gas-powered lawn mowers have 94 percent of the market share, with the rest being accounted for by electric cord mowers. Estimates are based on Black & Decker models with 8-amp and 12-amp motors.

Smart House (Home Automation & Real-Time Pricing)—A home automation system consists of an interface node near the utility meter that communicates to a smart thermostat, as well as appliance monitoring and control modules in the home. Communication between the utility and residence goes in both directions, allowing for a wide array of advanced services. The homeowner can control appliances in response to time-of-use rates or real-time price signals from the utility or can allow for utility control of appliances.

High-Efficiency Pool Pumps—Estimates are included for replacing a standard efficiency pool pump with a high-efficiency pump.

Downsized Pool Pumps with Oversized Piping—This measure encourages the combination of (1) properly sizing pool pump motors (which are often oversized) and (2) modifying the piping to minimize losses (which includes installing larger diameter piping, eliminating sharp 90-degree elbows, and possibly installing a larger filter).

Direct Load Control of Pool Pumps—Utility-controlled radio switches could be installed on residential pool pumps, which could be controlled by the utility during times of system peak demand. During system peak periods 100 percent of participating pool pumps could be turned off.

Pool Pump Timer—Timers or adjustment of existing timers on pool pumps can be used to control the operation timing of pool pumps. The timer would be set to turn off the pool pump during expected times of system peak demand.

Residential Lighting

Brief descriptions of residential lighting technologies follow:

Compact Fluorescent—Because prices and energy savings estimates vary based on procurement method and hours of operation, estimates for a single bulb or household were developed for each option (program).

Efficient Incandescent—Efficient incandescent light bulbs provide relatively equal lighting with reduced wattage due to a more efficient filament design and a phosphorescent coating. It is assumed that 80 percent of all standard incandescent lamps (40W, 60W, 75W, 100W) can be replaced with more efficient lamps.

Residential Security Lighting—High pressure sodium lamps operating 4,000 hours/yr were used for this estimate, although other types of lamps are available, such as mercury vapor and metal halide.

High Pressure Sodium (Outdoor)—Savings estimates for high pressure sodium fixtures that may be used for outdoor floodlight fixtures are based on 1,500 hours/yr operating time. This operating schedule assumes that the lights are turned off at bedtime.

Halogen Lamp (Outdoor)—One of the most significant improvements to incandescent lamps is to surround the filament with a separate capsule containing halogen gasses that capture vaporized tungsten and redeposit it on the filament, extending its life while preventing condensed tungsten from darkening the bulb. The halogen cycle creates more light per unit of electricity and provides a better quality of light.

Halogen Lamp (Indoor)—Thick walled A-lamps can be used in many residential applications.

Motion Detectors for Outdoor Lighting—Add-on controls that exclude the combination of both a motion detector and a photocell would be installed on existing outdoor lighting fixtures. Savings estimates assume that the motion detector would be activated only 5 percent of the time.

COMMERCIAL

Primary data sources included existing saturation surveys, energy audits, end-use load forecasts, and TVA institutional data. Hourly building simulations of prototypical buildings were developed using micro-AXCESS and TMY weather for Nashville, Tennessee, to estimate the energy and demand impacts of HVAC technologies and building shell improvements. The detailed hourly building energy analysis software used for analyses of the commercial prototype buildings, micro-AXCESS, is available through EPRI's (Electric Power Research Institute) Electric Power Software Center.

Secondary data sources included Competitek, EPRI reports, energy journals, case studies, other utility filings, manufacturers' literature, E Source reports, and previous work done by SRC and BCI. ESOURCE, formerly known as Competitek, is a proprietary information service and a subsidiary of Rocky Mountain Institute.

As much as possible, the energy impacts have been adjusted to be consistent with TVA's commercial end-use forecast (i.e., COMMEND EUIs [End Use Intensities in kWh/sf/yr] and electric/gas shares). For example, the lighting EUI for retail buildings for 1993 was disaggregated into different lighting categories (e.g., incandescent, fluorescent, mercury vapor, high pressure sodium, metal halide) to account for their inherent lighting efficiencies and assumed distributions. These disaggregated EUIs

FIGURE T7-11. **Commercial Technologies**

End-Use	Demand-Side Measure
Space Conditioning Equipment	High-Efficiency Chiller
	High-Efficiency Chiller w/ASD
	High-Efficiency DX A/C
	High-Efficiency Room A/C
	Cool Storage (Partial Ice)
	Rooftop Cool Storage (Partial Ice)
	Thermal Energy Storage (General)
	Heat Pipe Enhanced DX A/C
	Hotel Occupancy Sensors
	2-Speed Motor for Cooling Tower
	Speed Control for Cooling Tower
	Air Conditioning Maintenance
	HVAC Air Duct/Water Pipe Insulation
	Leak-Free Ducts
	HVAC Energy Management System
	Standard Efficiency Heat Pump (Electric Backup)
	High-Efficiency Heat Pump (Electric Backup)
	VAV System with Inlet Vanes
	ASD Ventilation Controls w/VAV
	Timer/Programmable Ventilation Control
	High-Efficiency Ventilation Motors
	Separate Makeup Air/Exhaust Hoods
	Dual-Fuel Heat Pump
	Ground-Source Water Loop Heat Pump
	Wood Furnace (Space Heating Only)
	Wood Boiler (Space and Water Heating)
	Passive Solar Space Heating and Cooling
	Temperature Setup/Setback
Space Conditioning Building Shell	Roof Insulation
	Wall Insulation
	Window Film
	Spectrally Selective Windows
	Light-Colored Roofs
Lighting	T8 Lamps / Electronic Ballasts
	Electronic Ballasts
	Refl/Delamp 4' - 40W Fluor. Lamps/ Electronic Ballasts
	Refl/Delamp 8' - 75W Fluor. Lamps/ Electronic Ballasts
	Refl/Delamp 4' - 40W Fluor. Lamps/ Hybrid Ballasts
	Refl/Delamp 8' - 75W Fluor. Lamps/ Hybrid Ballasts
	4' – 34W Lamps/Electronic Ballasts
	8' – 60W Lamps/Electronic Ballasts
	4' – 34W Fluor. Lamps / Dimming Ballasts
	Compact Fluorescent Lamps and Fixtures
	Photoelectric Control
	Energy Management System Lighting Control
	Occupancy Sensors
	Indoor HID Lamps—High Pressure Sodium
	Outdoor HID Lamps—High Pressure Sodium
	Metal Halide (32W)
	LED Exit Signs (Light-Emitting Diode)
	Fluorescent Exit Signs
	Electroluminescent Exit Signs
	Daylighting Design
	LED Traffic Signal
	Sulfur Lamp
Refrigeration	Multiplex: Air-Cooled/No Subcooling
	Multiplex: Air-Cooled/Ambient Subcooling
	Multiplex: Air-Cooled/Mechanical Subcooling
	Multiplex: Air-Cooled/Ambient & Mechanical Subcooling
	Multiplex: Air-Cooled/External Liquid Suction HX
	Open-Drive Refrigeration System (ASD)
	Anti-Condensate Heater Controls
	High R-Value Glass Doors
	Refrigeration Energy Management System (EMS)
	Dual-Path Supermarket Air Conditioning
Water Heating	Heat Pump Water Heater
	Solar-Assisted Water Heater
	Heat Recovery Water Heater
	DHW Heater Insulation
	DHW Heat Trap
	Low Flow/Variable Flow Showerhead
	DWH Recirculation Pumps
Cooking	Electric Forced Convection Oven
	Electric Natural Convection Ovens
	Energy-Efficient Electric Fryers
	Flash Bake Oven

then became the base case to which the DSM lighting technologies were compared. The use of these disaggregated EUIs helps to ensure that potential energy and demand impact estimates are consistent with the load forecast assumptions. These EUIs reflect the operating characteristics of the businesses in the TVA region, such as operating hours, lighting levels, etc.

The commercial technologies include electric conservation, load shifting, peak clipping, and beneficial electrification (load growth) measures. A listing of the commercial technologies included in the technology database is shown in *Figure T7-11*.

The technologies were grouped by end use. The primary end uses considered in the commercial sector included: Space Conditioning, Building Shell, Lighting, Refrigeration, Water Heating, and Cooking. For each end use, the technologies were mapped to an appropriate base technology and building type. In the commercial market, the following ten building types were considered:

- Office (OF)
- Restaurant, Fast Food, and Full Service (FF)
- Retail (RT)
- Grocery (GR)
- Warehouse (WH)
- School (SC)
- College or University (UN)
- Hospital (HS)
- Lodging, Hotel, or Motel (HM)
- Miscellaneous (MI)

The annual costs and energy impacts were expressed per thousand square feet for each appropriate building type. Energy-efficient office equipment was not included because often there is no incremental cost over less efficient models. Also, many of these efficient models are already the baseline in new purchases resulting from market transformation efforts such as EPA's Energy Star Program, which TVA supports.

Commercial Space Conditioning

Brief descriptions of the space conditioning or building shell technologies follow:

Space Conditioning

High-Efficiency Chiller—This measure consists of comparing standard efficiency [COMPRESSOR COP=5.0] centrifugal chillers to high-efficiency [COMPRESSOR COP=5.76] centrifugal chillers. This measure was analyzed only for hospitals and large offices and was modeled using micro-AXCESS.

High-Efficiency Chiller w/ASD—This option consists of retrofitting an adjustable speed drive (ASD) controller onto high-efficiency centrifugal chillers. The same assumptions apply here as in the high-efficiency centrifugal chillers. This measure was modeled in micro-AXCESS using an improved chiller part-load profile.

High-Efficiency Direct Expansion (DX) Air Conditioning (A/C)—The Energy Policy Act and ASHRAE figures indicate the following standards:

Cooling Capacity (kBtu/hour)	EER
65 – 135	8.9
135 – 760	8.3

An average baseline EER = 8.7 (1.38 kW/ton) is assumed. The high efficiency DX AC EER is assumed to be 9.8 (1.23 kW/ton). This measure was analyzed for all building types except hospitals.

High Efficiency Room AC Units—Federal Appliance Standards mandate the following efficiency standards for 1992:

Cooling Capacity (kBtu/hour)	EER
Less than 8,000	8.9
8,000 – 13,000	8.3
Greater than 13,000	7.9

An average baseline EER = 8.3 (1.45 kW/ton) is assumed. The high efficiency room AC EER is assumed to be 10.9. This measure applies to all building types.

Cool Storage (Partial Ice)—This load shifting measure is assumed to be specifically partial ice storage or load leveling, and is only applied to buildings with chillers. This measure was modeled using DSMSIM, an SRC Systems Software Model. The DSMSIM model uses basic algorithms to estimate the ice storage chiller and storage tank capacities based on the day with the highest accumulated cooling load (determined from base case load shapes developed by micro-AXCESS). Maximum cooling energy is shifted from on-peak to off-peak periods based on the partial ice storage capacity, using a chiller priority strategy. Ice-making capacity and efficiency derating factors are also taken into account. The capacities vary by building type and weather zone. The characteristics of the base and cool storage chillers were assumed to be the same (e.g., chiller type, COP).

Rooftop Cool Storage (Partial Ice)—Established test standards do not yet completely evaluate thermal energy storage systems; also suppliers of such systems are currently limited. The addition of thermal storage to this common A/C equipment offers humidity control, improved overall efficiency, and reduced demand during utility peak periods. Manufacturer estimates (from

Powell Energy Products, Inc.) for 5- to 20-ton rooftop thermal storage A/C equipment (The Ice Bear) were compared to standard efficiency rooftop DX A/C units. Demonstrations of this technology are underway or planned in the TVA region and throughout the United States.

Thermal Energy Storage (General)—The installation of a thermal energy storage system offers a whole range of options to permit all or part of a building's cooling or heating load to be shifted from peak to off-peak periods while still providing space conditioning.

Heat Pipe Enhanced DX A/C—Heat pipes installed upstream of the evaporator can substantially reduce the moisture content from incoming outside air, resulting in significant cooling savings. The performance of this technology was estimated using micro-AXCESS by setting up the baseline cooling setpoint by 4 degrees; this technique was suggested by experienced micro-AXCESS users. This applied only to DX AC systems. Cooling savings ranged from 0.8 to 30 percent (increases in heating and ventilation energy use were not included).

Hotel Occupancy Sensors—This measure is similar to a lighting occupancy sensor. The sensor turns off the air conditioning shortly after it detects the room is unoccupied. The option was estimated using micro-AXCESS by setting up the baseline cooling setpoint by 2 degrees during the on-peak period.

2-Speed Motor for Cooling Tower—This measure consists of replacing the single-speed motors in the cooling tower with a two-speed motor. This applied only to chiller systems. The energy savings are estimated to be 80 percent of the Speed Control for Cooling Tower measure.

Speed Control for Cooling Tower—This includes retrofitting an ASD (or VFD) to an existing cooling tower fan. This applies only to chiller systems. Load impacts from this measure were estimated from the micro-AXCESS model.

Air Conditioning Maintenance—This measure consists of annual cleaning and tuning up of DX A/C and chiller systems. The impacts of this measure were estimated using micro-AXCESS by increasing both the baseline compressor efficiency and capacity by 2 percent—suggested by experienced micro-AXCESS users.

HVAC Air Duct/Water Pipe Insulation for Chiller and DX AC—This measure consists of installing additional insulation on air ducts and additional insulation on chilled water pipes. The savings and cost estimates are based on ASHRAE methodology.

Leak-Free Ducts—This measure primarily consists of sealing all exterior ductwork for rooftop DX A/C equipment. Cooling and ventilation demand and energy savings of 7 percent for existing buildings and 3 percent for new buildings was estimated. These savings are based on a combination of estimates developed by Bosek, Gibson & Assoc. and micro-AXCESS simulation (by varying outside air percentage).

HVAC Energy Management System (EMS)—The impacts of this measure were estimated using micro-AXCESS by combining the inputs of two other simulated measures:
—Temperature Setup/Setback
—Timer/Programmable Ventilation Control
Chiller coil reset was eliminated from this combination since independent DOE 2.1 simulations of this particular measure for Florida by SRC yielded negative savings.

Standard Efficiency Heat Pump (Electric Backup)—This measure compares standard efficiency air-source heat pumps (EER=8.7, HSPF=6.8) to standard efficiency DX units (EER=8.7) with gas heat (AFUE=78 percent).

High-Efficiency Heat Pump (Electric Backup)—This measure compares a high-efficiency heat pump (EER=9.8, HSPF=7.5) to a standard efficiency DX unit (EER=8.7) with gas heat (AFUE=78 percent).

VAV System with Inlet Vanes—Micro-AXCESS was used to model ventilation fan, cooling, and heating energy and demand impacts between a constant volume system and a variable air volume system with inlet vanes for both DX A/C and chiller systems for all buildings.

ASD Ventilation Control with VAV—This measure includes an adjustable speed drive control for the ventilation fan in addition to the VAV system described above for the VAV System with Inlet Vanes. Energy and demand impacts of this combined measure were computed using micro-AXCESS. This was simulated for buildings with DX A/C and chiller systems. In addition to the cost of a VAV system, the installed capital cost for ASDs was included.

Timer/Programmable Ventilation Control—This measure was modeled using micro-AXCESS by simply shutting down the ventilation fan system one to three hours earlier (depending on the building type); consequently, the cooling and heating systems shut down (or shifted into night cycling mode), as well. This measure was not applied to the grocery, hospital, or lodging market segments.

High-Efficiency Ventilation Motors—This measure assumes the use of high-efficiency motors in place of standard efficiency motors, resulting in an average demand and energy savings of 3 percent for 1 to 25 horsepower motors.

Separate Makeup Air/Exhaust Hoods—This technology is typically installed in commercial kitchen areas to reduce the energy wasted in pre-conditioned supply air via exhaust hoods. Cooling energy and demand savings of 80 percent are estimated within the kitchen areas. This measure was applied to

the restaurant, school, college, hospital, and lodging market segments. It was assumed the kitchen areas with hoods are approximately 3 percent of school, college, and hospital; 10 percent of restaurant; and 2 percent of lodging total floorspace.

Dual-Fuel Heat Pump—A heating system which utilizes both electricity and fossil fuels. The system can be designed to minimize energy costs by economically dispatching the system based on outside temperature, system operating characteristics, and energy prices.

Ground-Source Water Loop Heat Pump—A ground-source water loop heat pump takes heat from a water source, such as a well or a surface water body, to deliver warm air to a building during the heating season and rejects heat from the indoor air to the water source to provide cooling.

Wood Furnace (Space Heating Only)—Estimates were made for a furnace which burns wood or biomass waste for space heat. In commercial buildings, this technology is appropriate for applications requiring one MBtu/hour or less.

Wood Boiler (Space and Water Heating)—Estimates were made for a boiler burning wood or biomass waste to supply space heating and water heating in commercial buildings. This technology is suitable for applications requiring more than one MBtu/hour.

Passive Solar Space Heating and Cooling—Basic passive solar applications utilize proper solar orientation, coupled with thermal mass, to heat a building in the winter and to reduce cooling load in the summer. These features provide a source of solar heat gain and a means to store heat collected.

Temperature Setup/Setback—This measure was modeled using micro-AXCESS. Based on the baseline prototype building characteristics, cooling is shut off at night, while for temperature setback, the heating setpoint was lowered to 55° F during off-peak hours. The measure is not applicable to grocery, hospital, and lodging. Modeling in micro-AXCESS did not incorporate adaptive recovery technology.

Building Shell

Roof Insulation—Additional insulation is installed, raising the R-value from 2.53 to 10.53 in existing buildings and from 10 to 20 in new buildings. The measure was simulated in micro-AXCESS to determine the energy impacts.

Wall Insulation—This measure was applied only to new buildings. The R-value of the wall was increased from 5.26 to 11.76 in the buildings simulated.

Window Film—This measure consists of installing window film on existing and new construction. The option was modeled using micro-AXCESS by decreasing the window shading coefficient and glass U-value. For existing buildings, the shading coefficient was reduced from 0.85 to 0.23, and the U-value from 1.06 to 0.69. For new buildings, the shading coefficient was not changed, but the U-value was reduced from 1.06 to 0.69.

Spectrally Selective Windows—This measure, applied only to new buildings, was modeled using micro-AXCESS by reducing the U-value from 1.06 to 0.22 and reducing the shading coefficient to 0.20. (ACEEE 1992 Proceedings)

Light-Colored Roofs—This measure consists of installing lighter colored roofs or applying a reflective coating at the time of roof replacement. The energy savings estimate of 7 percent is a conservative assumption based on a report by FSEC.

Commercial Lighting

For any lighting retrofit or new design, the entire lighting system should be considered. A lighting system might include both task and ambient lighting, lamps, ballasts, the number and location of switches, the number of lamps controlled by each switch, and the type of switch—on/off, dimming, occupancy, or timed.

The technical potential for savings available from lighting retrofits and lighting designs for new construction was determined by estimating savings for fixtures, applying a reasonable number of fixtures to each building type or activity within the building, and then multiplying those numbers by our estimate of the square footage of that type of building in the TVA service territory. Lighting technologies included in this database were selected to represent the more popular or promising ones, in terms of energy savings potential and the persistence of savings over time, from the enormous number of lighting products available.

TVA survey results were used to estimate the current penetration of some lighting technologies in the Valley. Where specific Valley information was not available, estimates for the United States were used.

Brief descriptions of the commercial lighting technologies follow:

T8 Lamps—Fluorescent lamps have three starting methods. Most lamps are only compatible with one starting method, but the T8 lamps can be rapid- or instant-started. T stands for tubular; the number describes lamp diameter in 1/8-inch increments. A T8 lamp is 8/8 inches in diameter; a T12 is 12/8 inches (or 1-1/4 inches) in diameter. Estimates considered were:

- **Existing Buildings**—Compared four 4 foot -T8 lamps with one electronic ballast to four 4 foot - 34W lamps with two magnetic ballasts that meet current standards.
- **New Construction**—Compared three 4 foot - T8 lamps with one electronic ballast to four 4 foot - 34W lamps with two magnetic ballasts that meet current standards.

Electronic Ballasts—An electronic ballast uses solid state components to provide current to a lamp at high frequency

(typically 25,000 to 60,000 cycles per second) in order to produce more light using fewer watts than magnetic ballasts.

Reflector/Delamp 4 foot - 40W Fluorescent Lamps/ Electronic Ballast—This measure (considered only for existing buildings) consists of modifying a 4 foot - 40W fixture by removing the four 40W lamps and installing an efficient reflector, along with two 34W lamps.

Reflector/Delamp 8 foot - 75W Fluorescent Lamps/ Electronic Ballast—This measure (considered only for existing buildings) consists of modifying an 8 foot - 75W fixture by removing the four 75W lamps and installing an efficient reflector, along with two 60W lamps.

Reflector/Delamp 4 foot - 40W Fluorescent Lamps/ Hybrid Ballast—This measure (considered only for existing buildings) consists of modifying a 4 foot - 40W fixture by removing the four 40W lamps and installing an efficient reflector, along with two 34W lamps. Hybrid ballasts use magnetic technology to power the lamp and electronic technology to control power to the cathodes.

Reflector/Delamp 8 foot - 75W Fluorescent Lamps/ Hybrid Ballast—This measure (considered only for existing buildings) consists of modifying an 8 foot - 75W fixture by removing the four 75W lamps and installing an efficient reflector, along with two 60W lamps.

4 foot - 34W Lamps/Electronic Ballasts—This measure compares four 4 foot - 34W lamps with one electronic ballast to four 4 foot - 40W lamps with two magnetic ballasts that meet current standards.

8 foot - 60W Lamps/Electronic Ballasts—This measure compares two 8 foot - 60W lamps with one electronic ballast to two 8 foot - 75W lamps and one magnetic ballast that meets current standards.

4 foot - 34W Lamps/Dimming Ballasts (Existing Buildings Only)—This measure compares four 4 foot - 34W lamps with the electronic dimming ballast (including daylight controls to four 4 foot - 40W lamps with two magnetic ballasts that meet current standards. The lighting energy and demand savings are based on benchmark results from DOE 2.1 simulations. The technical feasibility depends on the building type based on the percentage of perimeter floorspace (15 feet deep) to total floorspace.

Compact Fluorescent Lamps and Fixtures—This measure considers replacing a weighted mix of 60W, 75W, and 100W incandescent lamps and fixtures with the same mix of 15W, 18W, and 27W compact fluorescent lamps and fixtures in both new and existing buildings. The percentage breakdown of the mix varies by building type. The incremental installation cost is included for existing buildings. The annualized maintenance cost of replacing both incandescent and compact fluorescent lamps during the lifetime of the compact fluorescent ballast is considered.

Photoelectric Control—This measure consists of retrofitting photoelectric controls onto exterior lighting. Using micro-AXCESS, the base case exterior lighting schedule of 4:00 p.m. to 7:00 a.m. (set for most building types) was changed to automatically turn on and off relative to daylighting hours. Estimated exterior lighting energy savings ranged from 14.7 percent to 25.4 percent, depending on the base case schedule of each building type. As expected, there are no demand savings.

Energy Management System Lighting Control—This measure consists of retrofitting an energy management system (EMS) to automatically control the lighting operation. It was assumed that the EMS would save an average of 2 full load hours of lighting a day. This equates to lighting energy savings ranging from 7 percent to 16 percent relative to the operating hours for each building type. It is also assumed the lighting demand savings is 20 percent of the energy savings, thus ranging from 1 to 3 percent.

Occupancy Sensors—This measure consists of retrofitting occupancy sensors to shut off lights in unoccupied portions of a building. It is assumed that this measure saves 25 percent lighting energy and 5 percent lighting demand in both new and existing buildings.

Indoor HID Lamps - High Pressure Sodium (HPS)—This measure considers replacing one 150W incandescent lamp with one 35W HPS fixture in both new and existing buildings. Incremental installation cost is included for existing buildings. Annualized maintenance cost of replacing both incandescent and HPS lamps during the lifetime of the HPS ballast was considered.

Outdoor HID Lamps - High Pressure Sodium (HPS)—This measure considers a weighted mix of 70W, 100W, 150W, and 250W high pressure sodium lamps/fixtures replacing the same mix of 100W, 175W, 250W, and 400W mercury vapor lamps/fixtures. The percentage breakdown of the mix varies by building type.

Metal Halide (32W)—This measure considers replacing one 150W incandescent lamp with one 32W metal halide fixture in both new and existing buildings. The incremental installation cost is included for existing buildings. The annualized maintenance cost of replacing both incandescent and metal halide lamps during the lifetime of the metal halide ballast was considered.

LED Exit Signs—Light-emitting diode (LED) exit signs claim a 20-year life, are reducing in price, and have an energy consumption of less than 2 watts. This promising new product would replace exit signs now using 14 to 50 watts. If these

are recommended in an option, the power factor should be considered in selecting acceptable products.

Fluorescent Exit Signs—Most new fluorescent exit signs are equipped with two 5-watt twin-tube compact fluorescents. If these are recommended in an option, the power factor should be considered in selecting acceptable products.

Electroluminescent (EL) Exit Signs—EL exit signs have the lowest power consumption, but they also have the lowest luminance, as well. The EL lamps used are flat, thin-film sources. Typically thinner than a credit card, the lamps consist of a flexible plastic laminate made up of two electrode plates sandwiching a phosphor-doped dielectric film. Light is produced when the phosphors are excited upon application of alternating current to the electrode plates. Because of their slim design, Underwriters Laboratories (UL) lists EL retrofit kits for use in many existing "Listed" single-face exit signs and will "Classify" retrofit kits for use with specific manufacturers' emergency signs.

Daylighting Design—This measure would consist of a combination of dimming ballasts, doubling the window area, installing spectrally selective glass, and downsizing the cooling capacity by 10 percent. This measure applies to new buildings and excludes warehouses and lodging. Only lighting impacts were analyzed for this measure.

LED Traffic Signal—A recent breakthrough in the development of a blue LED (light-emitting diode) may be the last technical hurdle before the marketing of energy-efficient traffic signals. Each incandescent lamp in a traffic single uses 67 to 150 watts that could be replaced by an LED unit using only 9 to 25 watts.

Sulfur Lamp—The sulfur lamp is a small, rotating, air-cooled glass sphere filled with sulfur gas. A microprocessor- controlled magnetron stimulates the sulfur atoms with microwaves, generating light in the visible range. The light produced by the sulfur lamp has a high-quality color rendering and an adjustable color temperature.

Commercial Refrigeration

Brief descriptions of the commercial refrigeration technologies follow:

Multiplex: Air-Cooled/No Subcooling—This measure considers the retrofitting of a "conventional" refrigeration system (i.e., numerous stand-alone compressor systems for each display case line-up or walk-in) with a multiplex refrigeration system. The term "multiplex refrigeration" refers to the use of multiple refrigeration compressors mounted on a rack and piped to common suction and discharge manifolds. Refrigeration to each display case lineup is provided from the rack by a pair of liquid and suction pipes. Several circuits can be connected by separate pairs of refrigerant piping. Multiplex systems commonly consist of two, three, or four compressors that are sized such that the operation of all compressors simultaneously can provide adequate capacity to meet the design refrigeration load. During off-design operation, the multiplex compressors can be cycled on or off so that the capacity of the operating compressors closely matches the refrigeration load.

Multiplex: Air-Cooled/Ambient Subcooling—Ambient subcooling is the cooling of the liquid refrigerant below the condensing temperature by heat rejection to the ambient. Some subcooling normally occurs in the condenser, and additional ambient subcooling can be obtained through the use of a separate coil, usually attached to the condenser.

Multiplex: Air-Cooled/Mechanical Subcooling—Further cooling of the liquid refrigerant can be done through the use of a vapor compression system. Liquid refrigerant associated with a refrigeration system operating with a low suction temperature is mechanically subcooled by a system operating at a higher suction temperature.

Multiplex: Air-Cooled/Ambient and Mechanical Sub-cooling—This measure combines the benefits of ambient subcooling and mechanical subcooling.

Multiplex: Air-Cooled/External Liquid Suction HX—This measure involves the installation of an externally mounted heat exchanger instead of merely soldering the liquid and suction lines together. The result is more efficient liquid-to-suction heat transfer, providing more refrigeration capacity. This measure is applicable only for the very low and low temperature refrigeration applications and is a more efficient alternative to mechanical subcooling.

Open-Drive Refrigeration System (ASD)—Open-drive systems consist of one or two open-drive compressors driven by external adjustable speed drive electric motors. The main advantage of open-drive compressors over multiplex compressors is the additional electric savings due to operating open-drive compressors at low speeds, which is intended to increase compressor efficiency. An open-drive system requires larger compressors, and thus higher compressor capital costs, but smaller remote condensers, and thus lower condenser capital costs, compared to a multiplex system of equal capacity.

Anti-Condensate Heater Controls—It is assumed that this measure saves 5 percent energy and demand, and is applied to all market segments, except office, warehouse, and miscellaneous. The cost and impact estimates are based on an assessment study done for Bonneville, 1988.

High R-Value Glass Doors—This measure consists of replacing single-glass doors or retrofitting refrigeration cases with high R-value glass doors. An average of 30 percent energy and demand

savings is assumed. This technology is applied to all market segments except office, warehouse, and miscellaneous, with various levels of technical feasibility and current penetration.

Refrigeration Energy Management System—This technology consists of strategically controlling many or all refrigeration systems in a given facility. From the EPRI Commercial TAG Volume, an energy and demand savings of 10 percent and 5 percent is assumed. It is assumed that this technology is only applicable to the grocery market segment, which has an assumed current penetration of 50 percent (SRC).

Dual-Path Supermarket Air Conditioning—Similar to Heat Pipe Enhanced Air Conditioning, this technology removes a significant amount of moisture from incoming air before passing over the evaporator. Its best application is where there are high humidity levels; therefore, the dual-path air conditioner is only analyzed for the grocery market segment. The energy and demand impacts and costs have been estimated based on a case study in Miami, Florida, presented in an EPRI brochure, *Dual-Path Supermarket HVAC Systems,* 1991 (CU.2053.10.91). Although this is an air conditioning technology, it is placed with refrigeration because its applicability is focused on high refrigeration loads. It is assumed this technology has no current penetration.

Commercial Water Heating

Brief descriptions of the commercial water heating technologies follow:

Heat Pump Water Heater—This measure consists of replacing conventional electric hot water heaters with heat pump hot water heaters. The estimated energy and demand savings are 50 percent (assuming an average seasonal COP of 2.0). This measure has significantly higher capital cost compared to conventional electric water heaters (i.e., orders of magnitude). This measure was applied to all market segments.

Solar Assisted Water Heater—The solar water heating system actually assists rather than replaces an electric resistance water heater. When solar radiation is available, it is absorbed by collector panels and then transferred to the domestic hot water supply. Some systems heat water directly by circulating potable water through the solar loop. Others recirculate the same absorption fluid through the collectors and transfer the heat via a heat exchanger to the potable water supply.

Heat Recovery Water Heater—This measure consists of an electric water heater that utilizes a supplemental heat source from the cooling system waste heat from a double bundle chiller or condenser heat exchanger. There is an assumed 25 percent energy savings based on the WAPA Guidebook of Commercial DSM Technologies, assuming a summer and winter demand savings of 35 percent and 15 percent, respectively. The current penetration is assumed to be zero.

DHW Heating Insulation—This is a retrofit measure consisting of wrapping an existing water tank with additional insulation. Energy and demand savings of 5 percent are assumed. The technical feasibility and current penetration are assumed to be 50 percent and 20 percent, respectively (SRC).

DHW Heat Trap—This retrofit measure reduces hot water energy due to backflow through the pipes from natural convection. It is analyzed for all existing market segments; it is not analyzed in the new market since the technology is a requirement for some building codes. Energy savings of 10 percent are based on the WAPA Guidebook of commercial DSM technologies, while demand savings are assumed to be 2 percent. The technical feasibility and current penetration are assumed to be 80 percent and 15 percent, respectively (SRC).

Low Flow/Variable Flow Showerhead—This retrofit measure can easily be installed in place of existing showers and faucets to reduce the flow of hot water. It is assumed that there are approximately two showerheads and four faucets per water heater. The estimated energy and demand energy savings are 15 percent. Technical feasibility varies by building type based on an assumed percentage of hot water dedicated to showers and faucets:

- 80 percent—office, retail, school, college and lodging
- 50 percent—grocery, hospital, and miscellaneous
- 20 percent—restaurant

Current penetration of this measure is assumed to be 10 percent (SRC).

DHW Recirculation Pumps—This option consists of installing timers to prevent recirculation pumps on the hot water system, which are typically integrated with a boiler, and operating during periods of no hot water use. The energy saving due to this option was estimated to be 60 percent. There are no demand savings attributed to this measure, which is more applicable to schools, colleges, and hospitals than to other building types.

Commercial Cooking

Brief descriptions of the commercial cooking technologies follow:

Electric Forced Convection Ovens—This technology was modeled as a replacement option for either electric natural convection ovens or gas-fired forced convection ovens. Electric forced convection ovens have an efficiency of 64 percent compared to the 62 percent efficiency of electric natural convection ovens. Additionally, forced convection ovens can cook three times the volume of natural convection ovens. The option was applied to restaurants, groceries, schools, hospitals, and

lodging. The cost estimates are based on two $4,285 convection ovens per 5,000 square-foot restaurant. The efficiency of gas-forced convection ovens is 46 percent, versus 64 percent for electric forced convection ovens. The costs for other building types were prorated based on energy use.

Electric Natural Convection Ovens—This electric technology was analyzed to replace gas-fired natural convection ovens (for load building). The efficiency of gas natural convection ovens is 28 percent versus 62 percent for electric natural convection ovens.

Energy-Efficient Electric Fryers—This technology was modeled as a replacement technology applicable to the same building types as the forced convection ovens. The energy and demand savings were estimated to be 10 percent. The cost estimates are based on two $2,935 efficient fryers per 5,000 square feet of restaurant, prorated to other building types based on energy use. This technology was also analyzed to replace standard efficiency gas fryers with energy-efficient electric fryers (for load building). The heating efficiency of gas fryers is 45 percent, versus 100 percent for electric fryers.

Flash Bake Oven—The flash bake lightwave oven uses a combination of intense visible light and infrared energy to cook foods almost instantly from the outside in and the inside out. Dramatically faster and better, shorter cooking times can enhance food flavor and texture. These ovens are particularly suited for cooking many fast food products.

INDUSTRIAL

A list of industrial technologies was compiled by TVA. BCI and SRC suggested additional technologies. The technologies were ranked from 1 to 7, with 1 being the most important and 7 the least. Cost and energy impacts were sought for technologies that ranked 3 or better.

Technology data were not developed for the following technologies for the reasons listed below:

- **Ultrasound Treatment of Wet Textiles**—This can be used to improve the dye uptake in fabric dyeing processes. However, no information was found on the specific characteristics of this process.
- **Advanced Hybrid Membrane/Heat Pump Systems for Municipal Water Treatment**—No information on this technology was available.
- **Electron Beam Irradiation to Sterilize Municipal Water** — No information on this technology was available. A reference was found to a test performed by Massachusetts Institute of Technology in which a Van De Graaff generator was successfully used to detoxify waste water, however, based on the test, it was determined that a full-scale facility would not be economically beneficial.
- **Ceramic Membranes to Separate Oil/Water Emulsions**— No information on this technology was identified. Several references were found that referred to the development of ceramic membranes as representing a possible improvement in membrane separation processes in the future, but no specific information was provided.
- **Industrial Lighting**—Lighting applications (particularly indoor lighting) in industrial facilities are very similar to those in commercial warehouses and offices. No technology data unique to the industrial sector were developed.

The industrial technologies for which estimates were developed are shown in *Figure T7-12*.

Process Separation

Brief descriptions of the industrial technologies follow:

Freeze Concentration—Used for the separation or concentration of components in a liquid solution, freeze concentration is a substitute for conventional distillation and evaporation. In the

FIGURE T7-12. **Industrial Technologies**

End-Use	Demand-Side Measure
Process Separation	Freeze Concentration Electrolytic Separation Membrane Separation Electrochemical Synthesis
Process Heating	Industrial Process Heat Pumps DC Electric Arc Furnace Plasma Processing Induction Heating
Manufacturing	Flexible Manufacturing Module
Drying	RF & IR Drying
Fabrication/Finishing	Laser Processing Electrical Discharge Machining Electrogalvanization Electrochemical Machining Electron Beam Processing
Water Treatment	Waste Water Ozonation Seawater Desalinization by Reverse Osmosis
Motors	1 Horsepower High-Efficiency Motor 50 Horsepower High-Efficiency Motor 200 Horsepower High-Efficiency Motor

freeze concentration process, heat is removed from a liquid mixture until one component of the mixture crystallizes and can be easily separated. The advantages of freeze concentration include improved product quality, lower energy consumption, increased product recovery/quality, reduced capital and maintenance costs, and lower product shipping costs due to product concentration.

Electrolytic Separation—Electrolytic separation results in the production of new products as a result of passing an electrical current through a conductive electrolyte. Electrolytic technologies for the separation of chemicals and metals were among the earliest commercialized applications of electricity and have been economically significant since the turn of the century.

Membrane Separation—Membrane separation uses permeable barriers to filter selected components from mixtures. Membranes may be made out of polymers, ceramics, or metals and are usually categorized by the size of the particle filtered. Alternatives to membrane separation include conventional distillation and evaporation, freeze concentration, and electroseparation.

Electrochemical Synthesis—Electrochemical Synthesis is basically a form of electrolytic separation. The difference is that in electrochemical synthesis, new compounds are introduced at the electrodes in the electrolytic cell that react with the ions attracted to the electrodes. Thus, compounds are formed at the electrodes that could not be formed from the components of the electrolyte alone.

Process Heating

Industrial Process Heat Pumps—Heat pumpsw may be used to capture industrial waste heat. Where applicable, industrial process heat pumps can be used to capture relatively low temperature waste heat that has no other use and, using a moderate amount of mechanical energy, elevate the waste heat to a temperature that can supply process energy needs.

DC Electric Arc Furnace—Interest is increasing and units are being installed in the U.S. and abroad. The major benefit of a DC furnace is reduced electrode consumption as compared to 3-phase AC arc furnaces. Other benefits include lower noise levels, reduced maintenance, and less electrical disturbance on the power system.

Plasma Processing—Plasma processing involves the electrical production of a plasma in the temperature range from 2,000° to 10,000°C for metals production. At these high temperatures, the plasma is a mixture of molecules, atoms, electrons, and ions. It is the electrons and ions that allow for the conditions of electrical current or arc between two electrodes; the current may be AC or DC. The primary uses in metals production include scrap melting, heating steel in ladles, reduction of ores, treatment of electric furnace shop dusts, ferroalloy production, and the remelting of metals.

Induction Heating—Induction heating is a way to heat electrically conductive materials, such as metals. It is commonly used in process heating prior to metalworking and in heat treating, welding, and melting. Induction heating relies on electrical currents that are induced internally in the workpiece material. These so-called eddy currents dissipate energy and bring about heating. The basic components are an induction coil, an ac power supply, and the workpiece itself.

Manufacturing

Flexible Manufacturing Module—A flexible manufacturing module can be a single machine tool with part-changing equipment. A flexible manufacturing cell includes two or more computer numerical control machine tools linked to operate sequentially. A flexible manufacturing system is a combination of modules or cells that are all controlled by a central computer. Flexible manufacturing allows a company to quickly respond to changing demand and avoid creating a large product inventory to service a fluctuating demand.

Drying

Radio Frequency and Infrared Drying—These technologies cover the electromagnetic spectrum from visible light to radio waves. When a material absorbs infrared radiation, the motion of its molecules increases and it gets hotter. This is the basis of infrared process heating. Infrared radiation is produced by heating the filament of a source or emitter. Infrared heating can be applied to both conducting and nonconducting, whereas radio frequency drying/heating can only be used for dielectric, or nonconducting, materials. Radio frequencies for heating range from 2 to 200 MHz, which is in the range used for broadcasting and communications. A triode oscillator generates power in the RF range, and the products are usually heated between plate electrodes or through a series of rods.

Fabrication/Finishing

Laser Processing—Involves cutting, drilling, welding, marking, and selectively heat-treating a variety of materials. Lasers used for metalworking either have a gas lasing material (carbon dioxide mixed with helium and nitrogen) or are solid state (yttrium-aluminum-garnet crystal). Lasers are best suited to situations that involve the need for rapid prototypes, small production runs of precise parts, and/or rapid delivery of many different kinds of parts.

Electrical Discharge Machining—Uses an arc from an electrode to remove metal from the piece being machined. The workpiece and the electrode are in a dielectric bath. In a ver-

tical EDM machine, a computer-controlled electrode can be moved in three axes of motion and can create complex parts. Wire-cut EDM acts like a band saw and uses a continuous wire electrode to cut parts. EDM can be used to create intricate and unusual parts and can be used to machine any material that is conductive.

Electrogalvanization—This involves the deposition of zinc on a steel sheet in an electrolytic cell. A continuous sheet of steel is run through the cell and can be coated on one or two sides. The conventional alternative is hot-dip galvanizing, which produces a thicker coating, but in which it is difficult to coat only one side of the steel and the coated surface, when painted, is not totally acceptable for high visibility, high gloss areas.

Electrochemical Machining (ECM)—this process can be used for sinking, cutting, deburring, and grinding. A conductive workpiece is located in an electrolytic cell containing a conductive electrolyte. A high amperage, low voltage DC current passes from the workpiece through the electrolyte to a shaped electrode. The current causes particles on the workpiece surface to dissolve by electrochemical action. The dissolved material is removed as the electrolyte is pumped through the cell. As the process continues, the workpiece becomes a mirror image of the electrode. ECM is best suited to situations that involve hard or high strength materials and/or complex shapes.

Electron Beam Processing—This technology can be used for welding or selective surface hardening. A beam of electrons from a heated emitter in an electron gun is accelerated by attraction to the positively charged anode and focused by a magnetic coil. The kinetic energy of the electrons striking the workpiece is converted to heat that vaporizes the metal directly in the path and melts the adjacent metal. If the beam is directed at a joint between two pieces of metal, a weld is formed. Depending on the metal being processed, a high, partial, or nonvacuum may be required. Electron beam processing is used when high precision parts must be welded with minimal heat effects, maximum reproducibility, and no gas contamination. Electron beam processing is also suitable when high production rates are required.

Water Treatment

Waste Water Ozonation—This process is used for iron and manganese removal, oxidation of organics, microflocculation, bacterial disinfection, and viral inactivation. Ozone is generated on-site by an electrical discharge in an air or oxygen stream.

Seawater Desalinization—This process is used to produce potable water using seawater as a feedstock. The conventional approach is to evaporate seawater and condense the vapor as pure water. Reverse osmosis (RO) is an alternative to conventional evaporation techniques. The RO process uses semipermeable membranes which allow solution permeation, but act as barriers to the passage, or transport, of dissolved and suspended substance (i.e., salts, ions, and organic compounds). The solution transport in RO is accomplished by using a pressure high enough to overcome the natural osmotic pressure in the solution. The particle size of species separated is typically between 1 to 10 angstroms with a driving pressure of 200 to 1,000 pounds per square inch.

Motors

1 HP High-Efficiency Motor—Compares the 77.8 percent baseline efficiency motor to a high-efficiency motor. The high-efficiency motor reflects NEMA Efficiency Standard definition 12-6C, having a nominal efficiency of 80.0 percent. Three different operating hours were analyzed. A load factor of 0.70 was assumed.

50 HP High-Efficiency Motor—this compares the standard 50 hp motor with an efficiency of 91.4 percent to the high-efficiency motor is defined as having 93.1 percent efficiency. Again, three different annual operating hours were analyzed. A load factor of 0.70 was assumed.

200 HP High-Efficiency Motor—Compares the standard 200 hp motor with an efficiency of 94.2 percent to the high- efficiency motor is defined as 95.0 percent efficiency. Again, three different annual operating hours were analyzed. A load factor of 0.70 was assumed.

RENEWABLE/SELF-GENERATION

Renewable Energy

Renewable energy technologies were characterized in four reports by BCI for TVA. In these reports technology information was divided into four categories: Residential, Commercial, Industrial, and Self-Generation. Both dispersed renewable technologies (e.g., solar water heating), as well as more centralized generation technologies were considered. Some renewable technologies have been mentioned in the earlier sections. Renewable energy technologies considered are listed in *Figure T7-13*. Schiller Associates, a subcontractor to BCI, provided two cost estimates for wood burning plants at a host facility.

Self-Generation

Barakat & Chamberlin, Inc. subcontracted to Schiller Associates for the cogeneration technology characterization and market analysis. The market analysis, prepared by UNIMAR, Group. Ltd., identified potential industrial and commercial SIC codes where cogeneration would most likely occur. For these customers, Schiller Associates selected four system types as typical of cogeneration

installed in the under 30-megawatt range. The number of cost estimates (for purchase, installation, operation, and maintenance) that were developed are shown below:

- 8 – Natural gas-fueled reciprocating engine systems in the 100-kilowatt to 3,000-kilowatt size range
- 9 – Natural gas-fueled simple-cycle gas turbine systems in the 3,700-kilowatt to 21,500-kilowatt range
- 3 – Natural gas-fuel, combined-cycle gas turbine systems in the 13,400-kilowatt to 28,000-kilowatt range
- 1 – Coal-fueled, steam turbine (rankine cycle) system rated at 20,000-kilowatt

BENEFICIAL ELECTRIFICATION

Beneficial electrification encompasses both electrotechnologies and economic development. Because of this connection, it was advantageous to have one team assess the market, collect technology data, and develop the options. A team from Barakat & Chamberlin, Inc. assisted TVA in developing a comprehensive list of beneficial electrification (BE) technologies and in conducting qualitative, economic, and market screens on the list. Next, nine program concepts were developed and were evaluated in DSManager in fourteen options. Some adjustments to the original estimates were made for consistency with the assumptions made in the analysis of energy efficiency options. *Figure T7-14*, a summary of the beneficial electrification options, includes four industrial programs, one program focused on environmental technologies, two commercial programs, two residential programs and one program, focused on transportation.

Figure T7-15 lists the technologies for which fact sheets containing cost, energy, and demand impacts were developed.

FIGURE T7-13. **Renewable Energy Technologies**

End-Use	Demand-Side Measure
Residential	Wood Furnace
	Passive Solar Design
	Wood Stove
	Interactive (Solar and Wood Stove)
	Solar Hot Water
	Residential Rooftop PV (4kW)
	Landscape Shading
	Ground-Source Heat Pump
Commercial	Passive Solar
	Wood Furnace (Space Heating Only)
	Wood Boiler (Space and Water Heating)
	Solar Hot Water
	Commercial Rooftop PV (4kW)
	Daylight Design
	Photoelectric Control
Industrial	Biomass Process and Drying Heat
	Solar Assisted Industrial Process Heat
	Wood Waste
Generation	Biomass Fuel - Wood Waste
	Biomass Fuel - Animal Waste
	Landfill Gas
	Fuel Cells
	Small-Head Hydro
	Wind Turbines
	Remote Photovoltaics

TECHNOLOGY LISTS

The residential technologies included in options are listed in *Figure T7-16*. *Figure T7-17* contains residential technologies that should be considered if the site-specific application promises to be cost-effective. *Figure T7-18* contains residential technologies that should not be included in options. Emerging technologies that should be considered for option implementation are listed in *Figure T7-19*.

Commercial and industrial technologies included in efficiency or load management options are listed in *Figure T7-20*. Commercial and industrial technologies that should be considered, especially in comprehensive programs that customize the set of technologies appropriate for each site, are listed in *Figure T7-21*. Technologies that were not included in options are listed in *Figure T7-22*. These technologies were either not appropriate for our climate, incentives may be unnecessary for the technology to be accepted, or were eliminated for some other reason. Emerging technologies for the commercial and industrial sectors that should be considered for option implementation are listed in *Figure T7-23*.

Technologies included in Self-Generation/Renewable Generation options are listed in *Figure T7-24*.

Figure T7-25 contains a list of technologies included in beneficial electrification options.

FIGURE T7-14. **Summary of Beneficial Electrification Programs**

Program Name	Target Market	BE Technologies
Process Heating	SICs 30, 32, 33, 34, 35, 36 & 37	Induction, Resistance, Process Heat Pumps, Microwave RF Heating
Process Heating	SIC 33	DC Arc, Plasma Arc, Induction & Vacuum Melting
Curing & Drying	SICs 20, 22, 24, 26, 27, 28 & 30	UV Curing, EB Curing, Dielectric RF & Infrared Curing
Food Processing	SIC 20	Freeze Concentration, Reverse Osmosis
Textiles SIC 20	Vacuum Slots for Drying	
Chemicals and Metals	SICs 28, 33 &34	Electrolytic Reduction, Remelting, Electrogalvanization, & Electroslag
Environmental Technology	SICs 49, 20, 22, 28, 33, 34 & 36	Ultrafiltration, Microfiltration, Nanofiltration, Ozonation, & Reverse Osmosis
Space Conditioning and Water Heating	Schools, hospitals, & government facilities	Heat Pump Water Heaters, Air-Source Heat Pumps, & Dual-Fueled Heat Pumps
Cooking and Security Lighting	Restaurants, hotels, & other establishments	Electric Cooking & Security Lighting
Residential HVAC and Water Heating	Customers replacing non-electric heating and water heating systems	Heat Pump Water Heaters, Air-Source Heat Pumps, Ground-Source Heat Pumps, & Dual-Fuel Heat Pumps
Residential Security Lighting & Lawn Mowers	Promoted among relatively narrow range of customers in non-attainment and high crime areas	Electric Lawn Mowers & Security Lighting
Transportation - Electric Buses	Municipalities	Electric Buses
Transportation - Fleet Vehicles	Corporations and municipalities	Variety of Fleet Vehicles (vans, carts, fork lifts, etc.)
Transportation - Electric Autos	Residential consumers Electric cars	

FIGURE T7-15. **Beneficial Electrification Technologies**

End-Use	Demand-Side Measure
Residential	Heat Pump Water Heater
	Air-Source Heat Pump
	Ground-Source Heat Pump
	Dual-Fuel Heat Pump
	Security Lighting
	Electric Cordless Lawn Mower
	Electric Cord Lawn Mower
Commercial	Heat Pump Water Heater
	High-Efficiency Air-Source Heat Pump
	Dual-Fuel Heat Pump
	Water Chiller
	Thermal Energy Storage
	Security Lighting
	Convection Oven
	High-Efficiency Fryer
	Solid Element Burners
	Flash Bake Oven
Industrial—Process Industries	Electrolysis
	Reverse Osmosis
	Ultrafiltration
	Microfiltration
	Freeze Concentration
	Electrochemical Synthesis
	Ozonation/Oxidation
	Ultraviolet (UV) Curing
	Electron Beam Curing
	Dielectric Curing
	Infrared (IR) Curing
	Industrial Process Heat Pumps
	Resistance Heating
	Microwave Heating
	Radio Frequency (RF) Heating
Industrial—Textiles	Nanofiltration
	Radio Frequency (RF) Drying
	Infrared (IR) Drying
	Ultrasound Drying
	Vacuum Slot Drying
Industrial—Metals Fabrication	Induction Heating
	Resistance Heating
	Electroforming
	Electrical Discharge Machining
	Electrochemical Machining
	Electrofinishing
	Electron Beam Welding
	Plasma Welding
	Direct Arc Welding
	Laser Welding
	Ultraviolet (UV) Curing
	Infrared (IR) Curing
	Electrogalvanization
	Electroslag Casting
Industrial—Primary Metals	DC Electric Arc Furnace
	Plasma Arc Furnace
	Induction Melting (Coreless Induction Furnace)
	Vacuum Melting
	Plasma Ladle Refiner
	Induction Heating
	Resistance Heating
	Electrolytic Reduction
	Electroslag Remelting
Municipal	Reverse Osmosis
	UV-Ozonation
	Plasma Arc Furnace
Transportation	Electric Car
	Electric Van
	Electric Bus (Overhead Electric Cable)
	Electric Bus (Battery-Powered)
	Electric Rail
	Electric Work Vehicle

FIGURE T7-16. **Residential Technologies Included in Options**

End-Use	Demand-Side Measure
Cooling	Servicing Central Air Conditioner High-Efficiency Room Air Conditioner High-Efficiency Central Air Conditioner Servicing Room Air Conditioner Central AC Cycling or Direct Load Control Heat Pump Cycling or Direct Load Control
Cool/Heat	High-Efficiency Air-Source Heat Pump Ground-Source Heat Pump Insider Heat Pump Reduced Duct Leakage Servicing Heat Pump (Coils, Filters, Lubrication) Clock/Programmable Thermostat
Building Shell	Insulation (Ceiling) Double- or Triple-Pane Windows Low-Emissivity Window Reflective Glass/Window Film/Solar Screen Caulking/Weatherstripping Reduced Duct Leakage
Lighting	Compact Fluorescent Lamp High Pressure Sodium (Outdoor) Motion Detectors for Outdoor Lighting
Water Heating	Faucet Aerator Low Flow Showerhead Hot Water Pipe Insulation Water Heater Tank Wrap Water Heater Bottom Board Heat Pump Water Heater Maintain Heat Pump Water Heater Solar-Assisted Water Heating Storage Water Heater Cycling or Direct Load Control Standard Electric Water Heater Cycling or Direct Load Control
Appliances	High-Efficiency Frost Free Refrigerator High-Efficiency Freezer Servicing Refrigerator or Freezer (Clean Coils) Removal of Secondary Refrigerator or Freezer Clothes Dryer with Moisture Sensor Heat Pump Clothes Dryer High-Efficiency Dishwasher Smart House (Home Automation & Real-Time Pricing) High-Efficiency Pool or Spa Pump Horizontal-Axis Clothes Washer

FIGURE T7-17. **Residential Technologies Under Further Consideration**

End-Use	Demand-Side Measure
Cooling	Two-Speed Central Air Conditioner High-Efficiency Central Air Conditioner Ceiling Fan Thermal Energy Storage (Cooling)
Heating	Wood Furnace Electric Thermal Storage
Cool/Heat	Dual-Fuel Heat Pump Two-Speed Heat Pump Std. Add-On Heat Pump High-Efficiency Add-On Heat Pump Ducts in Conditioned Spaces Reduced Duct Heat Transfer
Building Shell	Insulation (Wall, Foundation) Reflective Roof Coating Radiant Roof Barrier Storm or Thermal Door
Lighting	Halogen Lamp (Outdoor Applications) Efficient Incandescent
Water Heating	High-Efficiency Electric Water Heater Early Replacement of Old Water Heater High-Efficiency Gas Water Heater
Appliances	Best Current Refrigerator or Freezer Early Replacement of Old Refrigerator or Freezer High-Efficiency Clothes Dryer High-Efficiency Range and Oven Induction Cooktop Downsized Pool Pumps w/Oversized Piping Direct Load Control of Pool Pumps Green Plug Motor Control

FIGURE T7-18. **Residential Technologies Not Included in Options**

End-Use	Demand-Side Measure
Cooling	Direct Evaporative Cooler Indirect Evaporative Cooler Two-Stage Indirect Evaporative Cooler Removal of Second Room Air Conditioner Attic Fan Whole-House Fan Shade Trees
Heating	Active Solar Space Heater Zoned Resistance Heating Resistance Heat & Heat Pump Cycling
Cool/Heat	Room Heat Pump Multi-Zone Heat Pump
Lighting	Halogen Lamp (Indoor Applications)
Water Heating	Heat Trap Water Heater Timer Water Heater Thermostat Setback Tankless Water Heater (Instantaneous) Heat Recovery Water Heater
Appliances	Refrigerator or Freezer Anti-Sweat Switch Duct Heat Recovery from Clothes Dryer Pool Pump Timer

FIGURE T7-19. **Residential Emerging Technologies**

End-Use	Demand-Side Measure
Cool/Heat	Gas Absorption Heat Pump Aerosol Duct Sealing
Lighting	Hafnium Single Crystal Filaments Sulfur Lamp
Water Heating	Ultrasonic Faucet Control
Appliances	Microwave Clothes Dryer Whole-House Surge Protection Cordless Lawn Mowers High Spin Speed Clothes Washer Low Energy and Water Use Dishwasher Golden Carrot Refrigerator Automatic Clothes Washer Controls 200-to 300-kWh Refrigerator/Freezer Low Powered Color TV Bubble Action Clothes Washer

FIGURE T7-20. **Commercial/Industrial Technologies Included in Options**

End-Use	Demand-Side Measure
Cooling	High-Efficiency Chiller
	Speed Control for Cooling Towers
	High-Efficiency DX A/C
	High-Efficiency Room A/C
	Thermal Energy Storage (Ice or Water)
	Rooftop Cool Storage
	HVAC Maintenance & Condenser Coil Cleaning
Cool/Heat	High-Efficiency Air-Source Heat Pump
	Ground Source Heat Pump
	Setback/Setup Thermostat
Ventilation	Adjustable Speed Ventilation Motor Drives
	Variable Air Volume Systems
	High-Efficiency Ventilation Motors
	Leak-Free Ducts
	Programmable Ventilation Control
	HVAC Air Duct/Water Pipe Insulation
Building Shell	Roof Insulation
	Wall Insulation
	High-Efficiency Windows (High R-value)
	Tinted Windows (Spectrally Selective)
	Low-Emissivity Films (Window Films)
	Passive Solar Design
Lighting	T8 Lamps
	Electronic Ballasts
	Ref./Delamp 4' - 40W Lamp/EE Ballasts
	Ref./Delamp 4' - 40W Lamp/Electronic Ballast
	Ref./Delamp 4' - 40W Lamp/Hybrid Ballast
	Ref./Delamp 8' - 75W Lamp/Electronic Ballasts
	4' - 34W Lamps/Electronic Ballasts
	8' - 60W Lamps/Electronic Ballasts
	Compact Fluorescent Lamps
	Compact Fluorescent Fixtures
	4' - 34W Fluor. Lamps/Dimming Ballasts
	Photoelectric Control
	Lighting Timers
	Occupancy Sensors
	Indoor HID Lamps - High Pressure Sodium
	Outdoor HID Lamps - High Pressure Sodium
	LED Exit Signs
	Fluorescent Exit Signs
	Electroluminescent Exit Signs
	Daylighting Design
Water Heating	Heat Pump Water Heater
	Heat Recovery Water Heater
	High-Efficiency Water Heater - Increased Insulation
	Add Heat Trap
	Low Flow Showerheads
	Pipe Insulation
	DHW Recirculation Pumps
	Solar-Assisted Water Heater
Refrigeration	Glass Doors for Refrigerated Cases (High R-Value)
	Anti-Condensate Heater Controls
	Dual-Path Supermarket Air Conditioning
	Ambient Subcooling
Appliances	Energy-Efficient Electric Fryers
	Electric Forced Convection Ovens
Miscellaneous	Interruptible Rate Option
Industrial	High-Efficiency Motor
	Motor Downsizing
	Adjustable Speed Drives
	Compressed Air Efficiency Improvements
	Process Efficiency Improvements

FIGURE T7-21. **Commercial/Industrial Technologies Under Further Consideration**

End-Use	Demand-Side Measure
Cooling	High-Efficiency Chiller w/ASD Heat Pipe Enhanced DX A/C Hotel Occupancy Sensors 2-Speed Motor for Cooling Tower Heat Recovery Absorption Chiller Outside Air Economizer Cycle Hydronic Economizer Cycle Cooling Towers - Fans Chilled Water Reset
Heating	Zonal Electric Heat
Cool/Heat	Closed Water Loop Heat Pump Ground-Coupled Heat Pump Dual-Fuel (Add-On) Heat Pump
Ventilation	Reduction in Fan Flowrate Fan Motor Downsizing
Building Shell	Double- and Triple-Pane Windows
Lighting	Lighting Management Systems
Water Heating	Desuperheater: Refrigeration or A/C Storage Water Heating
Refrigeration	High-Efficiency Evaporator Fan Motors Condenser Coil Cleaning Mechanical Subcooling Energy-Efficient Case Lighting High-Efficiency Evaporator Fan Motors
Office Equipment	Personal Computers Computer Printers Copiers
Miscellaneous	Energy Management System Time-of-Use Metering Real-Time Metering
Industrial	Other High-Efficiency Motors Voltage Unbalance Efficient Motor Rewinding Techniques

FIGURE T7-22. **Commercial/Industrial Technologies Not Included in Options**

End-Use	Demand-Side Measure
Cooling	Direct & Indirect Evaporative
Heating	Active Solar Space Heater
Ventilation	Reduction of Outside Air
Building Shell	Interior Shade Thermal Scanning Vestibule/Revolving Doors
Lighting	Task Lighting Electrodeless Fluorescent Halogen Lamps Metal Halide
Refrigeration	Multideck Strip Curtains Dual Gaskets Liquid Pressure Amplifier Evaporative Pre-Cooler for Air-Cooled Condensers Parallel Unequal Compressor Systems Variable Speed Compressor Systems
Appliances	High-Efficiency Griddle Low Temperature Dishwasher - Stationary Low Temperature Dishwasher - Conveyer Clothes Dryer - Moisture Sensor Clothes Dryer - Heat Pump Clothes Washer - High-Efficiency Motor
Office Equipment	Fax Machines Telephone Systems
Miscellaneous	High-Efficiency Pool Pump Low Pressure Drop Pool Filters Time-of-Day Pool Pumps

FIGURE T7-23. **Commercial/Industrial Emerging Technologies**

End-Use	Demand-Side Measure
Cool/Heat	Zeotropic Refrigerants
	GAX Absorption Heat Pump
	Absorption Heat Pump
	Aerosol Duct Sealing
	Electrohydrodynamic Heat Transfer Enhancement
Lighting	Hafnium Single-Crystal Filaments
	General Service Halogen IR
	Advanced Reflector Design
	Thermal Bridging for Fluorescent Fixtures
	Lower Cost Dimmable Ballast
	Integrated Fixtures/Controls
	Architectural Daylighting Device
	Electrodeless HID
	Coated Filament Incandescent
	Fluorescent Surface Wave Lamp
	Sulfur Lamp
	DC Lighting System
	LED Traffic Signals
Water Heating	Ultrasonic Faucet Control
	Ozonated Commercial Laundering
Refrigeration	Supermarket System Integration
Appliances	Microwave Clothes Dryer
	High Spin Speed Clothes Washer
	Automatic Clothes Washer Controls
	Bubble-Action Clothes Washer
	Green Plug Motor Controller
Industrial	Switched Reluctance Drive (Improved DC Motor)
	Five-Phase Motors (Improved Perm Magnet DC Motor)

FIGURE T7-24. **Renewable/Self-Generation Energy Technologies**

End-Use	Demand-Side Measure
Renewables	Landfill Gas - Fuel Cells
	Small-Head Hydro
	Biomass Fuel - Wood Waste
	Photovoltaics
Self-Generation	Reciprocating Engine Systems
	Gas Turbine Systems
	Coal-Fired Steam Turbine Systems

FIGURE T7-25. **Beneficial Electrification Technologies Included in Options**

End-Use	Demand-Side Measure
Residential	Heat Pump Water Heater Air-Source Heat Pump Ground-Source Heat Pump Dual-Fuel Heat Pump Security Lighting Electric Cordless Lawn Mower Electric Cord Lawn Mower
Commercial	Heat Pump Water Heater High-Efficiency Air-Source Heat Pump Dual-Fuel Heat Pump Security Lighting Convection Oven High-Efficiency Fryer
Industrial – Process Industries	Reverse Osmosis Ultrafiltration Microfiltration Freeze Concentration Ozonation/Oxidation Ultraviolet (UV) Curing Electron Beam Curing Dielectric Curing Infrared (IR) Curing Industrial Process Heat Pumps Microwave Heating Radio Frequency (RF) Heating
Industrial – Textiles	Nanofiltration Vacuum Slot Drying
Industrial – Primary Metals	DC Electric Arc Furnace Plasma Arc Furnace Induction Melting (Coreless Induction Furnace) Vacuum Melting Plasma Ladle Refiner Induction Heating Resistance Heating Electrolytic Reduction Electroslag Remelting
Industrial – Metals Fabrication	Induction Heating Resistance Heating Electrogalvanization Electroslag Casting
Municipal	Reverse Osmosis Ultraviolet-Ozonation
Transportation	Electric Car Electric Van Electric Bus (Battery-Powered) Electric Work Vehicle

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GLOSSARY

Below are definitions of terms that will be used often in this appendix. (Terms in definitions which are themselves defined in the Glossary are printed in *italics*.)

A

AC—Air Conditioning.

Add-Ons—Purchases of new or additional equipment of a type previously not present in an existing facility, such as the purchase of a food freezer for a home that previously had none or the purchase of a second room air-conditioner.

Administrative Costs—Expenses incurred by the utility for program planning, design, management, and administration. They include labor, office supplies, data processing, etc. They exclude the costs of marketing, purchase of equipment for programs, incentives, and monitoring and evaluation.

Advanced Batteries—An advanced technology battery that has more storage capacity than a lead acid battery.

AFUE—Annual fuel utilization efficiency (AFUE) is an efficiency rating used for gas appliances based on average usage including on and off cycling described in a standardized Department of Energy test procedure. These ratings are listed in publications from the Gas Appliance Manufacturers Association (GAMA).

Agricultural Sector—The group of nonresidential customers engaged in the production of crops or livestock, forestry, fishing, hunting, or trapping.

Ambient—Surrounding.

Annual Participation—The number of customers enrolled in a particular program for a given year.

Annual Participation Rate—The ratio of the number of participating units in a particular year to the number of eligible units.

ASD—An adjustable speed drive (ASD) may be used to control the speed of an electric motor.

ASHRAE—American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

Attributes—Measures or criteria used to evaluate options and strategies. For example, total TVA debt is an attribute.

Availability—The percentage of time that a TVA power plant (or generating unit in a power plant) can be called on to produce power.

Avoided Cost—The incremental cost to TVA for *capacity* or *energy* or both which, but for an acquisition from another source, the TVA would have to incur. (In other words, the cost of Plant A, which TVA would have acquired except for that fact that it was able to acquire Plant B.)

B

Base Load Capacity—Large power plants, often coal- or nuclear-fueled, which are designed to operate around the clock at high capacity factors.

Baseline—A mid-range set of assumptions on all variables, with a "business as usual" decision strategy.

Beneficial Electrification—Electricity may be used as a tool for economic development to fuel new products or replace other fuels for process improvement.

Biomass—Biomass involves the harvesting of stands of close growing whole trees, truck transport, tree storage, and drying using air heated by boiler flue gas, and combustion of the whole trees in a special deep bed burner at the bottom of the furnace.

Boiler—A component that consumes a fuel for a heat source to produce steam from water.

C

Capability—(1) With respect to *supply-side resources*, the amount of electric power that a generating unit or electric system can reliably deliver under specified conditions over a specified period of time; (2) with respect to *demand-side resources*, the ability and skills to perform *demand-side management* activities such as market research, program design, evaluation, etc.

Capacity—The amount of electric power that can be delivered by a generating unit or electric system, as determined by manufacturer's nameplate ratings or by testing. (For example, the capacity of a com-

bustion turbine power plant, based on its nameplate rating, would be stated as 225 *MW*.

Capacity Factor—A universal standard for measuring power plant performance. It compares a plant's actual output with its maximum potential output, expressed as a percentage.

CFC—*Chlorofluorocarbons.*

CH_4—*Methane.*

Chemical Coproduction—The production of a chemical product while simultaneously producing electricity.

Chlorofluoro-carbon (CFC)—A family of inert, nontoxic, and easily liquified chemicals used in refrigeration, air conditioning, packaging, and insulation or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere, they drift into the upper atmosphere, where their chlorine components destroy ozone.

Class 1 Areas—Nonattainment area—the part of a state where a state fails to attain and maintain pollutant levels below the National Ambient Air Quality Standards. States are required to impose additional control requirements on sources of ozone, carbon monoxide, particulates (PM 10), sulfur dioxide, nitrogen dioxide, and lead within the nonattainment area in order to attain the ambient standard.

Climate Challenge—The principal utility industry component of the President's Climate Change Action Plan, which provides for a voluntary reduction of greenhouse gases (primarily *CO2*).

CO—*Carbon Monoxide.*

CO_2—*Carbon Dioxide.*

Cogeneration—The use of a primary fuel, such as natural gas, to produce both electrical energy and thermal energy used as steam or process heat.

Coincident Peak—The *demand* of a TVA customer or group of customers at the time TVA's entire system is at its *peak load*.

Coincident Peak Demand—The load (in kW) of an end use, customer, or group of customers at the time the utility experiences its greatest demand for electricity.

Commercial Sector—The group of nonresidential customers that provides services, including retail, wholesale, finance, insurance, and public administration.

Conservation—A reduction in either *energy* usage or *peak demand* so as to provide the prior end-use service levels at a lower cost.

COP—Coefficient of Performance (COP) is dimensionless and defined as the useful energy effect divided by the energy from external sources.

Criteria—Measuring rods used in integrated resource planning. They are derived from issues or concerns. Examples include concerns over future rates, acceptable levels of environmental impacts, etc.

Cumulative Effects—The changes in electricity use and demand caused by all of a program's participants from the program's inception through the current year.

Cumulative Participation—The number of participating units from the start of a program through the current year.

Cumulative Participation Rate—The ratio of the number of participating units from the start of a program through the current year to the number of eligible units.

Customer Class—A group of customers with similar characteristics, such as economic activity or level of electricity use.

Customer Service Options—Actions taken to influence the nature of loads on the customer-side of the meter.

D

Decision—A choice that, although made ultimately by TVA's Board, contains input from all stakeholders.

Decision Analysis—A decision-making process that provides a mathematical framework by which a large set of resource *strategies* can be evaluated for a number of uncertain parameters. (For example, an ultimate decision might include five subdecisions, each with five key uncertain parameters, for which there are three values representing the range of likely outcomes. In this example, 1,115 scenarios would be evaluated in making the decision.)

Declining Block Rates—A utility rate where after a certain level of consumption in a period, additional consumption of energy is charged a lower rate.

Demand—The amount of electric energy used at a specific point in time, measured in watts (or multiples thereof, such as *kW*, *MW,* or *GW*). Demand is measured for individual customers, for groups or classes of customers, and for TVA's system as a whole.

Demand-Side Management (DSM)—Activities which influence electricity use on the customer's side of the meter. Examples include home weatherization, use of compact fluorescent lighting, etc.

Demand-Side Management Measure—A single technology, such as a compact fluorescent light bulb, which can be used to alter customer load.

Demand-Side Management Programs—Organized utility activities that are intended to affect the amount and timing of customer electricity use.

Demand-Side Management Resource—Bundles or packages of DSM activities that can be used to reduce customer energy demands, and thus be viewed in many respects like a generating source.

Diesel Generators—An electrical generator powered by a traditional diesel engine. Direct-Installation ProgramsActivities in which the utility (or its contractor) installs DSM measures in the facilities of participating customers; such programs generally cover low-cost measures, such as water-heater wraps and compact fluorescent lamps.

Dispatchable—Capable of being connected or disconnected from a utility's system as necessary for efficient operation of the system. Generally applies to generating facilities, but could also apply to a load that is interruptible when necessary.

Distributed Generation—Power generation facilities located close to energy users. These are normally small size units (i.e., less than 50 *MW*) and may include both generation and energy storage technologies.

Diversified Coincident Peak Demand Effect—The change caused by the utility's DSM program in the demand for electricity at the time the utility experiences its system peak.

Diversified Demand—The average load (in *kW*) across a group of customers or end uses.

DOE 2—A public domain building energy analysis software program developed with funding from the Department of Energy.

DX—Direct expansion (DX) refers to cooling equipment with a refrigerant to air coil and no chilled water system.

E

Early Replacement—The removal of equipment before it reaches normal retirement age and the substitution of new equipment for the old.

Eco-Efficiency—Sustainable manufacturing and pollution prevention practices.

Econometric Models—Models that use past statistical relationships between electricity sales and the major assumptions such as economic activity and prices to forecast future electricity sales.

Economic Dispatch—The hour-by-hour operation of TVA's system of generating units to meet hourly and daily load swings in a way that minimizes the cost of producing electricity.

Economic Potential—An estimate of the possible energy savings assuming that all energy-efficient options will be adopted and all existing equipment will be replaced with the most efficient whenever it is cost-effective to do so, without regard to market acceptance.

Economy Surplus Power (ESP)—A form of interruptible power sold by TVA. The price for ESP changes hourly and is based on a markup over the incremental cost of the power. There are several variations of ESP with different markups and interruption provisions.

EER—Energy efficiency ratio (EER) is a ratio calculated by dividing the cooling capacity in Btu's per hour (Btuh) by the power input in watts at any given set of rating conditions, expressed in Btuh per watt (Btuh/watt). These ratings are listed in publications by the Air-Conditioning & Refrigeration Institute (ARI).

EF—Energy Factor (EF) is a measure of the overall efficiency rating of a water heater certified by the Gas Appliance Manufacturers Association (GAMA).

Effluent—Wastewater—treated or untreated—that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Electric and Magnetic Fields—Two types of energy fields that are emitted from any device that generates, transmits, and uses electricity.

Eligible Market—The subset of the total market that is qualified to participate in a program based on the program's participation criteria.

EMF—*Electric and Magnetic Fields.*

Emission—Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

EMS—Energy management system is a term used for automated control of *HVAC* and lighting systems in buildings.

End Use—The ultimate benefits provided by electricity. For example, commercial electric energy uses can be segmented into several end uses, such as lighting, air conditioning, ventilation, heating, cooking, refrigerating, etc.

End-Use Model—An energy forecasting approach that focuses on the end uses of electricity, and the factors that influence such end uses.

Energy—The amount of power consumed over a period of time, measured in watt hours, *kWh*, *MWh*, or *GWh*.

Energy Efficiency—(1) With regard to *supply-side resources*, reducing the amount of fuel required to produce a given amount of electric energy; (2) with regard to *demand-side management resources*, reducing the amount of electric energy used without reducing the functionality of that use—for example, by replacing a 74 watt incandescent light bulb with an 18 watt compact fluorescent light bulb delivering the same amount of lumens.

Energy Efficiency Programs—Programs (sometimes called energy-conservation programs) that are aimed at reducing the energy used by specific end-use devices and systems without degrading the services provided, thereby reducing overall electricity consumption (*kWh*), often without regard for the timing of program-induced savings. Such savings are generally achieved by substituting technically more advanced equipment to produce the same level of end-use services (e.g., lighting or warmth) with less electricity.

Energy Storage—Mechanism of utilizing during the peak load period energy that was stored during the light load period when energy production costs were relatively low. The duration of an energy storage cycle rarely exceeds one week.

Environmental Externalities—Externalities are activities which result from the production and consumption of goods and services that impose costs or benefits on society that are not reflected in the prices of those goods or services. For example, negative externalities such as pollution and sonic booms can impose costs on a society that are not reflected in the prices of those goods associated with the pollution or sonic boom. Discussions of externalities in the utility industry have generally dealt with environmental externalities arising from various forms of pollution.

Environmental Mitigation—Making environmental pollutants less severe.

Equipment Cost—The price of components that the utility purchases directly for a *DSM* program, including the cost of *DSM measures* distributed free to participants.

Evaluation Criteria—Measures to evaluate the contribution of resource options to stated objectives and values.

Existing Buildings—Structures that are in use as of the beginning of the current year.

Externalities—Consequences or impacts of resource development that are not directly accounted for in the price paid for the resource developed.

F

Feedstock—The raw materials utilized by a chemical production facility to make the final product.

Firm Capacity—(1) With regard to *supply-side resources*, a binding commitment to purchase or sell *capacity*. Purchases increase the *capability* of TVA's system; sales decrease TVA's *capability*; (2) with regard to *demand-side management resources*, the amount of *capability* that must be provided to a customer under normal conditions.

Firm Power—Power sales that do not have provisions in the contract for interruptions. (See *Interruptible Power*)

Fixed Costs—Costs associated with constructing and maintaining resources in an operable condition, including capitalized construction costs, fixed operating and maintenance costs and fuel inventory costs. These costs are recovered whether or not the resource is actually operated.

Flexibility—The degree to which resource decisions can be changed over time as events unfold, and near-term futures become more clearly known.

Free Drivers—Customers who take DSM-program-recommended actions because of the program, but who do not participate directly in the program (e.g., they do not claim rebates).

Free Riders—Customers who would have adopted program-recommended actions even without the program, but who participate directly in the program (e.g., they claim rebates).

Fuel Cells—A device capable of converting a fuel and an oxidizer directly to electricity.

Fuel Switching Programs—Programs that encourage customers to change from one fuel to another for a particular end-use.

Full-Scale Programs—Mature, system-wide programs that are available to all of the eligible customers in the utility's service area.

Future—A combination of discrete values for key uncertainties that are being treated explicitly. For example, a *future* might assume a high rate of load growth, low oil prices, low coal prices, high interest rates, and no new carbon dioxide (CO_2) regulations.

Futures (Financial Market)—The sale of a product for delivery at some time in the future for a specified price. Most major commodity markets have well-organized active futures markets. For

example, farmers will sometimes sell part of their crop for fall delivery before it is planted.

G

General Information Programs—Programs that refer to utility efforts to inform customers about *DSM* options through such mechanisms as brochures, bill stuffers, TV and radio ads, and workshops.

Global Warming—The theory that certain gases such as *carbon dioxide (CO_2)*, *methane (CH_4)*, and *chlorofluorocarbon (CFC)* in the earth's atmosphere effectively restrict radiation cooling, thus elevating the earth's ambient temperatures.

Greenhouse Effect—The build-up of carbon dioxide or other trace gases that allows light from the sun's rays to heat the Earth but prevents a counterbalancing loss of heat.

Greenhouse Gas Emissions—A gas whose presence in the upper atmosphere contributes to the greenhouse effect by allowing visible light to pass through the atmosphere while preventing heat radiating back from the Earth from escaping. Greenhouse gases from anthropogenic sources include *carbon dioxide, nitrous oxide, methane,* and *chlorofluorocarbons (CFCs)*. There also are even larger quantities of naturally occurring greenhouse gases, notably ozone and water vapor, whose concentrations may be affected by interactions with atmospheric pollutants.

GW—Gigawatt, an amount of electric power equal to 1,000 *MW* or 1 billion watts.

GWh—Gigawatt hour, an amount of energy equal to 1,000 *MWh* or 1 billion watt hours.

H

Hazardous Waste—A byproduct of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special Environmental Protection Agency lists.

HSPF—Heating Season Performance Factor (HSPF) is the total heating output of a heat pump during its normal annual usage period for heating divided by the total electric power input in watt-hours during the same period. This rating is listed in publications by the American Refrigeration Institute (ARI).

HVAC—Heating, Ventilation, and Air Conditioning

Hydro Generation—A dam creates an upper and a lower water reservoir. The height difference between the two reservoirs establishes potential energy that is used to generate electricity by allowing water from the upper reservoir to flow through a hydro turbine to the lower reservoir.

I

Incentive—An award offered to encourage participation in a DSM program and adoption of recommended measures.

Incentive Programs—Programs that offer cash or noncash awards to customers, trade allies, or employees to encourage participation in a *DSM* program and adoption of recommended measures.

Incremental Cost—The additional cost incurred because of an activity. For example, a plant sitting idle has costs associated with it such as interest on funds used to build it and basic maintenance. When started up, the plant has additional costs such as fuel, additional maintenance, and other costs. These latter costs are the incremental costs of producing the product. Similar terms are avoided cost and marginal cost.

Incremental Fuel Cost—The cost of replacing a unit of fuel in today's market.

Incremental Participation—The number of annual participants in the current year minus the annual participants in the previous year.

Industrial Sector—The group of nonresidential customers that provides products, including agriculture, construction, mining, and manufacturing.

Integrated Resource Planning—A utility planning process that evaluates *supply-side resources* and *DSM resources* on a level playing field to reliably meet the future energy needs of customers.

Internalized Costs—Costs that result from the production and consumption of goods and services that are reflected in the price of those goods and services.

Interruptible Power—A type of *demand-side management* activity in which the power contract allows TVA limited rights to turn off the power when overall demand is high in return for a lower price to the customer. Many industrial customers buy part of their power as interruptible. (See *Firm Power*)

Issue—A concern expressed regarding TVA's energy resource plan or its implementation. For example, an industrial customer may see low electricity rates as vital to its continued operation.

kW—Kilowatt, which is the amount of power equal to 1,000 watts. Common measure of demand for electricity at any moment.

kWh—Kilowatt hour, which is the amount of energy equal to 1,000 watt-hours.

Common measure for use of electricity over time.

L

Life-Cycle Costs—Method of expenditure evaluation that recognizes the sum total of all costs associated with the expenditure during the time it is in use.

Limited Interruptible Power (LIP)—A form of interruptible power sold by TVA. LIP customers get discounts from firm power rates in exchange for granting TVA limited rights to interrupt the power if necessary when the power supply situation is very tight.

Load—The amount of power that is drawn from TVA's electric system at a given point in time.

Load Factor—A measure of the variability in electric usage, defined as the ratio of energy actually consumed to the potential consumption at peak load for the period of time of interest. Load factor is usually calculated over a one year (8,760 hours) time period.

Load Management—The control of customer demand during peak periods or during periods when supplies of electricity are short. Unlike energy conservation, load management may not conserve energy.

Load Not Served—A measure of the reliability of a power system.

Load Shape—The time-of-use pattern of customer electricity use, generally a 24-hour pattern or an annual (8,760-hour) pattern.

Load-Building Programs—Programs that aim to increase electricity consumption, generally without regard to the timing of the increased usage.

Load-Shifting Programs—Programs that aim to move electricity consumption from one time to another (usually from the on-peak to off-peak periods during a single day).

M

Market Potential—An estimate of the possible energy savings that would occur because of normal market forces (i.e., likely customer adoption over time of various actions without a *DSM* program)

Methane (CH_4)—A greenhouse gas that is colorless, nonpoisonous, and flammable and is created by anaerobic decomposition of organic compounds.

micro-AXCESS—A building energy analysis software program available through EPRI.

Mitigation—Measures taken to reduce adverse impacts on the environment.

Monitoring and Evaluation Cost—Expenditures associated with the collection and analysis of data used to assess program operation and effects.

MW—Megawatt, the amount of power equal to 1,000 KW or 1,000,000 watts.

MWh—Megawatt hour, the amount of power equal to 1,000 KWh or 1,000,000 watt hours.

N

Net Effect—The change in electricity use or demand for a participating customer that can be attributed to the utility *DSM* program, expressed in *MWh*/year and *MW*.

New Construction—Buildings and facilities that are constructed during the current year; it may also include major renovations of existing facilities.

New Construction Programs—Programs that affect the design and construction of residential and commercial buildings and manufacturing facilities; such programs may also include major renovations of existing facilities.

New Participants—Customers who take part in a program during the current year and did not participate in the program during the previous year.

NIMBY—Not in my backyard.

Non-Attainment Area—A geographic area that does not meet one or more of the National Ambient Air Quality Standards for the criteria pollutants designated in the Clean Air Act.

Noncoincident Peak—The peak demand imposed on TVA by a customer, group of customers or all the customers as a whole, but not necessarily at the same time.

Normal Replacement—The removal of worn-out (and perhaps obsolete) equipment and the installation of new equipment.

O

Off-Peak—The periods of time during which energy is being delivered far below the maximum demands that could be placed.

On-Peak—The periods of time during which energy is being delivered near, or at, the maximum *coincident peak load*.

Operating and Maintenance Costs—Noncapital, equipment-related expenses that continue over the life of the equipment; they include fuel costs, as well as costs for maintaining and servicing equipment.

Option—Actions TVA can take to resolve an issue. For example, if TVA forecasts an energy deficit, it has the option to meet it with *DSM* programs or other resources.

P

Participant Costs—Those expenses associated with taking part in a *DSM* program paid by the customer and not reimbursed by the utility.

Participants—Units used by a utility to measure participation in its *DSM* programs; such units of measurement include customers or households for residentials programs and customers, floor area, or *kW*-connected for commercial and industrial customers.

Participation Rate—The ratio of the number of participants in a program to the number eligible for the program, with both the numerator and denominator defined in the same units.

Peak Demand—The maximum rate of electricity use, expressed in *kW*.

Peak Load—The maximum *load* experienced by TVA's electric system over a given period of time.

Peak-Clipping Programs—Programs that aim to reduce electricity *demand* (*kW*) at certain critical times, typically when the utility experiences system peaks.

Peaking Capacity—Capacity that is available for use and used to meet *peak load*. Such capacity, usually represented by combustion turbines, often has low capital costs and high fuel costs, and is designed to operate for relatively short periods of time.

Penetration—The ratio of the number of new units of a specific type installed to the total number of new units installed during a given time (e.g., the fraction of new air-conditioner sales that exceeds an energy-efficiency ratio of 10).

Photovoltaics—Solar-photovoltaic (PV) power plants convert solar energy to electricity using a semiconductor material, usually silicon doped with phosphorus and boron, to generate dc current.

Point Sources—A stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, for example, a pipe, ditch, ship, ore pit, or factory smokestack.

PSD—*Prevention of Significant Deterioration.*

R

Real Prices—(Or constant dollar prices, prices excluding inflation) As applied to price changes, the rate of change in a price over time adjusted for the overall inflation rate. For example, if the price of a widget goes up 1 percent while the average price of all goods sold in the economy goes up 2 percent, the real price of the widget is said to have declined 1 percent.

Real-Time Pricing—*Energy* is priced at the cost of producing it at the time it is consumed.

Rebate—Money given to customers, contractors, homebuilders, or other trade allies who make equipment choices to help defray the incremental cost of *DSM* measures.

Reference Case—One given set of circumstances used to compare other sets of circumstances.

Reliability—The ability of TVA's electric system to deliver uninterrupted power to its customers.

Renewable Resources—Power plants or other generating devices whose fuel source is generally considered to be renewable. These include generators fueled by *biomass*, water, *photovoltaics*, solar, wave or wind energy.

Reserve Margin—The difference between the capability of TVA's electric system and expected peak load, expressed as a percentage of expected peak load.

Residential Sector—The group of customers to whom electricity is sold for household purposes, including space heating, water heating, air conditioning, lighting, and appliances in single-family, multi-family, and mobile homes.

Resources—*Supply-side* or *DSM* options that can be used by TVA to meet future customer energy needs.

Retrofit—Replacement or upgrading of equipment before it reaches normal retirement age.

Retrofit Programs—Programs that upgrade existing facilities and equipment.

Revenue Requirements—The amount that must be recovered from customers to cover a utility's fixed and variable costs.

Robustness—The degree to which an energy strategy meets an objective for most or all futures.

S

Saturation—On the demand side, the percentage of a group of customers that have a particular *end use*. For example, the residential saturation of heat pumps is 50 percent if half of residential customers have them. In the commercial sector, saturations (also know as fuel shares) are generally measured on a percentage of square footage basis.

SCADA—System Control and Data Acquisition

Scenario—The combining of one *strategy* with one *future*.

SEER—Seasonal Energy Efficiency Ratio (SEER) is the total cooling of a central unitary air conditioner or unitary heat pump in Btu's during its normal annual usage period for cooling divided by the total electric energy input in watt-hours during the same period. This rating is listed in publications by the American Refrigeration Institute (ARI).

Stranded Cost—Costs that a utility faces because of stranded investments. For example, a utility may owe money on a closed plant that is generating no income. If a stranded investment can operate and cover part of its cost, only the portion of the cost not covered would be stranded.

Stranded Investment—An investment in plant or equipment that loses its value because of competition that forces down the price of the product. In the electric utility industry, firms may have been allowed or directed by regulators to build high cost capacity to meet the obligation to serve their customers. If the market is open to competition, lower cost producers may capture these customers, causing the high cost capacity to close and become a stranded investment.

Strategy—A combination of *options* intended to fulfill a particular resource goal. For example, an energy deficiency in 2007 might be met with a combination of *supply-side resources* and *DSM resources*.

Sunk Cost—The sum of previous investments; monies that have already been spent.

Supply-Side Resource—Resources that meet customer needs by increased production of electricity.

Sustainable Development—Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

System Energy Requirements—The total energy the generating system needs to produce to meet customer needs over some time period, generally a year. System energy requirements include all sales and *system losses*. Customer needs are measured before *load management* measures are applied.

System Losses—Difference between the energy metered at the generator and the energy recorded at the customers' meters.

T

Take-back—Changes in customer behavior resulting in greater energy use stimulated by participation in a *DSM* program.

Target Market—The group of customers (a subset of the eligible market) that is the focus of utility marketing efforts.

Total Program Costs—All expenses associated with a *DSM* program regardless of whether borne by the utility, participating customer, or trade allies. The costs paid by customers and trade allies are first adjusted for incentives from the utility to avoid double-counting costs.

Total Resource Costs (TRC) Test—A benefit-cost test that measures the net costs of a *demand-side* program as a resource option based on the total cost of the program, including both the participants' and the utility's costs. The costs in this test are the program costs paid by both the utility and the participants plus the increase in supply costs for any period in which load has been increased. All equipment costs are included in this test.

Total Value Test—the *Total Resource Costs* test to not only include the total cost of an *option*, but also the effects upon the benefits or "value" that participants and ratepayers receive.

Trade Allies—Organizations (e.g., architect and engineer firms, building contractors, appliance manufacturers and dealers, and banks) that affect the energy-related decisions of customers who might participate in *DSM* programs.

U

Utility Costs—All the expenses (administrative, equipment, incentives, marketing, monitoring and evaluation, etc.) incurred by a utility in a given year for operation of a *DSM* program regardless of whether the costs are capitalized or expensed.

V

Valley-Filling Programs—Programs that typically seek to increase off-peak electricity consumption (without necessarily reducing *on-peak* demands).

Variable Costs—Costs associated with the generation of electricity that vary with the utilization of the generating station, such as fuel, consumable supplies, etc.

Variable Frequency Drive (VFD)—A variable frequency drive is a type of *ASD* that varies the frequency of the electricity to an electric motor to control its speed.

VOCs—*Volatile organic compounds.*

Volatile Organic Compounds—Any organic compound that participates in atmospheric photochemical reactions except for those designated by the

Environmental Protection Agency administrator as having negligible photochemical reactivity.

W

Weather Adjusted—(Or weather normalized) Having the effects of the difference between actual and expected normal weather removed. For example, TVA forecasts summer peaks for a normally expected Valley-wide average temperature of 96 degrees. If the peak one year occurs at 100 degrees, a weather adjusted peak will be estimated by applying a per degree adjustment factor to the four-degree difference.

Energy Vision

2020

8

Volume 2, Technical Document

Resource Integration

Volume 2, Technical Document 8
Resource Integration

Contents

This technical document has eight major sections that were originally separate information items. These were used in various discussions on the resource integration process that TVA used to develop Energy Vision 2020.

Resource Integration

STRATEGY MATRICES

The Strategy Matrices are detailed descriptions of the supply-side, environmental, customer service, and transmission improvement options contained in each strategy. The first strategy matrix, *Figure T8-1*, depicts how the initial strategies were formed from a list of customer service, supply-side expansion, and nuclear refinement strategies. By analyzing how each strategy behaves under key uncertainties, some strategies were eliminated and some new ones were created. In the second strategy matrix, *Figure T8-2*, many new strategies were formed to provide more flexibility to Energy Vision 2020, TVA's Integrated Resource Plan (IRP). The third strategy matrix, *Figure T8-3*, represents the final strategies that were evaluated in order to develop the Energy Vision 2020 portfolio.

FIGURE T8-1. **Strategy Matrix for Year 2010**

18-JAN-95

Acronym Key:
BFN Browns Ferry Nuclear Plant
BLN Bellefonte Nuclear Plant
CC Natural Gas Combined Cycle
CT Combustion Turbine
IGCC Integrated Gasification Combined Cycle
IPP Independent Power Producer
WBN Watts Bar Nuclear Plant
CO2 Carbon Dioxide
SO2 Sulfur Dioxide

	SUPPLY PROFILE						ENVIRONMENT		
	Nuclear (MW)	Coal (MW)	Natural Gas (MW)	Hydro & Storage (MW)	Renewables (MW)	Purchased Power (MW)	Clean Air Strategy	Biomass Cofiring	CO_2 Dispatch
Existing System in 1996	5577	14968	2292	5498	0	2300			
Existing System in 2010	5577	14968	2292	5498	0	1100			
Changes from Existing System									
Reference CC/IPP/Coal with Low-Price DSM	0	1155	5930	0	0	1740	Reference	No	No
Customer Service Strategies									
1 CC/IPP/Coal with No DSM	0	1575	6720	0	0	1740	Reference	No	No
2 CC/IPP/Coal with Block 1 DSM	0	1890	5310	0	0	1440	Reference	No	No
3 CC/IPP/Coal with Blocks 1 & 2 DSM	0	1155	4840	0	0	720	Reference	No	No
4 CC/IPP/Coal with Blocks 1, 2, & 3 DSM	0	735	4520	0	0	0	Reference	No	No
5 CC/IPP/Coal with Low-Price DSM	0	1155	5930	0	0	1740	Reference	No	No
6 CC/IPP/Coal with Low BE	0	1890	6570	0	0	1740	Reference	No	No
7 CC/IPP/Coal with High BE	0	1890	6720	0	0	1740	Reference	No	No
Supply-Side Expansion Strategies									
1 Coal Expansion	0	5168	3600	0	0	0	Reference	No	No
2 CC/Coal Expansion	0	1890	6890	0	0	0	Reference	No	No
3 CC Renewable Expansion	0	0	7490	0	1700	0	Reference	No	No
4 CC and IPP Expansion	0	0	6250	0	0	2520	Reference	No	No
Nuclear Refinement Strategies									
1 Defer WBN/BFN and Build	2235	735	4690	0	0	1140	Reference	No	No
2 Defer WBN/BFN and Cancel	0	1890	5010	0	0	1860	Reference	No	No
3 Defer BLN and Build	2424	0	5010	0	0	1440	Reference	No	No
4 Defer BLN and Cancel	0	1155	4990	0	0	1440	Reference	No	No
5 Convert BLN to CC	0	1575	6590	0	0	720	Reference	No	No
6 Partner BLN as Nuclear	1212	1155	5610	0	0	2040	Reference	No	No
7 Partner BLN as IGCC/Coproduct	0	1890	5010	0	0	1924	Reference	No	No
8 Convert BLN to IGCC/Coproduct	0	2520	5140	0	0	1140	Reference	No	No
9 Cancel Four Nuclear Units	0	1890	5010	0	0	1860	Reference	No	No
10 Cancel Three Nuclear Units/Build WBN 2	1170	1890	5010	0	0	720	Reference	No	No
Mixed Strategies									
1 Minimum Debt, Purchases/IPP/IPP Expansion	0	24	3750	0	0	5380	Fuel Switch	No	No
7 Low-Cost Producer 1, CC/IPP/Coal Expansion	0	1890	4710	163	0	1140	Reference	No	No
8 Low-Cost Producer 2, Coal/Coal Expansion	0	4253	3800	163	0	0	Reference	No	No
10 Max "Customer Value Index" (Off-Sys Sales, High BE, Declining Blk)	0	2933	4050	163	0	0	Reference	0.3%	No
11 Low TRC, Coal Expansion, and High DSM	0	1155	3900	163	0	0	Reference	0.3%	No
12 Max. Sales, Coal and Stor. Expn, High Off-Sys Sales	0	1613	7392	668	0	0	Reference	No	No
14 Competitive 1	0	1575	4880	1	0	2460	Reference	No	No
15 Competitive 2	0	1575	7190	1	0	1560	Reference	No	No
2 Min CO_2, Natural Gas Repowering	0	-1931	8850	163	0	0	Repowering	1.3%	Yes
3 Min CO_2, Nat Gas Repowering, & Renewables	0	-1931	4665	163	2240	0	Repowering	1.3%	Yes
4 Max Conservation	0	0	3876	163	0	1200	Reference	0.3%	No
5 Green Strategy, Waste Methane, Wind, & Solar	0	-1931	4721	668	3500	0	Repowering	0.3%	Yes
6 Renew, Waste Methane, Wind, Solar, & Biomass	0	-1931	3971	668	5740	0	Repowering	0.3%	Yes
13 Distributed Generation, CC, Cogen, IPP, & Fuel Cells	0	0	6310	0	500	3300	Reference	No	No
16 Maximum Diversity	0	1155	4676	506	700	1560	Reference	1.3%	No
17 Environmental Sustainability	0	-2609	8181	1011	300	0	Repowering	1.3%	Yes

Notes:
1. The reference strategy, cancel BLN 1 & BLN 2, defer and cancel WBN 2 and BFN 1 with a CC, IPP, coal expansion with low-price DSM provides common point for trade-off plots.
2. Reference clean air strategy is scrub Paradise Unit 3 and Allen Units 1-3 with various fuel switches.
3. Repowering clean air strategy is natural gas combined cycle repowering of Johnsonville and Allen units.
4. Fuel switching clean air strategy is switch to low sulfur coal at most plants and switch to natural gas at Allen.
5. Renewables include solar, wind, short rotation woody crops (SRWC), refuse-derived fuel (RDF), and methane options.

Initial strategies were formed from a list of customer service, supply-side expansion, and nuclear refinement options.

CUSTOMER SERVICE, PRICING/RATES					TRANSMISSION
DSM (MW)	Off Sys. Sales (MW)	Beneficial Electrification (MW)	Pricing (Time-of-Day/ Declining Block) (MW)	Price Feedback (MW)	Transmission Improvements
-1120	0	0	0	138	No
0	0	0	0	112	No
-1365	0	0	0	23	No
-2997	0	0	0	191	No
-4183	0	0	0	302	No
-1120	0	0	0	138	No
0	0	89	0	203	No
0	0	196	0	103	No
-1122	0	0	0	112	No
-1122	0	0	0	23	No
-1120	0	0	0	191	No
-1119	0	0	0	302	No
-1118	0	0	0	-160	No
-1119	0	0	0	55	No
-1118	0	0	0	-112	No
-1120	0	0	0	83	No
-1120	0	0	0	201	No
-1120	0	0	0	246	No
-1122	0	0	0	711	No
-1123	0	0	0	892	No
-1119	0	0	0	95	No
-1120	0	0	0	410	No
0	0	0	-892	-1137	No
-1118	1000	144	-892	297	No
-1120	1000	144	-892	767	No
-2930	0	196	169	670	No
-4185	0	0	0	395	No
0	2000	0	0	1007	Yes
-1118	0	0	0	-50	No
0	0	196	0	-27	No
-4180	0	0	0	35	No
-4187	0	0	0	535	Yes
-4183	0	0	0	276	Yes
-4487	0	0	0	596	No
-4468	0	0	0	256	No
0	0	0	0	-331	No
-1118	0	76	0	110	No
-4178	0	0	0	-87	No

FIGURE T8-2. Strategy Matrix for Years 2005 and 2020

09-MAR-95

Acronym Key:
BFN Browns Ferry Nuclear Plant
BLN Bellefonte Nuclear Plant
CC Natural Gas Combined Cycle
CT Combustion Turbine
IGCC Integrated Gasification Combined Cycle
IPP Independent Power Producer
WBN Watts Bar Nuclear Plant
CO2 Carbon Dioxide
SO2 Sulfur Dioxide

		SUPPLY PROFILE						ENVIRONMENT			CUSTOMER SERVICE, PRICING/RATES				
	Year	Nuclear (MW)	Coal (MW)	Natural Gas (MW)	Hydro & Storage (MW)	Renewables (MW)	Purchased Power (MW)	Clean Air Strategy	Biomass Cofiring	CO_2 Dispatch	DSM (MW)	Off Sys. Sales (MW)	Beneficial Electrification (MW)	Pricing (Time-of-Day/ Declining Block) (MW)	Price Feedback (MW)
Existing System in 2005		5577	14968	2292	5498	0	1800								
Existing System in 2020		5577	14968	2292	5498	0	1000								
Changes From Existing System															
2 Min CO_2 - (Nat Gas Repowering	2005	0	-1931	4835	0	0	0	Repowering	1.3%	Yes	-3171	0	0	0	-147
of Existing Coal)	2020	0	-1931	14300	162	0	0	Repowering	1.3%	Yes	-1480	0	0	0	-1990
3 Min CO_2 - (Nat Gas Repowering	2005	0	-1931	3765	0	740	0	Repowering	1.3%	Yes	-3172	0	0	0	-85
of Existing Coal & Renewables)	2020	0	-1931	11265	162	3840	0	Repowering	1.3%	Yes	-1480	0	0	0	-1347
8 Low-Cost Producer	2005	0	2378	2400	0	0	0	Reference	No	No	-999	1000	62	-796	367
(Coal-Based)	2020	0	9053	5400	162	0	0	Reference	No	No	-517	0	25	-1043	-216
9 Reference (Combined Cycle,	2005	0	0	4430	0	0	925	Reference	No	No	-997	0	0	0	57
Purchased Power, Coal)	2020	0	5775	8520	0	0	1225	Reference	No	No	-517	0	0	0	-596
10 Max "Customer Value Index" (Off-	2005	0	2978	2700	0	0	0	Reference	0.3%	No	-997	1000	180	167	242
Sys Sales, High BE, Declining Blk)	2020	0	9953	5850	162	0	0	Reference	0.3%	No	-517	0	71	169	-237
11 Low TRC/High DSM	2005	0	300	2250	0	0	0	Reference	0.3%	No	-3169	0	0	0	-268
	2020	0	7230	5550	162	1500	0	Reference	0.3%	No	-1480	0	0	0	-437
12 Maximum Sales	2005	0	878	5820	0	0	0	Reference	0.3%	No	0	1000	180	0	493
	2020	0	5078	10474	162	0	0	Reference	0.3%	No	0	0	71	0	-385
16 Maximum Capacity Diversity	2005	0	0	3902	0	0	625	Reference	1.3%	No	-999	0	62	0	122
	2020	0	5355	6122	162	1640	775	Reference	1.3%	No	-517	0	25	0	-629
18 Bellefonte Nuclear Partnership	2005	600	0	3960	0	0	775	Reference	1.3%	No	-998	0	0	0	55
	2020	600	5775	8050	0	0	1075	Reference	1.3%	No	-516	0	0	0	-542
20 Bellefonte Coproduct and	2005	0	0	2550	0	500	2284	Reference	0.3%	No	-997	0	0	0	330
Renewables	2020	0	5775	5850	162	1500	2584	Reference	0.3%	No	-517	0	0	0	184
23 Defer and Build BFN 1 and WBN 2	2005	1170	0	3510	0	0	775	Reference	No	No	-997	0	0	0	-285
with Reference Expansion	2020	2235	5355	6810	0	0	775	Reference	No	No	-517	0	0	0	-774
24 Minimize CO_2 with Less DSM	2005	0	-1931	5110	0	740	0	Repowering	1.3%	Yes	-2048	0	0	0	180
	2020	0	-1931	11735	162	3640	0	Repowering	1.3%	Yes	-958	0	0	0	-1384
28 Combined DSM and	2005	0	1778	2400	0	0	0	Reference	0.3%	No	-2047	1000	0	0	229
Off-Sys Sales	2020	0	7553	5700	162	1500	0	Reference	0.3%	No	-957	0	0	0	-274
29 Decentralized Generation	2005	0	0	4430	160	0	775	Reference	No	No	-998	0	0	0	90
with More Renewables	2020	0	0	10860	160	1900	925	Reference	No	No	-517	0	0	0	-1707
32 Bellefonte Coproduct, More DSM,	2005	0	0	2550	0	500	1384	Reference	0.3%	No	-2049	1000	0	0	454
and More Off-Sys Sales	2020	0	6510	5700	162	1500	1534	Reference	0.3%	No	-958	0	0	0	275
34 Low-Cost Renewables,	2005	0	-1931	5284	1011	740	450	Repowering	0.3%	Yes	-998	0	0	0	235
Low-Price DSM, Repowering	2020	0	2307	8115	1173	3340	450	Repowering	0.3%	Yes	-517	0	0	0	-253
39 Flexible Strategy with	2005	0	0	900	0	1000	3773	Reference	0.3%	No	-999	1000	62	0	648
External Options	2020	0	7665	4800	162	1500	1973	Reference	0.3%	No	-517	0	25	0	402
40 Flexible Strategy with	2005	0	0	2570	0	1250	1973	Reference	0.3%	No	-999	1000	62	0	583
Internal Options	2020	0	7665	5720	162	1500	1673	Reference	0.3%	No	-517	0	25	0	454
41 Low Cost, Low Rates,	2005	0	0	2850	0	1250	1534	Reference	0.3%	No	-999	1000	62	0	493
Improved Environment	2020	0	6930	5850	162	1500	1534	Reference	0.3%	No	-517	0	25	0	369

Notes:
1. The reference strategy, cancel BLN 1 & BLN 2, defer and cancel WBN 2 and BFN 1 with a CC, IPP, coal expansion with low-price DSM provides common point for trade-off plots.
2. Reference clean air strategy is scrub Paradise Unit 3 and Allen Units 1-3 with various fuel switches.
3. Repowering clean air strategy is natural gas combined cycle repowering of Johnsonville and Allen units.
4. Fuel switching clean air strategy is switch to low sulfur coal at most plants and switch to natural gas at Allen.
5. Renewables include solar, wind, short rotation woody crops (SRWC), refuse-derived fuel (RDF), and methane options.
6. Off-system sales begin in 1996 and end in 2004.
7. Strategies 3 and 12 contain additional transmission system capital and efficiency improvements.

New strategies were formed to provide more flexibility to TVA's Integrated Resource Plan.

TRANSMISSION	CAPACITY AND ENERGY BY FUEL TYPE											
Transmission Improvements	Nuclear (MW)	Nuclear (GWH)	Coal (MW)	Coal (GWH)	Natural Gas (MW)	Natural Gas (GWH)	Hydro & Storage (MW)	Hydro & Storage (GWH)	Renewables (MW)	Renewables (GWH)	Purchased Power (MW)	Purchased Power (GWH)
	5577	30171	14968	96212	2292	1009	5498	19268	0	0	1800	
	5577	32414	14968	100654	2292	1403	5498	20780	740	5898.5	1000	
		(CF)		(CF)		(CF)		(CF)		(CF)		(CF)
Yes	5577	67.1%	13037	84.2%	7127	20.4%	5498	42.4%	0	0	1800	4.4%
Yes	5577	67.1%	13037	85.1%	16592	39.1%	5660	42.1%	0	0	1000	0.6%
Yes	5577	67.1%	13037	82.9%	6057	16.4%	5498	42.4%	740	91.0%	1800	4.1%
Yes	5577	67.1%	13037	84.9%	13557	34.1%	5660	42.1%	3640	62.7%	1000	1.1%
No	5577	67.1%	17346	80.5%	4692	11.7%	5498	42.4%	0	0	1800	7.5%
No	5577	67.1%	24021	79.0%	7692	9.7%	5660	42.1%	0	0	1000	1.0%
No	5577	67.1%	14968	82.8%	6722	13.2%	5498	42.4%	0	0	2725	26.0%
No	5577	67.1%	20743	82.2%	10812	11.2%	5498	43.3%	0	0	2225	35.2%
No	5577	67.1%	17946	77.8%	4992	7.9%	5498	42.4%	0	0	1800	4.7%
No	5577	67.1%	24921	75.8%	8142	6.8%	5660	42.1%	0	0	1000	1.1%
No	5577	67.1%	15268	78.5%	4542	7.5%	5498	42.4%	0	0	1800	5.3%
No	5577	67.1%	22198	75.1%	7842	8.1%	5660	42.1%	1500	94.1%	1000	0.7%
Yes	5577	67.1%	15846	83.5%	8112	19.5%	5498	42.4%	0	0	1800	4.0%
Yes	5577	67.1%	20046	83.7%	12766	21.0%	5660	42.2%	0	0	1000	0%
No	5577	67.1%	14968	83.2%	6194	18.4%	5498	42.4%	0	0	2425	24.6%
No	5577	67.1%	20323	82.4%	8414	16.0%	5660	42.2%	1640	28.6%	1775	30.3%
No	6177	67.9%	14968	81.5%	6252	11.5%	5498	42.4%	0	0	2575	41.4%
No	6177	67.9%	20743	81.4%	10342	10.5%	5498	43.3%	0	0	2075	54.4%
No	5577	67.1%	14968	81.3%	4842	6.4%	5498	42.4%	500	94.1%	4084	27.5%
No	5577	67.1%	20743	80.0%	8142	6.4%	5660	42.1%	1500	94.1%	3584	28.4%
No	6747	63.7%	14968	79.8%	5802	9.2%	5498	42.4%	0	0	2575	21.9%
No	7812	67.1%	20323	79.1%	9102	9.4%	5498	43.3%	0	0	1775	29.1%
No	5577	67.1%	13037	84.4%	7402	22.7%	5498	42.4%	740	91.0%	1800	5.2%
No	5577	67.1%	13037	85.0%	14027	35.3%	5660	42.1%	3640	62.4%	1000	1.1%
No	5577	67.1%	16746	78.0%	4692	7.3%	5498	42.4%	0	0	1800	4.7%
No	5577	67.1%	22521	75.7%	7992	6.7%	5660	42.1%	1500	94.1%	1000	0.8%
No	5577	67.1%	14968	82.7%	6722	13.4%	5658	43.0%	0	0	2575	24.4%
No	5577	67.1%	14968	84.7%	13172	29.7%	5658	44.3%	1900	59.1%	1925	28.0%
No	5577	67.1%	14968	80.5%	4842	6.9%	5498	42.4%	500	94.1%	3184	24.5%
No	5577	67.1%	21478	77.9%	7992	6.6%	5660	42.1%	1500	94.1%	2534	26.6%
No	5577	67.1%	13037	84.5%	7576	25.0%	6509	35.8%	740	91.0%	2250	22.4%
No	5577	67.1%	17275	83.6%	10407	22.9%	6671	35.7%	3340	63.3%	1450	23.3%
No	5577	67.1%	14968	81.3%	3192	5.3%	5498	42.4%	1000	94.1%	5573	22.8%
No	5577	67.1%	22633	76.3%	7092	6.7%	5660	42.1%	1500	94.1%	2973	20.0%
No	5577	67.1%	14968	80.6%	4862	7.2%	5498	42.4%	1250	94.1%	3773	24.5%
No	5577	67.1%	22633	76.4%	8012	6.4%	5660	42.1%	1500	94.1%	2673	21.6%
No	5577	67.1%	14968	80.5%	5142	7.1%	5498	42.4%	1250	94.1%	3334	25.6%
No	5577	67.1%	21898	78.0%	8142	6.8%	5660	42.1%	1500	94.1%	2534	26.9%

FIGURE T8-3. Strategy Matrix for Years 2005 and 2020

09-APRIL-95

Acronym Key:
BFN Browns Ferry Nuclear Plant
BLN Bellefonte Nuclear Plant
CC Natural Gas Combined Cycle
CT Combustion Turbine
IGCC Integrated Gasification Combined Cycle
IPP Independent Power Producer
WBN Watts Bar Nuclear Plant
CO2 Carbon Dioxide
SO2 Sulfur Dioxide

	Year	SUPPLY PROFILE: Nuclear (MW)	Coal (MW)	Natural Gas (MW)	Hydro & Storage (MW)	Renewables (MW)	Purchased Power (MW)	ENVIRONMENT: Clean Air Strategy	Biomass Cofiring	CO_2 Dispatch	CUSTOMER SERVICE, PRICING/RATES: DSM (MW)	Off Sys. Sales (MW)	Beneficial Electrification (MW)	Pricing (Time-of-Day/ Declining Block) (MW)	Price Feedback (MW)
Existing System in 2005		5577	14968	2292	5498	0	1800								
Existing System in 2020		5577	14968	2292	5498	0	1000								
Changes from Existing System															
A 2 Min CO_2 - (Nat Gas Repowering	2005	0	-1931	4695	0	0	0	Repowering	1.3%	Yes	-3171	0	0	0	-187
of Existing Coal)	2020	0	-1931	14425	162	0	0	Repowering	1.3%	Yes	-1480	0	0	0	-1810
B 3 Min CO_2 - (Nat Gas Repowering	2005	0	-1931	3765	0	740	0	Repowering	1.3%	Yes	-3172	0	0	0	-126
of Existing Coal & Renewables)	2020	0	-1931	12150	162	3040	0	Repowering	1.3%	Yes	-1480	0	0	0	-1147
C 8 Low-Cost Producer	2005	0	2378	2400	0	0	0	Reference	No	No	-999	1000	62	-796	330
(Coal-Based)	2020	0	9053	5400	162	0	0	Reference	No	No	-517	0	25	-1043	-254
D 9 Reference (Combined Cycle,	2005	0	0	4430	0	0	925	Reference	No	No	-997	0	0	0	20
Purchased Power, Coal)	2020	0	5775	8520	0	0	1225	Reference	No	No	-517	0	0	0	-620
E 10 Max "Customer Value Index" (Off-	2005	0	2978	2700	0	0	0	Reference	0.3%	No	-997	1000	180	167	203
Sys Sales, High BE, Declining Blk)	2020	0	10388	5850	162	0	0	Reference	0.3%	No	-517	0	71	169	-313
F 11 Low TRC/High DSM	2005	0	300	2250	0	0	0	Reference	0.3%	No	-3169	0	0	0	-302
	2020	0	7230	5550	162	1500	0	Reference	0.3%	No	-1480	0	0	0	-468
G 12 Maximum Sales	2005	0	878	5820	0	0	0	Reference	0.3%	No	-1	1000	180	0	461
	2020	0	5498	9242	1173	0	0	Reference	0.3%	No	0	0	71	0	-341
H 16 Maximum Capacity Diversity	2005	0	0	3380	1011	60	775	Reference	1.3%	No	-999	0	62	0	95
	2020	0	4620	5410	2185	1740	925	Reference	1.3%	No	-517	0	25	0	-701
I 18 Bellefonte Nuclear Partnership	2005	600	0	3960	0	0	775	Reference	1.3%	No	-998	0	0	0	55
	2020	600	5775	8050	0	0	1075	Reference	1.3%	No	-516	0	0	0	-542
J 20 Bellefonte Coproduct and	2005	0	484	2550	0	750	1650	Reference	0.3%	No	-998	0	0	0	318
Renewables	2020	0	6994	5850	162	1500	1950	Reference	0.3%	No	-517	0	0	0	230
K 23 Defer and Build BFN 1 & WBN 2	2005	1170	0	3510	0	0	775	Reference	No	No	-997	0	0	0	-323
with Reference Expansion	2020	2235	5355	6810	0	0	775	Reference	No	No	-517	0	0	0	-799
L 24 Minimize CO_2 with Less DSM	2005	0	-1931	5110	0	740	0	Repowering	1.3%	Yes	-2048	0	0	0	144
	2020	0	-1931	12770	162	2840	0	Repowering	1.3%	Yes	-958	0	0	0	-1191
M 28 Combined DSM and	2005	0	1778	2400	0	0	0	Reference	0.3%	No	-2047	1000	0	0	188
Off-Sys Sales	2020	0	7553	5550	162	1500	0	Reference	0.3%	No	-957	0	0	0	-317
N 29 Decentralized Generation with	2005	0	0	3960	160	0	775	Reference	No	No	-998	0	0	0	39
More Renewables	2020	0	0	10860	160	1900	925	Reference	No	No	-517	0	0	0	-1596
O 32 Bellefonte Coproduct, More DSM,	2005	0	484	2550	0	500	900	Reference	0.3%	No	-2049	1000	0	0	428
and More Off-Sys Sales	2020	0	6994	5700	162	1500	1050	Reference	0.3%	No	-958	0	0	0	263
P 34 Low-Cost Renewables,	2005	0	-1931	6105	0	740	300	Repowering	0.3%	Yes	-998	0	0	0	203
Low-Price DSM, Repowering	2020	0	207	11025	1174	2090	450	Repowering	0.3%	Yes	-517	0	0	0	-771
Q 39 Flexible Strategy with	2005	0	484	900	0	1000	3289	Reference	0.3%	No	-999	1000	62	0	648
External Options	2020	0	8149	4800	162	1500	1489	Reference	0.3%	No	-517	0	25	0	402
R 40 Flexible Strategy with	2005	0	484	2570	0	1000	1489	Reference	0.3%	No	-999	1000	62	0	583
Internal Options	2020	0	8149	5420	162	1500	1489	Reference	0.3%	No	-517	0	25	0	454
S 41 Low Cost, Low Rates,	2005	0	484	2850	0	1250	1050	Reference	0.3%	No	-999	1000	62	0	493
Improved Environment	2020	0	7414	5850	162	1500	1050	Reference	0.3%	No	-517	0	25	0	369
T 44 Low-Cost Renew, Low-Price DSM,	2005	0	-1447	6225	0	0	450	Repowering	0.3%	Yes	-998	0	0	0	390
Repowering, BLN Coproduct Part	2020	0	691	10750	1174	2500	450	Repowering	0.3%	Yes	-517	0	0	0	-55
U 45 Low-Cost Renewables, More DSM,	2005	0	-1447	5145	0	0	300	Repowering	0.3%	Yes	-2048	0	0	0	252
Repowering, BLN Coproduct Part	2020	0	691	10750	1174	2100	450	Repowering	0.3%	Yes	-957	0	0	0	-12

Notes:
1. The reference strategy, cancel BLN 1 & BLN 2, defer and cancel WBN 2 and BFN 1 with a CC, IPP, coal expansion with low-price DSM provides common point for trade-off plots.
2. Reference clean air strategy is scrub Paradise Unit 3 and Allen Units 1-3 with various fuel switches.
3. Repowering clean air strategy is natural gas combined cycle repowering of Johnsonville and Allen units.
4. Fuel switching clean air strategy is switch to low sulfur coal at most plants and switch to natural gas at Allen.
5. Renewables include solar, wind, short rotation woody crops (SRWC), refuse-derived fuel (RDF), and methane options.
6. Off-system sales begin in 1996 and end in 2004.
7. Strategies 3 and 12 contain additional transmission system capital and efficiency improvements.

This table details the final strategies that were evaluated to develop TVA's portfolio of resource options.

TRANSMISSION	CAPACITY AND ENERGY BY FUEL TYPE											
Transmission Improvements	Nuclear (MW)	Nuclear (GWH)	Coal (MW)	Coal (GWH)	Natural Gas (MW)	Natural Gas (GWH)	Hydro & Storage (MW)	Hydro & Storage (GWH)	Renewables (MW)	Renewables (GWH)	Purchased Power (MW)	Purchased Power (GWH)
	5577	30171	14968	96212	2292	1009	5498	19268	0	0	1800	
	5577	32414	14968	100654	2292	1403	5498	20780	740	5898.5	1000	
		(CF)		(CF)		(CF)		(CF)		(CF)		(CF)
Yes	5577	67.1%	13037	84.2%	6987	20.7%	5498	42.4%	0	0	1800	3.4%
Yes	5577	67.1%	13037	85.1%	16717	39.5%	5660	42.1%	0	0	1000	0.7%
Yes	5577	67.1%	13037	82.9%	6057	16.1%	5498	42.4%	740	91.0%	1800	4.0
Yes	5577	67.1%	13037	85.0%	14442	34.2%	5660	42.1%	3040	69.4%	1000	0.3%
No	5577	67.1%	17346	80.4%	4692	11.5%	5498	42.4%	0	0	1800	7.5%
No	5577	67.1%	24021	78.9%	7692	9.6%	5660	42.1%	0	0	1000	1.0%
No	5577	67.1%	14968	82.7%	6722	13.0%	5498	42.4%	0	0	2725	25.8%
No	5577	67.1%	20743	82.2%	10812	11.1%	5498	43.3%	0	0	2225	35.1%
No	5577	67.1%	17946	77.8%	4992	7.7%	5498	42.4%	0	0	1800	4.7%
No	5577	67.1%	25356	74.6%	8142	5.8%	5660	42.1%	0	0	1000	0.8%
No	5577	67.1%	15268	78.4%	4542	7.4%	5498	42.4%	0	0	1800	5.2%
No	5577	67.1%	22198	75.0%	7842	6.0%	5660	42.1%	1500	94.1%	1000	0.7%
Yes	5577	67.1%	15846	83.4%	8112	19.4%	5498	42.4%	0	0	1800	3.9%
Yes	5577	67.1%	20466	83.9%	11534	17.4%	6671	42.2%	0	0	1000	0
No	5577	67.1%	14968	83.6%	5672	12.8%	6509	41.0%	60	87.7%	2575	25.6%
No	5577	67.1%	19588	84.1%	7702	11.7%	7683	41.1%	1740	28.7%	1925	32.5%
No	6177	67.9%	14968	81.5%	6252	11.5%	5498	42.4%	0	0	2575	23.8%
No	6177	67.9%	20743	81.4%	10342	10.5%	5498	43.3%	0	0	2075	32.6%
No	5577	67.1%	15452	81.3%	4842	5.9%	5498	42.4%	750	94.1%	3450	17.4%
No	5577	67.1%	21962	78.7%	8142	5.3%	5660	42.1%	1500	94.1%	2950	15.4%
No	6747	63.7%	14968	79.8%	5802	9.0%	5498	42.4%	0	0	2575	21.9%
No	7812	67.1%	20323	79.1%	9102	9.3%	5498	43.3%	0	0	1775	29.1%
No	5577	67.1%	13037	84.3%	7402	22.7%	5498	42.4%	740	91.0%	1800	5.2%
No	5577	67.1%	13037	85.0%	15062	35.3%	5660	42.1%	2840	71.9%	1000	0
No	5577	67.1%	16746	77.9%	4692	7.1%	5498	42.4%	0	0	1800	4.6%
No	5577	67.1%	22521	75.6%	7842	6.7%	5660	42.1%	1500	94.1%	1000	0.9%
No	5577	67.1%	14968	82.6%	6252	13.8%	5658	43.0%	0	0	2575	25.1%
No	5577	67.1%	14968	84.7%	13152	30.0%	5658	44.3%	1900	59.1%	1925	30.0%
No	5577	67.1%	15452	80.6%	4842	6.8%	5498	42.4%	500	94.1%	2700	13.4%
No	5577	67.1%	21962	78.1%	7992	6.5%	5660	42.1%	1500	94.1%	2050	12.7%
No	5577	67.1%	13037	84.5%	8397	24.0%	5498	42.4%	740	91.0%	2100	17.3%
No	5577	67.1%	15175	84.8%	13317	28.0%	6672	43.4%	2090	75.1%	1450	26.7%
No	5577	67.1%	15452	81.4%	3192	5.2%	5498	42.4%	1000	94.1%	5089	16.7%
No	5577	67.1%	23117	76.4%	7092	6.7%	5660	42.1%	1500	94.1%	2489	7.2%
No	5577	67.1%	15452	81.4%	4862	8.1%	5498	42.4%	1000	94.1%	3289	17.3%
No	5577	67.1%	23117	76.5%	7712	6.4%	5660	42.1%	1500	94.1%	2489	6.9%
No	5577	67.1%	15452	80.6%	5142	7.0%	5498	42.4%	1250	94.1%	2850	15.3%
No	5577	67.1%	22382	78.1%	8142	6.7%	5660	42.1%	1500	94.1%	2050	13.0%
No	5577	67.1%	13521	84.7%	8517	26.9%	5498	42.4%	0	0	2250	19.7%
No	5577	67.1%	15659	84.8%	13042	27.7%	6672	43.3%	2500	69.0%	1450	26.5%
No	5577	67.1%	13521	84.6%	7437	23.6%	5498	42.4%	0	0	2100	15.1%
No	5577	67.1%	15659	84.8%	13042	26.9%	6672	43.3%	2100	76.2%	1450	26.6%

RANKING OF OPTIONS

Following is a set of tables showing the ranking of supply-side and customer service options for Energy Vision 2020. The rankings of these options are used to help create the strategies, as shown in the Strategy Matrices *(Figures T8-1* through *T8-3).*

Figures T8-4 through *T8-12* show supply-side options, and *Figures T8-13* through *T8-18* show customer service options. The options are ranked by several key criteria. The criteria used are total resource costs, rate impact measure (RIM), customer value, average short-term rates, average mid-term rates, debt, and environmental characteristics.

All of the options were standardized in the supply-side and customer service options ranking. In the supply-side ranking, the capacity for base and peaking options was standardized to 500 megawatts and 250 megawatts, respectively. In addition, the construction lead time, if greater than seven years, was adjusted to seven years. One unit of either base or peaking was allowed to come on-line in the year 2001. All other system expansion was completed with pulverized coal and combustion turbine plants.

Customer service options were developed in a similar manner. For purposes of ranking, all customer service blocks were standardized at 250 megawatts. Penetration of a customer service block began in the year 1995 and full penetration (250 megawatts) was completed in the year 2005.

This methodology provides a comparison of supply-side and customer service options on an equal basis. However, the ranking results are not comparable to other expansion results in Energy Vision 2020.

The boldface column on each ranking table provides a frame of reference for purposes of comparison among tables.

FIGURE T8-4. **Bellefonte Repowering Options**

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020		
									SO_2 (Tons)	NO_x (Tons)	CO_2 (KTons)
BLN Repowering - IGCC Coproduction w/ Partners (2x242 MW)	Syn-Gas	86173	51.1	1287	44.8	49.3	30864	34090	521457	437186	139332
BLN Repowering - IGCC Demo w/ Partners (1x250 MW)	Syn-Gas	86460	51.2	1063	44.7	49.3	30572	33812	522020	437360	139053
BLN Repowering - IGCC with Coproduction (11x229 MW)	Coal-Gas	87417	51.7	165	45.0	49.9	31382	34396	520462	436568	139978
BLN Repowering - CC (10x222 MW)	Natural Gas	88158	52.1	-378	44.8	50.3	30478	33326	538600	442571	138940
BLN Repowering - Phased CC/IGCC-Phase A-CC (9x222 MW)	Coal-Gas	88218	52.1	-464	44.9	50.4	30799	33548	529762	439567	138753
BLN Repowering - IGCC (9x250 MW)	Coal-Gas	88241	52.1	-508	45.0	50.4	31011	33744	520248	437839	138586
Supercritical PC Plant (4x300 MW)	**Coal**	**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
BLN Repowering - PC (4x616 MW)	Coal	88317	52.2	-569	44.9	50.4	30853	33837	523942	438145	138931

Acronym Key:

BLN	Bellefonte Nuclear Plant	PC	Pulverized Coal	M	Millions	NO_X	Nitrogen Oxides
CC	Natural Gas Combined Cycle	CO_2	Carbon Dioxide	MW	Megawatts	RIM	Rate Impact Measure
IGCC	Integrated Gasification Combined Cycle	K	Thousands	MWh	Megawatt-Hours	SO_2	Sulfur Dioxide

FIGURE T8-5. Supply Option Comparison (Base Category / Coal Only)

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020		
									SO_2 (Tons)	NO_x (Tons)	CO_2 (KTons)
Shawnee Unit 11 (1x168 MW)	Coal	88137	52.1	-363	44.8	50.3	30544	33400	538592	448260	139224
Partially Completed PC Plant (1x710 MW)	Coal	88147	52.1	-389	44.8	50.3	30732	33584	525128	437768	139082
Advanced PFBC - No Development Cost (1x300 MW)	Coal	88232	52.2	-538	44.9	50.5	30879	33682	524977	437396	138291
State-of-the-Art PC Plant (1x400 MW)	Coal	88242	52.1	-502	44.9	50.4	31029	33910	520914	436690	138526
Supercritical PC Plant (4x300 MW)	**Coal**	**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Restart of WBF (1x56 MW)	Coal	88301	52.1	-498	44.8	50.4	30538	33425	542777	447129	139444
Supercritical PC Plant (4x300 MW)	Coal	88303	52.2	-562	44.9	50.4	30980	33874	524141	438198	139054
Advanced PFBC - w/ Development Cost (1x300 MW)	Coal	88316	52.2	-640	44.9	50.6	31030	33779	524359	437180	138198
Unit Power Purchase-15 Year	Coal	88325	52.2	-546	44.7	50.4	30220	33181	533915	443556	138952
Circulating AFBC (1x200 MW)	Coal	88331	52.2	-591	44.9	50.5	31022	33909	523172	437370	138974
First Generation PFBC (1x340 MW)	Coal	88334	52.2	-568	44.9	50.4	30915	33880	523486	437426	138487
AFBC Repowering, Generic (1x125 MW)	Coal	88344	52.2	-619	45.0	50.5	31441	34150	502340	430923	138665
Supercritical PC Plant (1x300 MW)	Coal	88360	52.2	-626	44.9	50.5	31092	33977	524220	437414	138840
First Generation PFBC Repowering (1x156 MW)	Coal	88395	52.2	-667	45.0	50.5	31471	34183	501609	430616	138078
NUG - Generic IPP Lignite CFBC (1x300 MW)	Coal	88429	52.2	-672	44.7	50.7	30182	33159	528976	440190	139098
Lignite-Fired CFBC (1x200 MW)	Coal	88513	52.3	-750	44.9	50.6	31113	34004	537571	442027	139050
NUG - Generic IPP PC w/ Cogeneration (2x170 MW)	Coal	88614	52.3	-780	44.7	50.7	30182	33080	522594	437188	138766
Generic PFBC Cogeneration (1x70 MW)	Coal	89708	52.9	-1728	44.7	51.4	29945	32688	522164	436896	137064

Acronym Key:

AFBC	Atmospheric Fluidized Bed Combustion
CFBC	Circulating Fluidized Bed Combustion
IPP	Independent Power Producer
NUG	Non-Utility Generation
PC	Pulverized Coal
PFBC	Pressurized Fluidized Bed Combustion
WBF	Watts Bar Fossil Plant
CO_2	Carbon Dioxide
K	Thousands
M	Millions
MW	Megawatts
MWh	Megawatt-Hours
NO_X	Nitrogen Oxides
RIM	Rate Impact Measure
SO_2	Sulfur Dioxide

FIGURE T8-6. **Supply Option Comparison (Base Category / Coal-Gas Only)**

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020: SO_2 (Tons)	NO_x (Tons)	CO_2 (KTons)
Coal Refinery/ IGCHAT, Greenfield (1x530 MW)	Coal-Gas	86778	51.4	688	45.1	49.5	31822	34583	520817	437042	139173
Coal Refinery/IGCC, Greenfield (1x530 MW)	Coal-Gas	86881	51.5	581	45.1	49.6	31934	34730	520747	437046	139067
IGCC w/ Coproduction, Greenfield (1x498 MW)	Coal-Gas	87527	51.8	24	45.1	50.0	31609	34506	520424	437379	139462
IGCHAT w/ Coproduction, Greenfield (1x598 MW)	Coal-Gas	87590	51.8	0	45.0	50.0	31386	34336	520567	437361	139258
IGCHAT w/ Coproduction, F-CT (2x203 MW)	Coal-Gas	87638	51.8	25	45.0	49.9	31338	34273	520592	436206	139776
IGCHAT w/ Coproduction, G-CT (2x420 MW)	Coal-Gas	87790	51.9	-96	44.9	50.0	31211	34032	521038	436376	139672
IGCC w/ Fertilizer Coproduction (3x227 MW)	Coal-Gas	87910	52.0	-238	45.0	50.2	31454	34282	520600	436519	138632
IGCHAT, G-CT (2x420 MW)	Coal-Gas	88138	52.1	-396	44.9	50.3	30856	33679	520295	436050	138591
Coalbed Methane (1x2 MW)	Coal-Gas	88141	52.1	-355	44.7	50.3	30846	33743	518427	437149	137012
IGCHAT, F-CT (2x303 MW)	Coal-Gas	88189	52.1	-449	44.9	50.4	30922	33686	520335	436063	138708
Partnered IGCC w/Coproduction, Greenfield (1x530MW)	Coal-Gas	88193	52.1	-421	44.8	50.4	30550	33318	538769	442732	138934
IGCC (3x245 MW)	Coal-Gas	88237	52.1	-507	44.9	50.4	31023	33900	520107	436280	138182
Supercritical PC Plant (4x300 MW)	**Coal**	**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
NUG-Generic IPP IGCC (1x110 MW)	Coal-Gas	88990	52.5	-1104	44.6	50.9	29927	32988	538026	442356	138404
Coal-Gas - Repowering / Conversion Options											
Repower ALF w/ IGCC (1x500 MW)	Coal-Gas	88364	52.2	-549	44.9	50.4	30919	33749	520946	436546	138459
Repower WBF w/ IGCC (1x242 MW)	Coal-Gas	88497	52.2	-675	44.9	50.5	31039	33828	520628	436447	138561
Repower JOF 1-6 w/ IGCC (1x242 MW)	Coal-Gas	88549	52.3	-747	45.0	50.6	31312	34027	508182	432744	138203
Repower JOF 7-10 w/ IGCC (1x250 MW)	Coal-Gas	88590	52.3	-764	45.1	50.6	31262	33982	505874	432131	138026

Acronym Key:

ALF Allen Fossil Plant
CC Natural Gas Combined Cycle
CHAT Cascaded Humidified Advanced Turbine
CT Combustion Turbine
F F-Series
G G-Series
IGCC Integrated Gasification Combined Cycle
IGCHAT Integrated Gasification Cascaded Humidified Advanced Turbine
IPP Independent Power Producer
JOF Johnsonville Fossil Plant
NUG Non-Utility Generation
PC Pulverized Coal
WBF Watts Bar Fossil Plant
CO_2 Carbon Dioxide
K Thousands
M Millions
MW Megawatts
MWh Megawatt-Hours
NO_X Nitrogen Oxides
RIM Rate Impact Measure
SO_2 Sulfur Dioxide

FIGURE T8-7. **Supply Option Comparison (Base Category / Gas Only)**

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020: SO_2 (Tons)	NO_x (Tons)	CO_2 (KTons)
Landfill Methane (1x2 MW)	Methane	88087	52.0	-294	44.7	50.2	30846	33787	518472	437164	127369
CHAT, F-CT (1x288 MW)	Natural Gas	88158	52.1	-377	44.8	50.3	30508	33287	538942	442617	138931
CC (1x470 MW)	Natural Gas	88204	52.1	-429	44.8	50.4	30599	33492	538341	442587	138870
CC Repowering, Generic (1x425 MW)	Natural Gas	88213	52.1	-440	44.8	50.4	30776	33561	531387	440361	138712
Supercritical PC Plant (4x300 MW)	**Coal**	**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Repower ALF w/ CC (1x705 MW)	Natural Gas	88301	52	-507	45	50	30725	33610	531197	428773	138666
NUG - Generic IPP CC (1x150 MW)	Natural Gas	88326	52.1	-511	44.7	50.4	30182	33212	538736	442762	138787
NUG - Generic IPP CC (2x260 MW)	Natural Gas	88330	52.2	-542	44.7	50.5	30182	33212	521829	437156	137280
Small CC (1x42 MW)	Natural Gas	88339	52.2	-563	44.8	50.5	30661	33586	538189	442805	138783
Repower JOF 7-10 w/ CC (1x465 MW)	Natural Gas	88344	52.2	-608	45.0	50.5	31331	34082	514674	434521	138661
Power Purchase - Base Load (1x300 MW)	Natural Gas	88449	52.2	-633	44.7	50.5	30182	33212	537802	442431	138720
Fuel Cell - MCFC or SOFC (1x2 MW)	Natural Gas	88684	52.3	-785	44.7	50.6	30867	34064	537059	442471	138373
Small Cogeneration CC (3x10 MW)	Natural Gas	89293	52.7	-1387	44.7	51.1	30485	33491	519502	438804	137040
Generic CC Cogeneration (2x210 MW)	Natural Gas	89580	52.8	-1587	44.6	51.2	29880	32901	518960	436333	136234

Acronym Key:

ALF Allen Fossil Plant
CC Natural Gas Combined Cycle
CHAT Cascaded Humidified Advanced Turbine
IPP Independent Power Producer
JOF Johnsonville Fossil Plant
MCFC Molten Carbonate Fuel Cell
NUG Non-Utility Generation
PC Pulverized Coal
SOFC Solid Oxide Fuel Cell
CO_2 Carbon Dioxide
K Thousands
M Millions
MW Megawatts
MWh Megawatt-Hours
NO_X Nitrogen Oxides
RIM Rate Impact Measure
SO_2 Sulfur Dioxide

FIGURE T8-8. **Supply Option Comparison (Base Category / Nuclear Only)**

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
BLN - Partnership	Nuclear	88135	52.1	-382	44.7	50.4	30220	33050	522617	436943	136391
ALWR (1x1300 MW)	Nuclear	88258	52.2	-533	45.0	50.4	31222	33997	518890	435684	135874
Supercritical PC Plant (4x300 MW)	**Coal**	**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Gas Turbine - Modular Helium Reactor (3x289 MW)	Nuclear	88348	52.2	-636	45.1	50.5	31362	34241	519552	435951	135939
BFN 1 Recovery w/ Fixed Cost (1x1065 MW)	Nuclear	88380	52.2	-622	45.0	50.4	30996	33868	523209	437234	136495
Recover BFN 1 (1X1065 MW)	Nuclear	88599	52.4	-863	45.1	50.6	31390	34111	522685	437121	136299
BLN 1&2 Cancellation	Nuclear	88266	52.2	-524	44.9	50.4	30942	33845	524181	437457	138943
BFN 1 Cancellation	Nuclear	88266	52.2	-524	44.9	50.4	30942	33845	524181	437457	138943
WBN 2 Cancellation	Nuclear	88266	52.2	-524	44.9	50.4	30942	33845	524181	437457	138943
Completion of BLN 2 (1x1212 MW)	Nuclear	88338	52.2	-560	44.9	50.3	31064	33886	523272	437236	136542
Completion of WBN 2 (1x1170 MW)	Nuclear	88533	52.3	-773	45.0	50.6	31232	34134	522943	437178	136357
Completion of BLN 1 (1x1212 MW)	Nuclear	88685	52.4	-896	45.1	50.4	31347	34000	523944	437570	136205

Acronym Key:
ALWR Advanced Light Water Reactor
BFN 1 Browns Ferry Nuclear Plant Unit 1
BLN 1&2 Bellefonte Nuclear Plant Units 1&2
WBN 2 Watts Bar Nuclear Plant Unit 2
CO_2 Carbon Dioxide
K Thousands
M Millions
MW Megawatts
MWh Megawatt-Hours
NO_X Nitrogen Oxides
RIM Rate Impact Measure
SO_2 Sulfur Dioxide

FIGURE T8-9. **Supply Option Comparison (Base Category / Renewables Only)**

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
RDF Companion Boiler - WBF (1x60 MW)	RDF	87268	51.6	350	45.0	49.7	31840	34488	521935	438327	136912
RDF Companion Boiler - Kingston (1x60 MW)	RDF	87268	51.6	350	45.0	49.7	31840	34488	521935	438327	136912
RDF - FBC Repower - WBF (1x56 MW)	RDF	87426	51.7	256	45.1	49.7	31956	34799	521528	438149	136835
RDF-Fired Stoker (1x40 MW)	RDF	87514	51.8	29	45.5	49.9	33601	36182	520247	437069	136718
Wind - 39M Variable Speed A Turbine (444x.45 MW)	Renewable	88265.7	52.2	-537	44.9	50.5	31131	34011	522088	436579	138356
Supercritical PC Plant (4x300 MW)	**Coal**	**88266.5**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Wind - 33M Variable Speed A Turbine (285x.35 MW)	Renewable	88303	52.2	-575	44.9	50.5	31159	34031	521858	436496	138318
Biomass WTE Boiler (1x100 MW)	SRWC	88619	52.4	-855	44.9	50.7	30990	33884	537493	442477	137295
Large Solar-Photo - Fixed Flat Plate (1x50 MW)	Solar	88820	52.5	-1105	44.9	51.0	31558	34415	533805	440998	137525

Acronym Key:
A Advanced
FBC Fluidized Bed Combustion
M Meter
PC Pulverized Coal
Photo Photovoltaic
RDF Refuse-Derived Fuel
WBF Watts Bar Fossil Plant
WTE Whole Tree Energy
CO_2 Carbon Dioxide
K Thousands
M Millions
MW Megawatts
MWh Megawatt-Hours
NO_X Nitrogen Oxides
RIM Rate Impact Measure
SO_2 Sulfur Dioxide

FIGURE T8-10. **Supply Option Comparison (Base Category / Hydro Only)**

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_x (Tons)	CO_2 (KTons)
NUG - Generic IPP Run of River Hydro (4x20 MW)	Renewable	88134	52.0	-343	44.7	50.3	30220	33098	536938	441964	138416
Hydro Modernization	Renewable	88394	52.2	-641	44.9	50.5	30902	33799	530570	439794	138793
Hydro - Existing Nonpower Projects (1x10 MW)	Renewable	88522	52.3	-805	45.0	50.7	31542	34275	520160	436025	138243
Hydro - Existing Projects (1x24 MW)	Renewable	88777	52.5	-1077	45.1	50.9	31783	34670	521280	436443	137992
Hydro - New Conventional Projects (1x65 MW)	Renewable	89431	52.9	-1805	45.4	51.6	32985	35382	518447	435504	137341

Acronym Key:
IPP Independent Power Producer
NUG Non-Utility Generation
CO_2 Carbon Dioxide
K Thousands
M Millions
MW Megawatts
MWh Megawatt-Hours
NO_X Nitrogen Oxides
RIM Rate Impact Measure
SO_2 Sulfur Dioxide

FIGURE T8-11. **Supply Option Comparison (Peak Category / Gas Only)**

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_x (Tons)	CO_2 (KTons)
CHAT, G-CT (1x400 MW)	Natural Gas	88141	52.1	-362	44.7	50.3	30494	33322	538715	442532	138919
Water Spray Cooling CT Inlet Air	Natural Gas	88220	52.1	-474	44.9	50.4	30847	33721	524476	437570	139003
Intercooled Aeroderivative CT (1x125 MW)	Natural Gas	88256	52.2	-519	44.9	50.4	30975	33871	524211	437446	138914
Simple Cycle CT (1x150 MW)	Natural Gas	88266	52.2	-524	44.9	50.4	30942	33845	524181	437457	138943
Power Purchase - Peaking (1x300 MW)	Natural Gas	88277	52.2	-526	44.9	50.4	30838	33765	524166	437454	138947
New CT for Steam to DuPont (Johnsonville) (1x174 MW	Natural Gas	88337	52.2	-606	44.9	50.5	31107	33973	523683	437296	138886
Integrated Fuel Cell CT (1x2.5 MW)	Natural Gas	88502	52.3	-726	44.9	50.6	31231	34205	523572	437163	138661

Acronym Key:
CHAT Cascaded Humidified Advanced Turbine
CT Combustion Turbine
G G-Series
CO_2 Carbon Dioxide
K Thousands
M Millions
MW Megawatts
MWh Megawatt-Hours
NO_X Nitrogen Oxides
RIM Rate Impact Measure
SO_2 Sulfur Dioxide

FIGURE T8-12. **Supply Option Comparison (Storage Options Comparison)**

Option	Fuel Type	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020		
									SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
Raccoon Mountain Modernization	Electricity	87891	51.9	-165	44.9	50.1	30994	33823	514655	434026	137708
Raccoon Mountain Addition	Electricity	88030	52.0	-328	45.0	50.3	31169	33922	514987	434183	137615
Advanced Battery (1x20 MW)	Coal	88050	52.0	-333	44.9	50.3	31023	33812	514347	433925	137542
SMES (1x500 MW)	Coal	88052	52.0	-341	44.9	50.3	31092	33882	514415	433964	137567
CAES w/ Recuperation (3x337 MW)	Natural Gas	88197	52.1	-466	44.9	50.4	30956	33753	523053	436994	138930
Inlet Air Precooling w/Storage (16x61 MW)	Natural Gas	88200	52.1	-457	44.9	50.4	30891	33615	524312	437574	138988
CAES w/ Humidification (3x337 MW)	Natural Gas	88206	52.1	-471	44.9	50.4	30943	33699	523890	437252	139007
IGCASH plus NGCASH (1x850 MW)	Natural Gas	88268	52.2	-532	44.9	50.4	31087	33982	518388	435435	138397
Lead Acid Battery (1x20 MW)	Electricity	88292	52.2	-554	44.9	50.5	31011	33901	524370	437513	138933
Rorex Creek Pump-Storage (3x292 MW)	Electricity	88316	52.2	-604	45.0	50.5	31135	33989	525653	437945	139052
Laurel Branch Pump-Storage (4x386 MW)	Electricity	88323	52.2	-611	45.0	50.5	31147	33999	525611	437932	139046
Reynolds Creek Pump-Storage (3x366 MW)	Electricity	88384	52.2	-680	45.0	50.6	31252	34078	525172	437783	138983
IGCASH (1x410 MW)	Coal / Gas	88401	52.2	-676	45.0	50.5	31251	34109	517682	435197	138814
NUG - Generic IPP Pump-Storage	Electricity	88569	52.3	-786	44.9	50.6	30838	33711	523328	437020	138497

Acronym Key:

CAES	Compressed Air Energy Storage	NUG	Non-Utility Generation	MW	Megawatts
IGCASH	Integrated Gasification Compressed Air Storage with Humidification	SMES	Superconducting Magnetic Energy Storage	MWh	Megawatt-Hours
		CO_2	Carbon Dioxide	NO_X	Nitrogen Oxides
IPP	Independent Power Producer	K	Thousands	RIM	Rate Impact Measure
NGCASH	Natural Gas Compressed Air Storage with Humidification	M	Millions	SO_2	Sulfur Dioxide

FIGURE T8-13. **Customer Service Options (Beneficial Electrification)**

Option	System Peak MW Impact	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
Supercritical PC Plant (4 X 300 MW)		**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Residential HVAC and Water Heating	110	88780	51.9	2571	44.8	50.3	30600	33524	535702	441408	139580
Process Melting	-71	88817	51.8	-450	44.9	50.4	31336	34043	526744	438231	140179
Cooking and Security Lighting	-22	88822	52.0	3179	44.9	50.5	31304	34209	523538	437094	139696
Process Heating and Melting	-78	88872	51.8	-457	44.9	50.5	31343	34048	526517	438161	140155
Electrotechnologies/ Textiles	-2	89060	51.9	-145	45.0	50.5	31353	34189	525578	437855	140090
Security Lighting and Lawn Mowers	0	89124	51.9	-494	44.9	50.4	30983	33800	529809	439384	139651
Electrotechnologies/ Food Processing	-47	89139	51.8	-457	44.9	50.4	31337	34043	526741	438230	140179
Electrotechnologies/ Chemicals & Metals	-5	89239	51.8	-458	44.9	50.5	31348	34184	526016	437996	140141
Curing & Drying	-16	89511	51.8	-241	44.9	50.5	31347	34052	526334	438102	140130
Environmental Technologies	-29	89802	51.8	-475	44.9	50.5	31345	34049	526461	438147	140149
Fleet Vehicles	0	89933	52.0	-140	45.0	50.6	31016	33782	530207	439499	139572
Space Conditioning and Water Heating	-19	91311	51.5	14265	45.2	50.7	31258	34174	534849	440960	141249
Electric Buses	0	92036	52.0	2685	44.9	50.4	30979	33795	529656	439336	139644
Electric Autos	0	93145	52.0	6689	44.9	50.5	31010	33776	530307	439532	139593

Acronym Key:

CT	Combustion Turbine
CO_2	Carbon Dioxide
HVAC	Heating, Ventilation, Air Conditioning
K	Thousands
M	Millions
MW	Megawatts
MWh	Megawatt-Hours
NO_X	Nitrogen Oxides
RIM	Rate Impact Measure
SO_2	Sulfur Dioxide

FIGURE T8-14. Customer Service Options (Commercial Sector)

Option	System Peak MW Impact	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
Energy Efficient Rates	53	87935	52.7	-1040	45.0	50.6	30600	33508	521306	436510	137385
Water Heating Conversion	27	87950	52.4	-645	44.8	50.4	30590	33597	527044	438430	138233
Commercial Lighting Rebates	417	87980	52.5	-698	44.9	50.5	30593	33502	524854	437685	137798
Comprehensive Measure Financing	105	88029	52.4	-638	44.8	50.4	30591	33280	527894	438762	138033
Comprehensive Appliance Rebates	57	88074	52.5	-648	44.9	50.5	30597	33506	525191	437797	137853
Comprehensive Measure Rebates	190	88109	52.4	-569	44.9	50.5	30596	33138	527913	438783	137993
Commercial New Construction	124	88130	52.5	-672	44.9	50.5	30598	33286	527515	438670	138016
Small Commercial Retrofit-Direct Install	122	88147	52.5	-695	45.0	50.5	30660	33707	525374	437805	138003
Commercial New Construction-Renewables	23	88183	52.4	-563	44.8	50.4	30595	33283	527671	438685	138000
Commercial Cool Storage	57	88238	52.1	-883	44.8	50.4	30596	33155	534000	440930	139002
Commercial HVAC Rebates	133	88256	52.4	-608	44.9	50.5	30566	33322	529300	439282	138227
Supercritical PC Plant (4 X 300 MW)		**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Rooftop Cool Storage	70	88275	52.1	-474	44.8	50.3	30597	33156	533986	440920	138997
Small Commercial HVAC Maintenance Program	14	88395	52.3	314	44.8	50.3	30590	33002	529664	439388	138204

Acronym Key:
CT Combustion Turbine
HVAC Heating, Ventilation, Air Conditioning
CO_2 Carbon Dioxide
K Thousands
M Millions
MW Megawatts
MWh Megawatt-Hours
NO_X Nitrogen Oxides
RIM Rate Impact Measure
SO_2 Sulfur Dioxide

FIGURE T8-15. Customer Service Options (Industrial Sector)

Option	System Peak MW Impact	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
Industrial Tech Rebates - HE Motors	11	87819	52.6	-803	44.9	50.5	30594	33361	523008	437050	137429
Industrial Tech Rebates - AS Drives	4	87969	52.7	-967	45.0	50.6	30569	33179	522697	436968	137169
Industrial Process EE - Distributor Served	110	88037	52.7	-774	44.9	50.5	30561	33171	523051	437055	137186
Industrial Process EE - Direct Served	98	88049	52.7	-776	44.9	50.5	30562	33171	523011	437043	137180
Supercritical PC Plant (4 X 300 MW)		**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Industrial Tech Rebates - CA Efficiency	3	88356	52.7	-893	45.1	50.7	30515	33443	522273	436820	137311

Acronym Key:
AS Adjustable Speed
CA Compressed Air
CT Combustion Turbine
EE Energy Efficiency
HE High Efficiency
Tech Technology
CO_2 Carbon Dioxide
K Thousands
M Millions
MW Megawatts
MWh Megawatt-Hours
NO_X Nitrogen Oxides
RIM Rate Impact Measure
SO_2 Sulfur Dioxide

FIGURE T8-16. **Customer Service Options (Residential Sector)**

Option	System Peak MW Impact	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
Res Water Heater Conversion Program	89	87725	52.8	-610	44.9	50.6	30594	33556	519719	435940	137147
Res Refrigerator Turn-in	18	87834	52.9	-828	45.2	50.6	30516	33773	521465	436542	137386
Res Heat Pump Water Heater Leasing	88	87855	52.8	-2661	44.9	50.6	30556	33313	520491	436216	136960
Res Efficiency Products Catalog	99	87864	52.6	-582	44.9	50.5	30590	33596	523229	437142	137720
Res New Homes	121	87889	52.6	-649	44.9	50.5	30594	33283	524254	437503	137494
Res Lighting Retail Component	75	87892	52.5	-659	44.8	50.5	30592	33359	524547	437571	137621
Res Heat Pump Leasing	334	87931	52.3	-735	44.8	50.4	30590	33358	528759	439077	138249
Res Low Income	66	87935	52.6	-593	45.0	50.6	30596	33505	523160	437136	137608
Res Direct Install	386	87937	52.6	-585	45.0	50.6	30595	33649	522999	437069	137746
Res Heat Pump Rebates	305	87969	52.4	-415	44.8	50.4	30592	33134	528956	439143	138159
Res Self-Audit	22	87995	52.5	-988	44.9	50.5	30593	33646	523753	437296	137905
Res Student Self-Audit	22	88042	52.6	-1010	44.9	50.5	30606	33515	524314	437524	137691
Res Ground Source Heat Pump Leasing	19	88061	52.3	-1934	44.8	50.3	30558	32618	531340	440046	137928
Res Heat Pump Loans	317	88079	52.3	-477	44.8	50.4	30592	33229	529434	439304	138353
Res Efficient Air Conditioning	85	88131	52.2	-436	44.8	50.4	30595	33283	530994	439848	138588
Res Appliance Rebates	26	88230	52.9	-999	45.2	50.9	30560	33338	522149	436717	136873
Supercritical PC Plant (4 X 300 MW)		**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**

Acronym Key:

CT	Combustion Turbine	K	Thousands	MWh	Megawatt-Hours	SO_2	Sulfur Dioxide
Res	Residential	M	Millions	NO_X	Nitrogen Oxides		
CO_2	Carbon Dioxide	MW	Megawatts	RIM	Rate Impact Measure		

FIGURE T8-17. **Customer Service Options (Load Management Programs)**

Option	System Peak MW Impact	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020 SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
Commercial Group Load Curtailment	173	88096	52.2	-446	44.8	50.4	30589	33226	532452	440356	138799
Res Load Management - Air Conditioners	54	88179	52.2	-539	44.8	50.4	30591	33645	530137	439487	138812
Supercritical PC Plant (4 X 300 MW)		**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Res Load Management w/ SCADA	32	88294	52.2	-681	44.9	50.6	30746	34077	527879	438532	138745
Res Load Management - Water Heaters	86	88328	52.2	-674	44.9	50.5	30592	33555	530515	439642	138780
Flexible Load Managed Water Heater Program	86	88378	52.2	-656	44.9	50.5	30622	33581	531283	439866	138780
Res Load Management - Storage Water Heaters	41	88463	52.3	-791	45.0	50.6	30631	33590	530444	439604	138687
Res Load Management - New Technology	64	88474	52.3	-806	45.2	50.5	30840	34169	527053	438305	138691

Acronym Key:

CT	Combustion Turbine	CO_2	Carbon Dioxide	MWh	Megawatt-Hours
Res	Residential	K	Thousands	NO_X	Nitrogen Oxides
SCADA	Supervisory Control and Data Acquisition Systems	M	Millions	RIM	Rate Impact Measure
		MW	Megawatts	SO_2	Sulfur Dioxide

FIGURE T8-18. **Customer Service Options (Miscellaneous Programs)**

Option	System Peak MW Impact	Total Resource Costs (95 M $)	RIM Test ($/MWh)	Customer Value Test (95 M $)	Short-Term Rates ($/MWh)	Mid-Term Rates ($/MWh)	Debt 2001 (M $)	Debt 2007 (M $)	Emissions Average Annual 1996-2020		
									SO_2 (Tons)	NO_X (Tons)	CO_2 (KTons)
Landfill Gas/ Fuel Cells	43	87544	52.6	-594	44.8	50.4	30553	33310	522179	436724	137086
Small Head Hydro	5	87717	52.7	-428	44.9	50.5	30591	33554	521513	436547	137435
Existing Cogeneration - Commercial	75	87842	52.5	-557	44.8	50.4	30588	33642	524667	437629	137965
Commercial Flexible Lighting Options	570	87963	52.5	-603	44.9	50.5	30592	33462	524997	437715	137862
New Cogeneration - Industrial	30	88031	52.6	-622	44.9	50.5	30588	33642	521910	436688	137596
Flexible Comprehensive Financing	224	88044	52.4	-536	44.8	50.4	30591	33279	527532	438632	137963
Flexible Group Load Curtailment	275	88161	52.2	-507	44.8	50.4	30589	33643	529877	439360	138792
New Cogeneration - Commercial	17	88193	52.4	-541	44.8	50.4	30589	33643	525770	438011	138129
Supercritical PC Plant (4 X 300 MW)		**88266**	**52.2**	**-524**	**44.9**	**50.4**	**30942**	**33845**	**524181**	**437457**	**138943**
Photovoltaics/ Technology Advancement	2	88610	52.3	378	44.8	50.4	30594	33152	530673	439760	138431
Photovoltaics	1	89099	52.3	1631	44.9	50.4	30603	33292	529929	439503	138375

Acronym Key:

CT	Combustion Turbine	M	Millions	NO_X	Nitrogen Oxides
CO_2	Carbon Dioxide	MW	Megawatts	RIM	Rate Impact Measure
K	Thousands	MWh	Megawatt-Hours	SO_2	Sulfur Dioxide

UNCERTAINTY IN THE RESOURCE PLAN

Summary

Energy resource plans being made today must account for the undeniable fact that the future will be unlike expectations of the future. If TVA knew the future state of the energy world, resource plans could be made simply to best meet various planning criteria. However, the future is uncertain. Resource plans must account for a range of possible future events. Plans must be flexible enough to change as certain key parameters change; also, they should be able to withstand shifts in the long-term parameters that drive electric utility operation.

UNCERTAINTY TREATMENT PROCESS

An exhaustive list of parameters that could vary in the future was identified through discussions in the Energy Vision 2020 Building Block teams, the Energy Vision 2020 Review Group, the Forecast Review Board, the Tennessee Valley Industrial Committee, Tennessee Valley Public Power Association, and environmental review groups; as well as reviews of other utility resource plans. Almost 50 individual items were identified as uncertain items to be explored in Energy Vision 2020.

Each uncertain item is described and a range of possible outcomes identified for the future. Since in Energy Vision 2020, TVA is evaluating its resource options for a number of planning criteria, variations in the item are needed for the different criteria. Four planning criteria are being used to represent the more extensive list. These are total resource costs, electric rates, carbon dioxide output, and debt.

RESULTS OF THE UNCERTAINTY REVIEW PROCESS

The evaluation of each uncertain item for the four planning criteria shows items that are most critical in future resource planning. They result in the largest variation from the mid-range forecast and thus should be considered further in the next, more detailed phase of the evaluation.

Issues that were found to be most sensitive include the following;

- Load Growth
- Nuclear Issues
  - Capacity Factor
  - Operations and Maintenance Cost
  - Capital Cost
- Environmental Issues
  - Carbon Dioxide Compliance
  - Air and Water Environmental Controls
- Price
  - Natural Gas
  - Revenue from Coproducts (Combined Cycle)

Issues for which selected sensitivity evaluation can be performed include the nuclear moratorium and the inability to site central station generating capacity.

Process to Represent Uncertainty in the Resource Plan

As stated previously, if TVA knew the future state of the energy world, resource plans could be made simply. Alternative actions would be chosen to meet the various planning criteria without risk.

The real world is, however, highly uncertain. When energy resource plans were being made for 1995 twenty years ago, innumerable factors about the energy world in 1995 were not known. Load growth was projected to double every seven years. Construction costs were projected to be stable with project construction lead times short; fuel prices were to remain relatively low. Of course, these projections were far from the actual experience. Neither the Public Utility Regulatory Policy Act, the National Energy Act of 1992, nor the pile of regulations brought on by such events as Three Mile Island existed. There were no regulations on sulfur dioxide emissions and other environmental issues. Forecasting twenty years into the future still remains highly speculative, yet planning resource capabilities requires a long-term outlook.

Resource plans must account for a range of possible future events. Plans should be sufficiently flexible to change as key parameters change, and they should, once implemented, be capable of withstanding shifts in the long-term parameters that drive electric utility operation (robustness).

FIGURE T8-19.
Normal Distribution

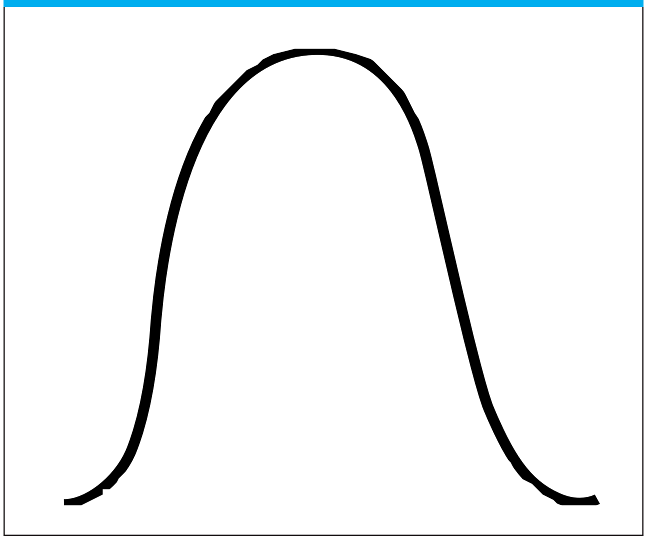
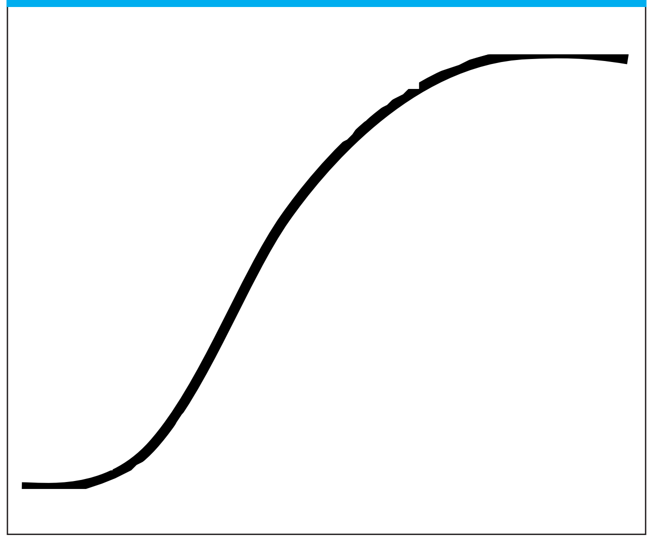


FIGURE T8-20.
Cumulative Distribution



Two important questions are: "What future events should be considered when making resource plans?" and "What future events, if known today, would change the plan significantly?" In the planning process, it is desirable to ensure that all parameters that can impact resource plan selection are sufficiently represented and considered.

Identification of numerous parameters that could vary in the future is the first step in the representation of uncertainty. An exhaustive list of parameters has been developed through discussions by the Energy Vision 2020 Building Block teams, the Forecast Review Board, and Energy Vision 2020 Review Group and in analyzing resource plans from many other utilities.

Each issue or parameter must be quantified so that its impact on resource plans can be evaluated. A wide range of future possibilities of the parameter was developed that typically is represented by a probability distribution as described in the following section.

An exhaustive resource evaluation would include every parameter that has been identified as an issue. This list of anywhere from 20 to 100 issues would be explored fully and all evaluations would consider their impacts.

Realistically and computationally, the number of parameters must be reduced to those that are significant to the decision at hand. In order to determine those uncertain parameters that can significantly impact a resource planning decision or actually change a decision, a sensitivity evaluation is performed on each parameter.

These sensitivity diagrams, sometimes referred to as "tornado" diagrams because of their shape, help to narrow the large number of uncertain issues to a much smaller, more manageable list.

Issues that can cause significant impacts on resource plan results are then used in the complete, detailed evaluation and integration of supply- and demand-side alternatives.

A Quantifiable Description of the Future

Given that the future is so uncertain, how can it be considered? In general, parameters can be described mathematically by a probability distribution. A probability distribution describes the likelihood of the value of a parameter. Typically, a "normal" distribution can be used to describe most uncertain parameters. *Figure T8-19* shows a normal distribution where the y-axis indicates the probability of the value that occurs on the x-axis.

A cumulative distribution can then be constructed that accumulates the probabilities and the values sum so that *Figure T8-19* becomes as shown in Figure *T8-20*. The y-axis accumulates to 1.0 (or 100 percent). The accumulated level represents that percentage of the values that are at least that large.

In order to utilize this information in a resource plan, it is necessary to determine discrete values that can be used to represent the distribution. Typically, 3 points on the cumulative probability distribution are chosen to represent the curve so that the points represent a value that has a 10 percent prob-

FIGURE T8-21. **Uncertainty Items from Sample IRPs**

Bonneville Power Administration
- Load Growth
- Salmon Migration
- System Operation
- Endangered Species Act
- Availability of Reserves
- Capacity from Neighbors (Contracted)
- Extreme Weather Impacts

Duke Power Company
- Load Growth
- Load Factor
- Coal Fuel Price Escalation
- Oil Fuel Price Escalation
- Capital Cost (Coal, Combustion Turbine, Combined Cycle)

Entergy
- Weather
- Mechanical Failures
- Customer Demand
- Inflation
- Fuel Prices (Gas & Oil)

Georgia Power Company
- Financial
- Environmental Cost
- Load Growth
- Fuel Cost
- Unit Cost

New England Electric System
- Load Growth
- Schedule Delays
- Conservation/Load Management Effectiveness
- Performance of Existing Facilities
- Schedule Delays of Cogeneration Sources
- Future Gas & Coal Prices
- Non-Utility Generator Siting/Licensing Problems
- Externalities

Niagara Mohawk Company
- Load Growth
- Economic Growth
- Fossil Fuel Prices
- Regulation
- Externalities
- Non-Utility Generators (NUGS)
- Demand-Side Management (DSM) Participation

Pacific Corporation
- Load Growth
- Electrification
- Loss of Resources
- High Gas Prices
- Carbon Dioxide Tax
- Environmental Externalities
- Renewable Resources
- Demand-Side Acquisition
- Plant Performance

Virginia Electric Power Company
- Economic Growth
- Load Growth
- Fossil Fuel Prices
- Regulation
- Price of Sulfur Allowance
- Demand-Side Effectiveness
- Plant Efficiency and Reliability

Wisconsin Power and Light Company
- Economy
- Fuel Price
- Fuel Availability
- Technologies

Uncertain parameters considered as issues by other electric utilities throughout the country are shown in this table.

ability of being that amount or less; a 50 percent probability of being that amount or less; and a 90 percent probability of being that amount or less.

These three points represent, respectively, approximately 25, 50, and 25 percent of the distribution.

There are numerous techniques available for developing these cumulative probability distributions. Such techniques include probability assessment interviews with experts, delphi techniques, and historical data.

Typical Uncertain Parameters in Integrated Resource Planning

Figure T8-21 shows parameters considered in sample integrated resource plans from electric utilities in the country over the past five years. Some issues, such as load growth and fuel cost, are fairly standard. Other issues may be regional, such as “Salmon Migration” an issue important in the Pacific Northwest. In this part of the country, it may be air quality in the Smoky Mountain National Park or mining restrictions for Appalachian coal.

FIGURE T8-22. **Example of Future Drivers in Utility Industry and How They Translate into Resource Planning Parameters**

DRIVERS (SAMPLES)	TRANSLATE INTO THIS UNCERTAIN PARAMETER
Environment	
• Continuing Increase in Controls	Cost of Existing Coal Availability of Existing Coal
• Local Requirements	Cost/Availability of Coal
Fuel Markets	
• Low-Cost Alternate Fuels	Low Fuel Price
• High Availability of Renewables	Low-Cost Renewable
• Reduced Availability of Gas/Oil	Gas Price
• Abundance of Gas/Oil	Gas Price
• Foreign Markets Develop for U.S. Coal	High Coal Price
Nuclear Industry	
• Public Acceptance, Good Performance, Relicense	Unit Availability Capacity Factor
• Increase Regulatory Requirements	Capacity Factor Schedule Delays Cost
• Moratorium on Nuclear Power	Unit Availability
Regulation	
• Fence Stays/Lose Anti-Cherry Picking	Lose Load
• Wholesale Deregulation	Gain/Lose Load
• Retail Deregulation	Gain/Lose Load
Technology	
• Breakthrough on: Fuel Cells, Combined Cycle, Fusion, Material	Capital Cost Operating Cost
• Transmission Breakthrough	Loss Reduction
• Telecommuting/Interactive Customers	Reduced Load
• Beneficial Electrification	Increased Load
• Cheap Natural Gas End Use	Reduced Load
Economic Activity	
• Cost Containment - Decentralize Work Force	Load Increase
• International Competition: Exports - Technology and Service	Load Increase
• International Competition: Imports Due to U.S. Regulation, High Wages, Declining Material Resources	Load Decrease
• Graying of Valley	Load Increase
Legislation	
• Reduce TVA Debt Ceiling to $15 Billion	Increased Rates
• TVA Chosen as Federal Showplace for Energy and Environment	Increased Load

Issues raised by various groups have been translated into quantifiable values for the resource evaluation.

Specific Uncertainty Building Block Results

The Energy Vision 2020 Uncertainty Building Block Team developed an exhaustive list of issues from previous meetings, other building blocks, and integrated resource plans. Each of these items has been described in this document and a range of outcomes developed. A set of key uncertainties is identified later in this document.

Figure T8-22 shows how the issues raised by various groups have been translated into quantifiable values for the resource evaluation. In the environmental area, for example, the continuing increase in controls on particular environmental emissions can translate into reduced availability of the generating plants, higher capital cost to continue to operate the plants, and increased operation and maintenance costs to operate the plants.

Exhaustive List of Uncertainties for Energy Vision 2020

Figure T8-23 shows the complete list of uncertain parameters that have been considered in Energy Vision 2020. These items are described briefly in the following section.

ISSUE 1: HYDROELECTRIC ENERGY

Energy supplied by the TVA-operated hydroelectric plants varies depending on weather and associated rainfall patterns in the Valley.

Historical TVA weather and rainfall data for almost 100 years has been modeled with the current TVA hydro system in place. While there are some hydro modernization projects underway, expected hydroelectric generating output is not expected to vary greatly because of it. The range of

FIGURE T8-23. **Uncertainties in Resource Plan**

ITEM	(UNITS)	RANGE Low	Medium	High
HYDRO ENERGY	(Billion kWh)	13	18 [1]	22
COAL				
Capital Additions & Improvements	($/kW/Year) (94$)	12.5	13.6 [1]	14.8
Operating & Maintenance Cost	($/kW/Year) (94$) (Escalation)	21.7 -2% Base	21.7 [1] -1% Base	21.7 +1% Base
Plant Life Extension	(MW)	No Retirements	No Retirements	750 MW Retired
Reliability of New Units	(Equivalent Forced Outage Rate)	6%	9% [1]	20%
Fuel Cost (5# Coal in 2000)	(¢/MBtu) (Escalation Rate)	100 2.8%	109 [1] 3.3%	121 4.0%
Fuel Cost Existing System	(¢/MBtu) (Escalation Rate)	119 3.0%	131 3.5%	146 4.1%
COMBINED CYCLE				
Market Price of Coproduct in 2000 for Integrated Gasification Combined Cycle	($/Ton)	91	262 [1]	320
Gas Cost (2000)	(¢/MBtu) (Escalation Rate)	256 2.4%	342 [1] 5.3%	418 7.9%
NUCLEAR				
Moratorium		Normal Operation	Normal Operation [1]	Units Do Not Operate after 2006
Return to Service/Commercial Operation Date		Base Schedule [1]	12-17 Month Delay	24-33 Month Delay
Capacity Factor	(%)	55	67 [1]	86
Operating Cost	($/kW/Year) (94$)	55	69 [1]	83
Fuel Cost	(¢/MBtu)	35	41 [1]	50
Spent Fuel Storage	($/MWh)	1.0	1.0 [1]	2.0
Capital - Additions & Improvements	($/kW/Year)	9	12 [1]	19
Capital Cost	(Billion $)			
	Bellefonte 1	1.3	2.6 [1]	3.5
	Bellefonte 2	0.9	1.8	2.4
	Watts Bar 2	1.2	2.4	3.2
	Browns Ferry 1	1.1	2.2	2.9
Browns Ferry License Extension		No Extension, Replace in 2013	Yes [1]	Yes
Summer Limits on Discharge Water Temperature		Lose 150 MW	No Impacts [1]	No Impacts
Decommissioning Cost	(Million $/Unit)	200	300 [1]	600
COGENERATION				
Cost	($/kW)	159	175 [1]	263
Availability	(MW)	1800	2000 [1]	N/A
TRANSMISSION				
Electromagnetic Field		No Additional Impacts [1]	+ $50 Million/Unit for New Site Central Generation	+ 50% Cost of Overall Trans-mission System
Transmission Limit Wheeling Requirements		Increased Reserve Margin for 1200 MW of Reduced TM Capability	Normal TM Capability [1]	Normal TM Capability

FIGURE T8-23. **Uncertainties in Resource Plan** *CONTINUED*

ITEM	(UNITS)	RANGE Low	Medium	High
PURCHASED POWER				
Quantity		1125 MW	1500 MW [1]	1875 MW
Price (2000)	(Escalation)	-2% Medium	56 $/MWh (6.5% Escalation)	+3% Medium
ENVIRONMENTAL QUALITY				
Carbon Dioxide Emission Cost		Voluntary Compliance No Additional Controls [1]	$5/Ton by 2002 above Limits	$5/Ton by 2002 and $10/Ton by 2010 above Limits
Sulfur Dioxide Allowance Price (2000)	($/Ton)	211	284 [1]	409
Air Quality Combined • Clean Air Capital Cost • Air Toxics • Visibility • Ozone		No Additional Controls [1]	• Low NO_x Controls at Cumberland and Gallatin • Reduced Hg by 2010 • SNCR by 2010	• Low NO_x Controls at Cumberland and Gallatin • Reduced Hg by 2002 • SNCR by 2002
Water Quality Combined • Thermal Plant Regulations • Aquatic Biota • Toxins • Water Flow Alteration • Toxics, Bioaccumulation, pH		No Additional Regulations [1]	• Cooling Towers at All Steam Plants in 2002 @ 130 $/kW (1994$)	• Cooling Towers and Additional Runoff Control @ 190 $/kW in 2002 (1994$)
LOAD REQUIREMENT				
Load Growth	(%) 1994-2000 2000-2020	0.0 0.0	2.2 [1] 1.9 [1]	3.4 3.2
Interruptible Load and Emergency Appeals (2000)	(MW)	700	1900 [1]	2560
Competition with Neighbors, Open Access, and Fence - Growth	(%) 1994-2000 2000-2020	0.9 1.0	2.2 [1] 1.9 [1]	2.1 2.2
SITING		No Restrictions [1]	No Central Station Options	No Central Station Options
DEMAND-SIDE MANAGEMENT EFFECTIVENESS	(MW) Savings in Year 2010	3124	5494 [1]	8219
NEW TECHNOLOGY COST		Reduce Cost 50%	Reference [1]	Reference
COMBUSTION TURBINE				
Reliability	(%)	68	84 [1]	90
Plant Life	(Years)	25 Years [1]	30 Years	30 years
Plant Efficiency	(Btu/kWh)	9,000	10,500 [1]	12,000
DISCOUNT/INTEREST RATE	(%)	6	8 [1]	12

[1] Indicates value in Energy Vision 2020 Reference

hydro generation over the 100-year period would indicate a 10 percent likelihood of the energy output being around 13 billion kilowatt-hours or less, and a 10 percent chance the energy output could be 22 billion kilowatt-hours or higher. The mid-range forecast of around 18 billion kilowatt-hours has a 50 percent chance of the output being lower or higher. While hydro variation may occur for several years at a time, it is less likely to remain consistently at a high or low level over the long term. Thus, this uncertainty is more significant to short-term plans of, say, five years or less.

Although not being treated explicitly, another scenario that could create a range of outcomes in long-term hydro generation is the TVA use and control of the Cumberland River Projects.

TVA could lose some of the Cumberland Projects due to license extension requirements. TVA could gain hydro output through negotiated control of additional segments of the river generating output operated by Southeastern Power Administration (SEPA).

ISSUE 2: COAL

Below are various uncertainties involving TVA's coal usage.

Issue 2.1: Capital Additions and Improvements for New Coal Capacity

Capital additions and improvements are betterments of plants. They are expected to have a long life and are therefore capitalized. In contrast, the cost of current repairs and minor replacement is charged to operating expense.

The medium estimate for a mature commercial supercritical pulverized coal plant (4 units of 300 megawatts each) is $13.6 per kilowatt per year. For the range of values, the low is $12.5 per kilowatt per year and the high is $14.8 per kilowatt per year (This is in 1994 dollars.)

Issue 2.2: Coal and Combined Cycle Operating and Maintenance Costs

Operating and maintenance costs for fossil units are divided into fixed and variable components. Variable operating and maintenance cost is the incremental cost of generation incurred only if the unit generates. Fixed operating and maintenance cost at an operating unit is incurred whether or not the unit operates. The mid-range of both the fixed and variable operating and maintenance costs escalate using standard TVA escalation with a 1 percent improvement (fiscal year 1999 to fiscal year 2020). The low case includes a 2 percent improvement, while the high case includes a 1 percent increase (fiscal year 1999 to fiscal year 2020). For the mid-range case, the fixed operating and maintenance cost is $21.7 per kilowatt per year of dependable capacity (in 1994 dollars) and the variable operating and maintenance cost is 0.39 mills per kilowatt-hour (based on 1994 dollars). The same base is used for both low and high, while the standard TVA escalation rate with a 2 percent annual improvement for the low, and a 1 percent annual increase in escalation is assumed for the high.

Issue 2.3: Plant Life Extension

Additions and improvements are made to the existing fossil units at a steady rate to ensure the units continue to operate into the future. One range of uncertainty would be a TVA decision to retire a coal facility that is low in the loading order. For purposes of illustration, the Widows Creek Units 1-6 were retired, representing 750 megawatts of capacity that must be replaced.

Issue 2.4: Reliability (Coal and Combined Cycle Units)

The reliability of a generating unit is a measure of the hours during a year that the unit is available to operate and includes the possible reduction in full unit output due to derating conditions. This excludes the time a unit is out for scheduled maintenance.

An unscheduled outage may be defined as a total loss of generation due to a failure of a component essential to unit operation. A derating is a failure of a component that may only reduce the amount of generation available from the unit. Reliability measure of equivalent forced outage rate is made up of these two factors.

The mid-range forecast is 9 percent; while the high is 20 percent, and the low is 6 percent.

Issue 2.5: Fuel Cost (Coal)

Fuel prices for coal facilities are based on FOB mine price projections combined with transportation rates to determine delivered price forecasts to each TVA stockpile. Delivered fuel price forecasts of three independent consultants have been averaged to obtain the TVA coal spot price forecast. These consultants are Energy Ventures Analysis, Inc., Hill and Associate, Inc., and J. D. Energy, Inc.

For a new coal facility at Tennessee River Mile 160 for a 5.0 pound sulfur dioxide per million Btu coal plant, the mid-range price projection (in 2000) is 109 cents per million Btu with a 3.3 percent escalation rate. The low forecast is projected to be 100 cents per million Btu with a 2.8 percent escalation. High projection is 121 cents per million Btu with 4.0 percent escalation.

For TVA's existing coal facilities, the mid-range price forecast is 131 cents per million Btu with a 3.5 percent escalation rate. The low forecast is 119 cents per million Btu (3.0 percent escalation), and the high forecast is 146 cents per million Btu (4.1 percent escalation).

FIGURE T8-24. **Range of Values for Coproduct**

Year	Low $/Ton	Medium $/Ton	High $/Ton
1995	82.7	237.4	290.0
1996	84.4	242.1	295.8
1997	86.0	247.0	301.8
1998	87.8	251.9	307.8
1999	89.5	256.9	314.0
2000	91.3	262.1	320.2
2001	96.0	282.3	352.9
2002	99.7	299.6	383.1
2003	103.3	318.0	416.1
2004	107.2	337.1	450.8
2005	109.0	351.4	481.0
2006	113.2	373.1	522.3
2007	116.9	394.6	564.5
2008	120.0	414.3	606.4
2009	124.4	439.2	657.6
2010	127.9	463.0	708.9
2011	133.8	495.6	775.3
2012	139.2	527.3	844.2
2013	143.3	555.2	909.0
2014	147.6	584.9	979.6
2015	151.1	613.5	1051.1
2016	155.1	643.6	1127.9
2017	158.1	673.0	1206.8
2018	161.4	702.6	1288.4
2019	163.8	729.9	1369.2
2020	166.4	758.7	1456.5

The viability of coal gasification combined cycle projects depends on the value of the coproducts. This chart shows the range of values for a byproduct of coal gasification.

Issue 2.6: Market Price of Coal Gasification – Combined Cycle Coproduct

Coal gasification technology is commercially utilized for producing synthesis gas for chemical applications including the production of ammonia, methanol, and methyl tertiary butyl ether (MTBE). The viability of coal gasification combined cycle projects depends on the value of the coproducts. Much of the gas produced is used up producing the coproduct, and the remaining low heat value gas is used to produce electricity. The following estimate in *Figure T8-24* is representative of various coproducts for screening purposes.

ISSUE 3: COMBINED CYCLE FUEL PRICE – NATURAL GAS

For the year 2000, the forecast for natural gas prices at a new combined cycle facility at Tennessee River Mile 160 is 342 cents per million Btu. This is expected to escalate at 5.3 percent per year. In preparing this medium natural gas price forecast, TVA relied on forecasts by Energy Ventures Analysis, Inc., Jofree Coporation, and ICF Resources.

The low and high values are 256 cents per million Btu with a 2.4 percent escalation and 418 cents per million Btu with an escalation rate of 7.9 percent. The high and low forecasts for gas prices were derived using several nationally recognized forecasters such as Gas Research Institute, American Gas Association, DRI/McGraw-Hill, and the Energy Information Administration.

ISSUE 4: NUCLEAR

Below are various uncertainties relative to TVA's use of its nuclear facilities.

Issue 4.1: Nuclear Moratorium

Issues that affect nuclear production include those events that alter the perception or physical capability of these facilities.

A major event either industry-wide or world-wide could cause a partial or complete shutdown of all nuclear units. Similarly, an event could create a shutdown of a specific unit type or vendor type for a period of time.

The range of outcomes assumed here are from the reference forecast to a shutdown of all nuclear units on the TVA system in fiscal year 2006.

Issue 4.2: Return to Service or Commercial Operating Dates on Nuclear Units

A range of operating dates are 12- to 36-month delays beyond the base for all the nuclear units beginning production after Watts Bar Unit 1.

Issue 4.3: Nuclear Capacity Factor

Capacity factor, the percentage of actual power generated compared to its maximum potential generation, is an uncertainty that impacts cost per kilowatt-hour of the nuclear facilities, as well as total production cost. The leading contributor to lost generation, or capacity factors less than 100 percent, for the nuclear industry as a whole is refueling, during which time the unit is unavailable for power generation. Additional lost generation may occur during operations due to testing, equipment maintenance, or other outages.

In this evaluation the mid-range capacity factor for nuclear units is 67 percent, with a low of 55 percent and a high of 86 percent based on TVA historical information and industry projections.

Issue 4.4: Nuclear Operating Cost

Operating costs cover those expenses incurred over the operating life of the unit. Nuclear costs are grouped into four categories: operating and maintenance, capital additions and improvements, fuel, and decommissioning. Operating and maintenance costs for nuclear units are projected in the medium case to be $69 per kilowatt of dependable capacity based on TVA's experience at the operating nuclear units since 1989. Nuclear operating and maintenance costs are driven by staffing levels. Typically, two-thirds of the total operating and maintenance budget goes directly to paying salaries, expenses, and benefits. Industry operating and maintenance costs escalated during the 1980s at rates in excess of general inflation as plant staff and contractors were added to respond to new regulatory requirements. The level of new regulations has dropped dramatically in the past five years, however, and the rate of operating and maintenance cost increases has likewise dropped. The nuclear industry has developed a strategic plan for reducing costs at operating units while still maintaining high levels of safety and performance. The trend in the nuclear industry is clearly toward smaller plant staffs, and a reduction in operating and maintenance cost is expected to follow. Industry targets for staffing levels at 2-unit sites like Sequoyah, Watts Bar, and Bellefonte is 0.5 persons per installed megawatt. This staffing level would result in operating and maintenance cost of about $55 per kilowatt per year, and this is used as the low value, with the high value at $83 per kilowatt per year. These estimates would escalate at 4.5 percent annually.

Issue 4.5: Nuclear Fuel Cost

TVA cost for nuclear fuel consists of two components; sunk cost and incremental fuel costs.

Sunk Cost of Fuel

TVA accumulated a uranium inventory during the 1980s of about 11 million pounds due to plant deferrals/cancellations and the 1985 extended outage. Interest on this inventory was capitalized throughout this period. The resulting high book value of uranium is driving TVA nuclear fuel costs. TVA is considering a write-off of the excess book value of uranium. This must be done if fuel costs are to be competitive before the inventory has been used. Barring write-off action, the existing inventory will affect fuel costs through 2001. Other actions have been initiated to reduce fuel costs, including renegotiation of contracts that will save approximately $70 million over the term of the contracts, loaning uranium from inventory, and utilization of fuel delivered for Watts Bar and Bellefonte in the operating plants at Browns Ferry and Sequoyah where practical, and purchasing enrichment services on the spot market at discounts of 30-35 percent relative to current term contracts. However, the effect of these other actions is small compared to the uranium book value.

Sunk cost is made up of two components: excess interest (approximately $1 billion dollars) and excess uranium inventory (approximately $400 million).

Incremental Cost

Incremental cost of nuclear fuel is the cost that TVA would pay today to replace the fuel. For Energy Vision 2020 considerations, TVA's nuclear plant fuel costs are based on an average incremental fuel cost for each of the nuclear plants. The incremental nuclear fuel costs (in 1994 dollars) are:

- Pressurized Water Reactor Fuel (Sequoyah, Watts Bar, and Bellefonte)—41.4 cents per million Btu
- Boiling Water Reactor (BWR) Fuel (Browns Ferry)—41.7 cents per million Btu

Escalation of Nuclear Fuel Cost

The nuclear fuel escalation rate may be affected by a number of factors including the general inflation rate, availability of nuclear fuel, demand for conversion, enrichment, and fabrication services, as well as spent fuel disposal costs.

For the next 30 years, abundant supplies of reasonably priced U_3O_8 will be available. The primary sources of supply will be inventories, production of existing projects, and known reserves, along with substantial quantities obtained from the nuclear weapon dismantlement program. In addition, enrichment and fabrication capacity exceeds demand. This situation is expected to continue for the foreseeable future.

Based on these considerations, nuclear fuel is expected to escalate at a rate equal to or less than general inflation during the period of 1995-2020. Energy Vision 2020 assumes escalation equal to general inflation. With a medium escalation forecast of 2.5 percent, the low is projected at 2.0 percent, with a high escalation forecast of 3.5 percent.

Issue 4.6: Spent Fuel Storage

A nuclear plant uses around 20 tons of fuel annually. A very small percentage of nuclear waste remains radioactive for thousands of years. The Nuclear Waste Policy Act of 1982 established a program to build a national underground high-level waste repository early in the next century. Currently a fee of $1 per megawatt-hour is collected to pay the Department of Energy for the disposal site. A high range is $2 per megawatt-hour.

Issue 4.7: Nuclear Additions and Improvements Costs

The cost of modifying an operating unit is a capital cost aggregated under the term additions and improvements. Modifications to nuclear facilities are driven by three causes:

• Implementation of regulation-driven modifications
• Facility improvements to increase reliability and capacity
• Routine replacement of existing capital equipment

During the 1980s, most modifications were driven by new regulations, many of which were issued following the 1979 Three Mile Island accident. A number of these regulations involved expensive modifications to plant systems and equipment. In recent years, however, new regulations have decreased, and in general, have had a lower financial impact. This trend reflects the maturing of the nuclear industry and increased knowledge about nuclear safety.

Nuclear industry additions and improvements costs dropped significantly with the completion of regulation-driven modifications. By 1990, the average rate of additions and improvements expenditure had been reduced to approximately one-quarter of the 1984 to 1986 high. While some regulation-driven changes continue to occur, utility investments are now more focused on general maintenance and performance upgrades.

TVA's additions and improvements costs are projected to be typical of the industry. Energy Vision 2020 assumes additions and improvements costs of $20 million per site per year plus $5 million per unit per year (in 1994 dollars). Additions and improvements for Bellefonte are $12 per kilowatt per year for the mid-range with a low of $9 per kilowatt per year and $19 per kilowatt per year for the high. Escalation is expected to be 4.5 percent.

Issue 4.8: Capital Cost-Bellefonte Unit 1

TVA and other nuclear engineering and construction firms (e.g., NUS Corporation, United Engineers & Constructors, Fluor-Daniel, MPR Associates, B&W Nuclear Services, and Stone and Webster Engineering Corporation) extensively reviewed the status and condition of the existing construction. Many of TVA's problems on other units were traced to the lack of good configuration control during the construction process. A detailed effort was conducted to firmly establish the licensing basis for the site. TVA then compared design records for the plant with construction records to confirm consistency. These records were then compared to actual construction, demonstrating that:

• The records existed and were retrievable.
• The records were consistent.
• The construction matched the design records.
• Design and construction were consistent with regulatory requirements.

Independent inspections performed by the Nuclear Regulatory Commission have confirmed these conclusions. Equipment and system inspections have shown that the construction quality problems encountered at other TVA facilities do not exist at Bellefonte. Agreements were reached with the Nuclear Regulatory Commission regarding the work required to resolve 14 potential regulatory concerns, representing the bulk of any remaining regulatory risk.

Consequently, the effort required at Bellefonte is largely associated with completing the remaining 12 percent of the construction work. A review of the remaining work shows that a substantial portion of remaining construction is associated with "close-out" type efforts (e.g., applying insulation and painting). Good record quality and frequent plant inspections allow this work to be estimated with a high level of confidence. In developing completion estimates, engineering firms with recent experience in completing other nuclear projects (e.g., Comanche Peak) were heavily involved to ensure that all necessary work was identified. In addition, TVA's experience in completing Watts Bar Unit 1 was fully considered. Bellefonte's completion plan utilizes the same "engineering-first" approach discussed previously.

The cost estimate to complete Bellefonte has been reviewed 21 times to date and provides a very definitive statement of the work scope required to place that unit in service. This definitive knowledge of scope positions the Bellefonte project to exercise several alternative contracting structures, including fixed price/lump sum contracting of facility completion.

More than half the cost to complete Bellefonte is not associated with construction but to put a well-trained operating staff in place for unit start-up. Because staffing and operator training have been done many times before in the industry, they can be estimated with a high level of confidence. Extensions in the start-up schedule can affect the cost to these items, in that the staff costs will continue to be carried as a capital expense until the unit enters service.

Estimates were also developed for the cost to complete Watts Bar Unit 2 and the cost to recover Browns Ferry Unit 1. These estimates were developed using a process similar to that used for Bellefonte in which a detailed examination was made of the work required and experience with previous projects fully considered.

Other Cost Uncertainty Considerations

While every effort has been made to provide the most accurate cost and schedule estimates possible, some uncertainty still remains. The process used to estimate costs captures the effect of previous contributors to cost increases by using actual experience as the estimate basis. Management representatives were involved in reviewing all cost estimates to ensure that the experience from each project was reflected in each new estimate. Work plans were reviewed in detail and the level of certainty assessed with the

FIGURE T8-25. **Cost to Complete Nuclear Units**

	Millions $			
	Bellefonte 1	**Bellefonte 2**	**Browns Ferry 1**	**Watts Bar 2**
Low	1311	912	1187	1097
Medium	2622	1824	2374	2194
High	3470	2420	3150	2910

This chart shows the low, medium, and high range of cost estimates to complete these nuclear generating units.

cost estimated for each line item. Management reserve requirements were determined based on results of this study and included in the base cost estimate. The management reserve requirement ranged from 10 percent to 30 percent depending on the level of risk.

To accommodate uncertainties not otherwise covered, adjustments are applied to the detailed engineering cost estimates based on the errors in past cost forecasts. The low completion cost estimates are the detailed engineering cost estimates themselves with the management reserve included.

The medium and high estimates are based on the low estimates adjusted for past errors in forecasting nuclear plant construction costs. The historical record of forecasting nuclear plant construction cost for plants in the United States and in the TVA region was reviewed for accuracy. The general conclusion of this review was that for plants 4 to 6 years from completion, the actual cost to complete was significantly greater than the forecast or estimated cost. The actual costs to complete were generally 100 to 200 percent greater than the forecast costs.

TVA's nuclear project cost estimate accuracy since 1987 was also reviewed. This review indicates that the error in forecasting future nuclear plant costs ranged from 100 percent to 230 percent. From 1987 to 1994, the average error in estimates made 4 to 6 years before completion was approximately 165 percent.

The major dilemma facing forecasters of nuclear plant completion costs is to what degree past forecast errors have been corrected in current estimates. The low forecasts assume that the latest engineering cost estimates are accurate. The high estimates, which use a multiplier of 2.65, assume that forecast errors will continue in the future at the same level experienced in the past. The mid-range or medium estimate of the cost to complete assumes that the future forecast error will be somewhat less than historical errors. Past forecast errors were due, at least in part, to rapidly changing regulations and the difficulty in managing large nuclear construction projects. Future errors could therefore be reduced if regulations were more stable and with improved construction project management. The medium forecast is based on the assumption that future forecast errors will match the minimum historical TVA error, which is approximately 100 percent. Thus, the medium forecast in *Figure T8-25* is twice the low estimate.

There is likewise a range of capital cost estimates for completion of the nuclear units. This range is shown in millions of dollars in *Figure T8-25.*

Issue 4.9: License Extension

The operating licenses for Browns Ferry Units 1, 2, and 3 currently expire in 2013, 2014, and 2016, respectively. The Nuclear Regulatory Commission, however, issued regulations establishing the requirements for obtaining an extension in the operating license for up to 20 additional years. The original rule issued by the Nuclear Regulatory Commission in 1991 is currently being revised and is expected to be finalized in mid-1995.

TVA, along with other utilities and industry organizations, has completed some preliminary review of the potential for extending operating licenses. No technical issues have been identified that would preclude license extension on Browns Ferry. In fact, Browns Ferry provides some unique benefits for license extension as a result of the extensive work being done to recover these units.

While it is difficult to accurately estimate the cost and schedule requirements for obtaining a license extension in advance of final issuance of the rule, the cost appears to be low (potentially on the order of $10 million).

Given the status of the rule, however, it is impossible to predict with certainty the success of an application for license extension at this time. Therefore, Energy Vision 2020 considers cases where license extension does not occur, as well as cases in which it does occur.

Issue 4.10: Nuclear Summer Limits – Temperature Water Discharge

Cooling towers are provided to support operation of the Sequoyah and Browns Ferry Nuclear Plants during periods of high river water temperature. Nonetheless, on rare occasions during extremely hot conditions, these units may be required to reduce generation. A loss of 150 megawatts is considered in the Energy Vision 2020 analyses.

Issue 4.11: Decommissioning Costs

At the end of the facility's operating life, the reactor plant must either be dismantled or placed in a state of protective storage. A safe storage mode would be followed by removal of the reactor plant after a period of dormancy. The decision as to the mode of decommissioning will be influenced by a number of factors pertinent at the time of final plant shutdown. These factors include

FIGURE T8-26. **TVA Estimates of Nuclear Plant Decommisioning Cost [1]**

Value	Pressurized Water Reactors (PWRs)	Boiling Water Reactors (BWRs) [5]
Low [2]	$200 Million per Unit	$250 Million per Unit
Medium [3]	$300 Million per Unit	$350 Million per Unit
High [4]	$600 Million per Unit	$700 Million per Unit

1 Estimates are based on the DECON option.
2 The low values for the PWRs and BWRs are based on the Nuclear Regulatory Commission formula of $105 and $130 million (in January 1986 dollars), respectively, escalated to 1994 dollars.
3 The medium values represent the average of the industry estimates escalated to 1994 dollars.
4 The high values were calculated at twice the industry average.
5 The higher BWR cost reflects a margin for potential additional decommissioning cost associated with a BWR unit.

TVA has developed low, medium, and high estimates for decommissioning its nuclear power plants. The NRC formula for pressurized water reactors and boiling water reactors was used in developing the estimates.

potential use of the site for other purposes, cost of the alternatives, minimization of occupational radiation exposure, availability of low-level disposal space, availability of a high-level waste repository or spent fuel monitored retrievable storage facility, regulatory requirements, and public opinion.

As shown in *Figure T8-26*, TVA has developed low, medium, and high estimates for decommissioning its nuclear power plants. In developing the estimates, the Nuclear Regulatory Commission formula for Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs) was used to determine the low values. A medium value was determined from the range of current industry estimates to be $300 million (approximately 90 percent of the industry estimates are lower than this value). The high value was developed by doubling of the medium estimate. The high cost estimate, which is double the medium estimate, considers the uncertainties of decommissioning, including spent fuel disposal, and low-level waste disposal.

Some recent industry estimates for decommissioning are as high as a billion dollars, due primarily to high estimates for off-site storage and management of spent fuel and other high-level wastes. TVA's plan for spent nuclear fuel is to store it on-site at the plant locations where it is generated until the Department of Energy (DOE) accepts physical custody by shipment off-site to a monitored retrievable storage facility or to an underground repository for ultimate disposal by burial. TVA has sufficient outside site area at each of its nuclear facilities to store any high-level waste associated with decommissioning activities. This would be done, possibly in containers provided by the Department of Energy, until the federal government is able to fulfill its contractual obligation to move the fuel off-site.

ISSUE 5: COGENERATION

Below are uncertainties related to cogeneration.

Issue 5.1: Cost of Cogeneration

Cogeneration projects are being developed throughout the United States. As replacement power, capital cost of construction is an uncertain issue that is treated in a resource plan. In this case, the capital cost range is from a base of $175 per kilowatt for the medium with a 10 percent reduction for the low and a 50 percent increase projected for the high.

Issue 5.2: Available Amount of Cogeneration

The amount of cogeneration may be limited, especially if it is located outside the Tennessee Valley. A limit of 2,000 megawatts is placed on cogeneration capability to study the sensitivity of results of this issue.

ISSUE 6: TRANSMISSION

Below are three uncertainties that involve transmission issues.

Issue 6.1: Transmission-Related Electromagnetic Fields

Concern over possible health effects due to electromagnetic fields (EMF) could cause difficulties in siting transmission lines. To lower magnetic field levels, extensive reconstruction of existing transmission lines would be required, and new lines would be much more expensive.

Several methods that can be used to reduce EMF include:

- Building transmission lines underground with appropriate protection
- Increasing ground clearance of overhead lines
- Installing reverse-phasing (double circuit) lines
- Using photovoltaics, batteries, and other types of modular technologies at the customer level and thereby mitigating the need for transmission service

In Energy Vision 2020, the range of this uncertain parameter has been represented as follows: the low-range case is one in which no additional controls/modifications are required. The mid-range case is $50 million increase in the cost to build transmission for a greenfield site, while the high is represented by a 50 percent increase overall in transmission costs.

Issue 6.2: Wheeling Requirements

Transmission access (wheeling) involves allowing another utility company or retail customer access to the transmission system to send electricity from one utility to another utility. The rules of such access are being developed in response to the Energy Act of 1992. Wheeling requirements are subject to the availability

of the TVA system, good faith requests and responses, facilities upgrades and additions, scheduling and operations, losses, opportunity costs, etc. The wheeling rate being developed by TVA is comprised of three components: reactive power production, firm transmission service rate—base, and margin basis.

Issue 6.3: Transfer Limitations on Interconnections

Limitations on interconnections could cause two short-term responses. If Bellefonte is built, some excess energy may be available for export for a short period of time. This energy export could be limited under certain transmission scenarios. Second, reliability requirements could increase with reduced transfer capabilities, thus requiring replacement of capacity earlier if Bellefonte is canceled.

The limit on transfer capability is modeled in the uncertainty study through an increased reserve requirement.

ISSUE 7: PURCHASED POWER

Following are two uncertainties that involve purchased power.

Issue 7.1: Purchased Power Amount Available

The amount of power available from other utilities depends on the load and power supply situations of these potential suppliers and the timing of the need for TVA. While there is a mid-range of 1,500 megawatts of purchases available in the medium forecast, a range of 25 percent less or greater represents the low and high forecasts. Thus, the low range assumption is purchased power levels at 1,125 megawatts while the high range is 1,875 megawatts.

Issue 7.2: Purchased Power Price

In the year 2000, the purchased power projected prices are $56 per megawatt-hour with an escalation rate of 6.5 percent annually for the next five years. The low range is represented by a 2 percent reduction in escalation rates, while the high range is represented by a 3 percent increase in the escalation rates.

ISSUE 8: ENVIRONMENTAL QUALITY

The impact of future environmental issues is divided into several uncertainties for discussion.

Issue 8.1: Emission Caps on Carbon Dioxide

Carbon dioxide emissions are capped in the medium forecast at 1990 levels by the year 2002. The cost of additional emissions above 1990 levels of 83 million tons are priced at $5 per ton.

For the more constrained projection, in addition to the medium limits, an additional constraint by 2010 is a ceiling of 80 percent of 1990 levels. Emissions over that ceiling are priced at $10 per ton. Escalation of these values from 1994 are at 4 percent.

Issue 8.2: Sulfur Dioxide Price Allowance

The price of sulfur dioxide emission allowances on the market will vary in the future. The medium projection of $284 per ton (in 2000) is projected to range from $211 to $409 per ton. By 2010, that range is $201 to $723 per ton with a medium of $321 per ton. Escalation beyond that period is 0 percent for the medium, with a range from -1 to +3 percent.

Issue 8.3: Environmental – Air

Figure T8-27 shows the air quality components of the environmental issue. Additional information on these environmental air uncertainties can be found in the Environmental Uncertainties Appendix.

Issue 8.31: Clean Air Capital Cost

Capital costs associated with compliance with TVA's Clean Air Strategy may vary. These capital projects help control sulfur dioxide, nitrogen oxides, and other emissions. The medium forecast is $210 million, with a low of $180 and a high of $236 million in the year 2000. These include expenditures at the majority of the coal-fired power plants.

Issue 8.32: Air Toxics

Issue 8.33: Visibility

Issue 8.34: Ozone

The above-named three issues have been combined into one control scenario with a range of possible costs to control the pollutants related to these issues.

The control of mercury is the key issue in air toxics; visibility is affected by "haze," and the requirements for the ozone

FIGURE T8-27. **Environmental – Air**

	Control Issue	Assumed Control Methods
Health-Air Toxics	Mercury	• Wet Scrubbers at Selected Units • Scrubbers at Selected Units • #2 Coal at Selected Units
Visibility	Haze (Sulfate)	• Wet Precipitators at Selected Units • SNCR at Selected Units
Ozone	Non-Attainment Areas • Nashville • Smoky Mountains • Further Nitrogen Oxides Limits	• SNCR at Selected Units

This chart shows the air quality components of the environmental issue.

FIGURE T8-28. **Environmental – Water**

Control Issue	Assumed Control Methods
Thermal Existing Plant Regulations	• Cooling Towers
Aquatic - Biota	• Closed Mode Operation and/or Cooling Towers
Water Toxins	• Mixing Zone Controls • Linkage Regulations
Water Flow Alteration	• Minimum In-Stream Flows
Water Toxics, Bioaccumulation, & pH	• Surface Water • Discharge (Eliminate)

This chart shows the issues and possible controls.

controls relate to non-attainment areas in Nashville and the Smoky Mountain regions.

Mercury can be controlled through expenditures to add wet precipitators and scrubbers. In addition, an incremental operating cost of around $2.5 per megawatt-hour will occur at selected plants in 2002. Haze is controlled through expenditures of $410 million capital and an incremental operating cost of $2 per megawatt-hour at Bull Run, John Sevier, and Kingston plants by 2002; with a moderate impact having control by 2012. Ozone can be enhanced through capital expenditures of $68 million plus an added $2 per megawatt-hour operating cost at Cumberland and Gallatin by 1996. A more stringent case would also require $93 million capital and a $2 per megawatt-hour operating cost increase at Cumberland, Gallatin, Bull Run, John Sevier, Kingston, and Widows Creek plants.

Issue 8.4: Environmental – Water

Figure T8-28 shows the issues and possible controls. Additional information on these environmental water uncertainties can be found in the Environmental Uncertainties Appendix.

Issue 8.41: Thermal Plant Regulations

Issue 8.42: Aquatic Biota

Issue 8.43: Water Toxins

Issue 8.44: Water Flow Alteration

Issue 8.45: Water Toxics, Bioaccumulation, and pH

These five issues have been combined into one control scenario with a range of possible costs to control these issues.

Thermal limits at existing plants can be met by adding cooling towers. Aquatic biota concerns can be met through operating in a closed mode or by adding cooling towers.

Water toxins can be reduced by implementing mixing zone controls or linkage regulations. Minimum in-stream flows would require expenditures and additional operating and maintenance costs to stabilize water flow.

Surface water discharges can be eliminated at a substantial capital cost and added operating cost to control toxics, bioaccumulation, and potential of hydrogen (pH).

ISSUE 9: LOAD REQUIREMENTS

The load requirements issue involves several uncertainties, which are addressed individually below.

Issue 9.1: Native Load Growth

Total demand for electricity is measured in peak load requirements and in annual energy requirements. The growth rates for the medium forecast of peak loads from 1994 to 2000 is 2.2 percent per year, with a low of zero percent and a high of 3.4 percent. These rates are calculated from a 1994 base peak load of 24,400 megawatts. The growth rates for the period 2000 to 2020 are 1.9 percent for the medium, with a low of 0.0 percent and a high of 3.2 percent.

Issue 9.2: Deliverability of Interruptible Load

Issue 9.3: Customer Response to Emergency Appeal

These two items are combined in the sensitivity analysis. The medium reduction in load requirements is 1,900 megawatts (in 2000) with a low forecast of 700 and a high forecast of 2,560 megawatts. These reductions in load are equivalent to reduced capacity reserve requirements. The low scenario increases desired reserve levels by around 4 percent with the high decreasing reserves by 2.5 percent.

Limited Interruptible Power (LIP) and Economy Surplus Power (ESP) contracts allow TVA to interrupt load if needed when peak loads occur on the TVA system. The frequency and amount of actual interrupted load may vary from the contracted amount for several reasons including the fact that the load under interruptible contract may simply not be engaged at the time of the peak load. A medium value for the year 2000 is 1,765 megawatts available to be interrupted, while a low of 700 megawatts and a high of 2,160 megawatts are forecast.

Voluntary public appeals may result in peak load reductions ranging from 0 to 400 megawatts with a medium forecast of 140 megawatts. Any reduction of peak load results in a lower probability of loss of load, which makes the power system more reliable and lowers desired reserve requirements.

Issue 9.4: Competition with Neighbors and Open Access

In recent years, the electric utility industry has undergone a fundamental change. The world of regulated monopoly is being replaced by a world of competitive pressures. Wholesale open access (the right of wholesale customers to buy power from generating utilities other than the one whose lines serve them) can be mandated by the Federal Energy Regulatory Commission (FERC). Retail firms, such as large industrial customers, are looking for the same privilege, and retail open access is beginning to be mandated by some state regulatory bodies. In a more competitive market, TVA's success as a generating company will be greatly affected by whether TVA is successful in being a low-cost provider.

TVA has incorporated these competitive assumptions into its forecasts. In the medium forecast, TVA will maintain its current territory and will not gain outside customers nor lose customers inside its service territory.

TVA's forecast price of electricity, discussed earlier, is expected to remain competitive with other utilities. Market and regulatory changes would have less impact in the medium case, than in the high or low cases. As a result, the net impact of competition in the medium forecast is an even balance of gains and losses of sales.

The prospect of increasingly competitive markets increases the uncertainty in the forecast. If TVA operates at lower costs than the competition, and regulations permit, TVA may have opportunities to gain customers. This is termed high competitive success. Likewise, if TVA is a higher cost producer than its competitors, it is likely to lose customers-described as low competitive success. Both cases assume that deregulation of the electric market continues. The high and low forecasts recognize the risks and opportunities of increased competition.

TVA analyzed competitive impacts for all sales. The effort was aimed at looking at the market rather than specific customers. In the low competitive success case, TVA will lose customers to competing electric utilities. In order to estimate the potential for losing sales to competition, TVA's customer survey—completed by many of the distributors of TVA power and directly served customers—was used to identify the amount of load that appeared to be at high risk.

In the high competitive success case, TVA will gain customers from its competition. To estimate the potential for this gain in the wholesale markets, loads of municipal and cooperative distributors in neighboring regions were used. The chance of gaining any distributor was partly influenced by the wholesale price paid by that distributor. Because a very large percentage of TVA's sales are wholesale, compared to neighboring utilities, the potential gain in the wholesale market in the high competitive success case was smaller than the potential loss in the low competitive success case.

For directly served customers, less specific information on nearby opportunities was available. Because TVA is surrounded by states with large industrial loads, a judgment was made that potential gain is higher than loss of industrial loads.

Wholesale and retail gains in load were assigned the highest probability for the low electric price forecast, making TVA more competitive. A more complete discussion of all uncertainties in the forecast can be found elsewhere in the uncertainty section.

ISSUE 10: SITING

Availability of sites to use in developing new power supply alternatives is important to enable capacity to be added as required. Some additional capacity could be constructed on existing sites. However, there are other issues such as water usage and environmental output that could reduce site potential. Two levels of assumptions are being analyzed for the sensitivity of this issue. In the reference case, there are no constraints. A second scenario assumes there are no central station options built; rather, future requirements are met by fuel cells, batteries, and other distributed generation sources.

ISSUE 11: DEMAND-SIDE MANAGEMENT (DSM) EFFECTIVENESS OR MARKET PENETRATION

High and low forecasts of the impact of demand-side management programs are evaluated to determine their sensitivity. The mid-range scenario reduces the peak load by 5,494 megawatts in the year 2010, while low reduction is 3,124 megawatts, and the high reduction is 8,219 megawatts.

ISSUE 12: NEW TECHNOLOGY COST AND AVAILABILITY

The cost of power produced using new technologies could be significantly impacted by breakthroughs in theoretical concept, design, materials, and other factors. In order to consider the potential effect of improvements in new technologies, a 50 percent reduction in the capital cost for generating options using new technologies has been included.

ISSUE 13: DYNAMIC OPERATING BENEFITS

Operating flexibility is defined as the benefit of a unit's operating flexibility in responding to system load variations. The ability to "turn down," for example, from a maximum capacity level to a minimal level over the period of the day as the load requirements decrease would have some benefit. Another alternative is to make expenditures in capital to enable generating equipment to respond appropriately to instantaneous and short-term conditions. These benefits are being determined in a separate sensitivity review outside this evaluation.

ISSUE 14: COMBUSTION TURBINES

The uncertainties pertaining to combustion turbines have been subdivided into the issues below.

Issue 14.1: Reliability of New Combustion Turbines

Reliability of peaking capacity is critical since the periods of time the units are called on are peak load hours. The medium projection for combustion turbine reliability is 84 percent, while a low of 68 percent and a high of 90 percent are evaluated.

Issue 14.2: Plant Life of Existing Turbines

Plant life of new capacity is assumed to be 30 years in the medium forecast. The low case assumes a life of 25 years.

Issue 14.3: Efficiency of Combustion Turbines

A range of efficiency is evaluated for the combustion turbines. A medium forecast of 10,500 Btu per kilowatt-hour is forecast. A "high value" or low heat rate of 9,000 and a "low value" or high heat rate of 12,000 Btu per kilowatt-hour is used to represent the range.

ISSUE 15: DISCOUNT RATE

ISSUE 16: INTEREST RATE

The discount rate (economic evaluation rate for investments or minimum attractive rate of return) is used to perform equivalence calculations (e.g., present value) necessary for comparing investment alternatives. The discount rate includes an amount for the time value of money and contains an implicit forecast of inflation expectations. A very basic consideration in selecting a discount rate is the cost of capital. No corporation can stay in business for the long term by investing at return rates less than the rates paid for funds. Keeping this in mind and noting the need to compare options with various forms and sources of financing, TVA has chosen the long-term interest rate as the discount rate to be used in Energy Vision 2020.

The interest rate TVA pays for funds is projected to rise somewhat over the next 10 years as worldwide demand for capital increases after the European and Japanese economies begin to recover. However, the moderate rate of inflation and declining federal budget deficit will keep rate increases moderate.

Since discount and interest rates must be set consistently, a medium discount and interest rate of 8 percent is evaluated with a low range of 6 percent and a high range of 12 percent.

Sensitivity of Resource Plans to Uncertain Parameters

Tornado diagrams are useful in determining the parameters that are significant in the decision-making process. This ensures that the most important parameters continue to be considered in the evaluation and allows less important parameters to be dropped from the analysis.

Figure T8-29 shows the most significant items as identified from the tornado diagrams.

To describe the tornado diagram, the following information can be used to illustrate development of the tornado diagram. The 30-year annual resource costs (discounted to 1994 at 8 percent) for the reference set of assumptions with Bellefonte completed are $93,382 million.

To determine the sensitivity of this resource plan to coal prices, the range of coal prices is used to develop total resource costs. As described in Issue 2.5, the low forecast is projected to be 100 cents per million Btu in the year 2000 with a 2.8 percent escalation. The high coal price forecast is 121 cents per million Btu with a 4.0 percent escalation. These are ranges around

FIGURE T8-29. **Uncertainties to Consider Further**

	EVALUATION CRITERIA			
Uncertainty	**Total Resource Cost**	**Rates**	**Debt in 2007**	**Carbon Dioxide Emissions**
Nuclear Moratorium	●	●	●	●
Nuclear Capacity Factor	●	●		●
Nuclear Operating and Maintenance Cost	?	●		
Nuclear Capital Cost	?	●	●	
Carbon Dioxide Compliance	●	●		
Environmental-Air	?	?	?	
Environmental-Water			●	
Load Growth	●	●	●	●
Competitive Success	●		●	●
Sites	●			
Coproduct Revenue	●	●		
DSM Effectiveness	?	●	?	?
Natural Gas Price	?	?		

Based on the tornado diagrams which follow, the most significant uncertainty items are shown here.

the medium forecast of 109 cents per million Btu and a 3.3 percent escalation rate.

With the low coal price forecast, the total resource cost becomes $93,103 million or a reduction in total costs of $279 million. If the high coal prices are assumed, the total resource cost increases to $93,951 million, which is an added cost of $569 million.

Thus, the variation in total resource cost due to the uncertainty in coal prices ranges from a reduction of $279 million to an increase of $569 million.

Results of the sensitivity evaluations are shown in *Figures T8-30* through *T8-37*. As described above, the tornado diagram shows the impact each uncertainty has on the basic nuclear completion decision.

Figure T8-30 shows the change in long-term total resource costs for a range on 35 parameters described earlier in this paper. Using zero as the base, the increases or decreases in total resource costs are shown as bars from zero.

Figure T8-31 shows the variation in the planning criterion of electric rates. *Figure T8-32* shows the change in debt in the year 2007 due to variations in the various parameters. Change in average annual carbon dioxide emissions are shown in *Figure T8-33*.

Since some of the uncertain items only make a difference under selected expansion strategies, *Figures T8-34* through *T8-37* show the impact of these "special issues" on the selected criteria.

Natural gas prices show up in a scenario in which natural gas-based capacity is constructed, e.g., combined cycle. The effectiveness of demand-side management programs is only important in scenarios in which demand-side management options are pursued. Finally, the value received from coproducts is important in the scenarios in which integrated gasification combined cycle plants with coproduction facilities are installed.

In the *Figures T8-34* through *T8-37*, these different alternatives are evaluated for the same four criteria—total resource costs, electric rates, debt, and average annual carbon dioxide emissions.

Conclusions

Issues that were carried forward into the Energy Vision 2020 evaluation are listed below:

- Load Growth
- Nuclear Issues
  - Capacity Factor
  - Operating and Maintenance Cost
  - Capital Cost
- Environmental Issues
  - Carbon Dioxide Compliance
  - Air and Water Environmental Controls
- Price
  - Natural Gas
  - Revenue from Coproduct (Combined Cycle)
- Demand-Side Management Effectiveness

Issues for which selected sensitivity evaluation can be performed include the nuclear moratorium and the inability to site central station generating capacity.

FIGURE T8-30. **Change in Total Resource Costs – Existing System, Nuclear Completion, and Coal-Based Expansion**

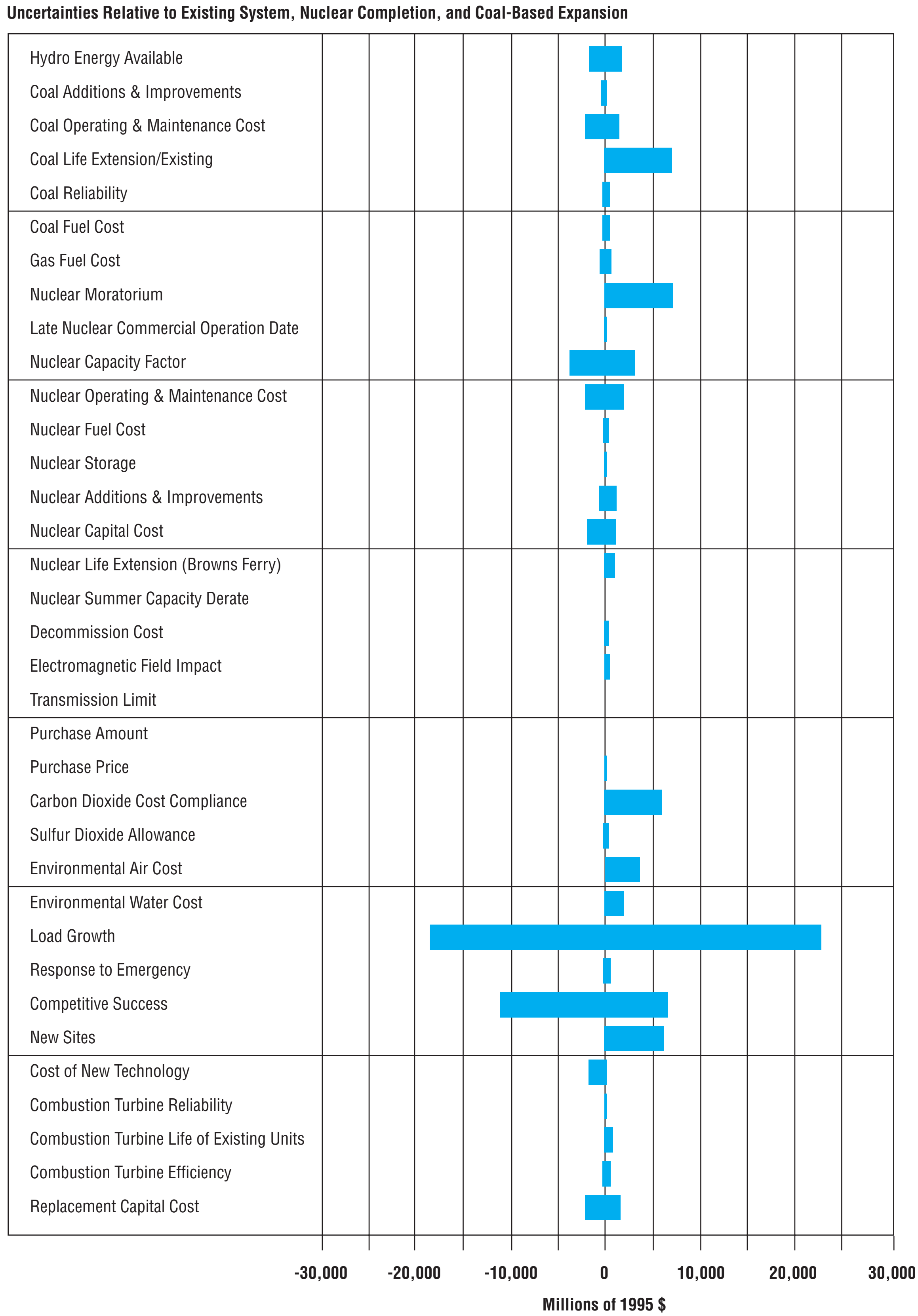


FIGURE T8-31. **Change in Electric Rates – Existing System, Nuclear Completion, and Coal-Based Expansion**

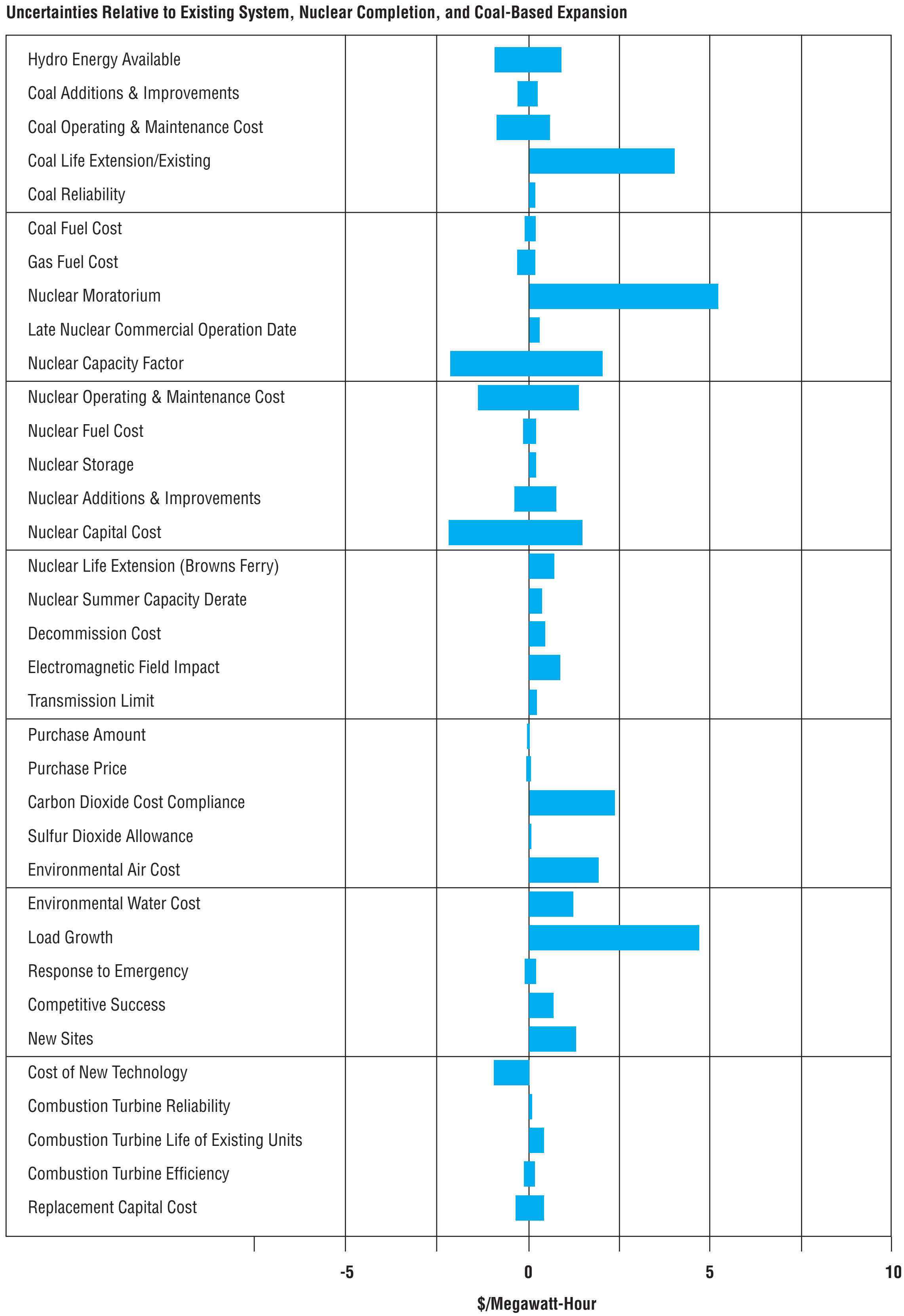


FIGURE T8-32. **Change in Debt in Year 2007 – Existing System, Nuclear Completion, and Coal-Based Expansion**

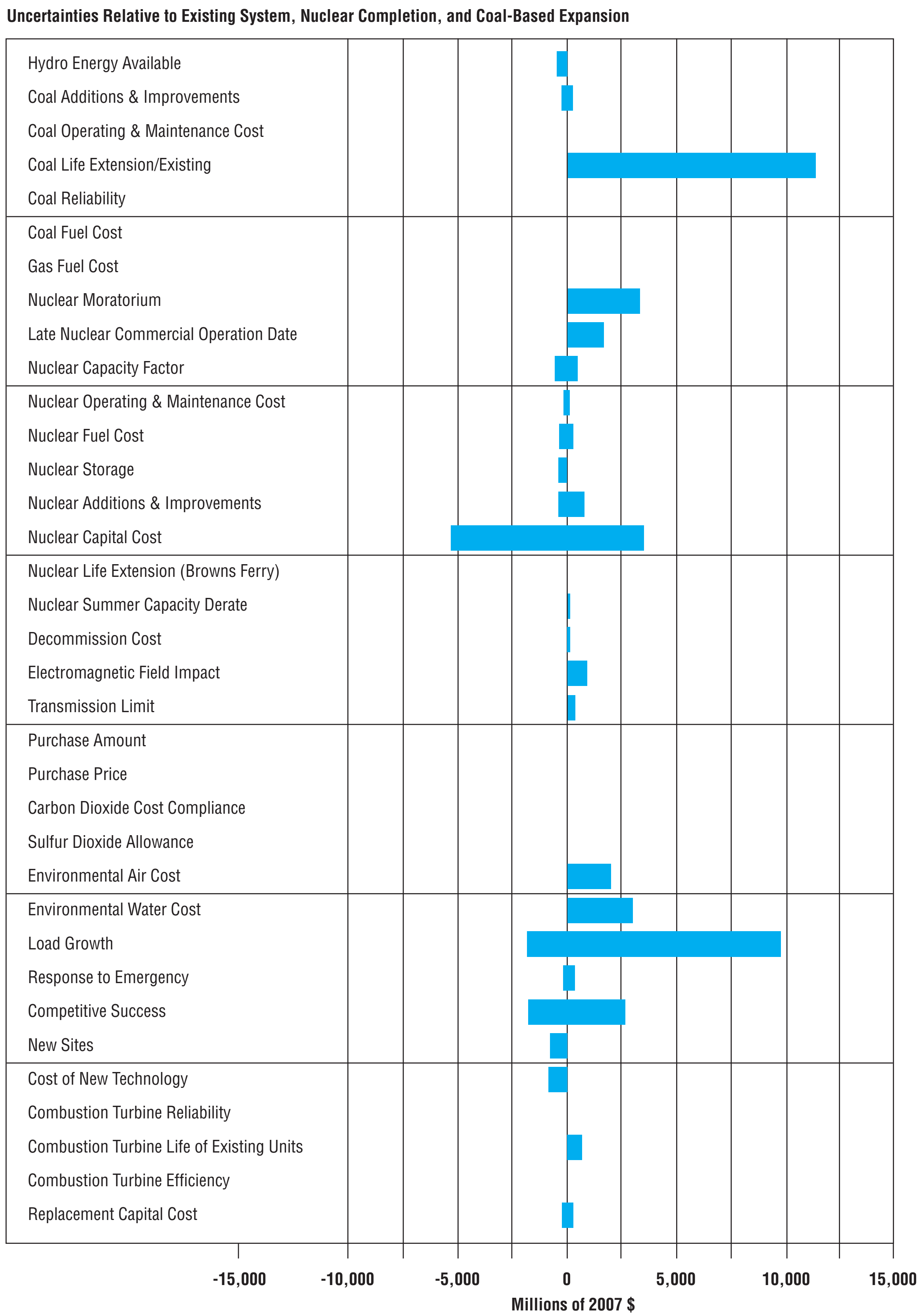


FIGURE T8-33. **Change in Average Annual Carbon Dioxide Emissions – Existing System, Nuclear Completion, and Coal-Based Expansion**

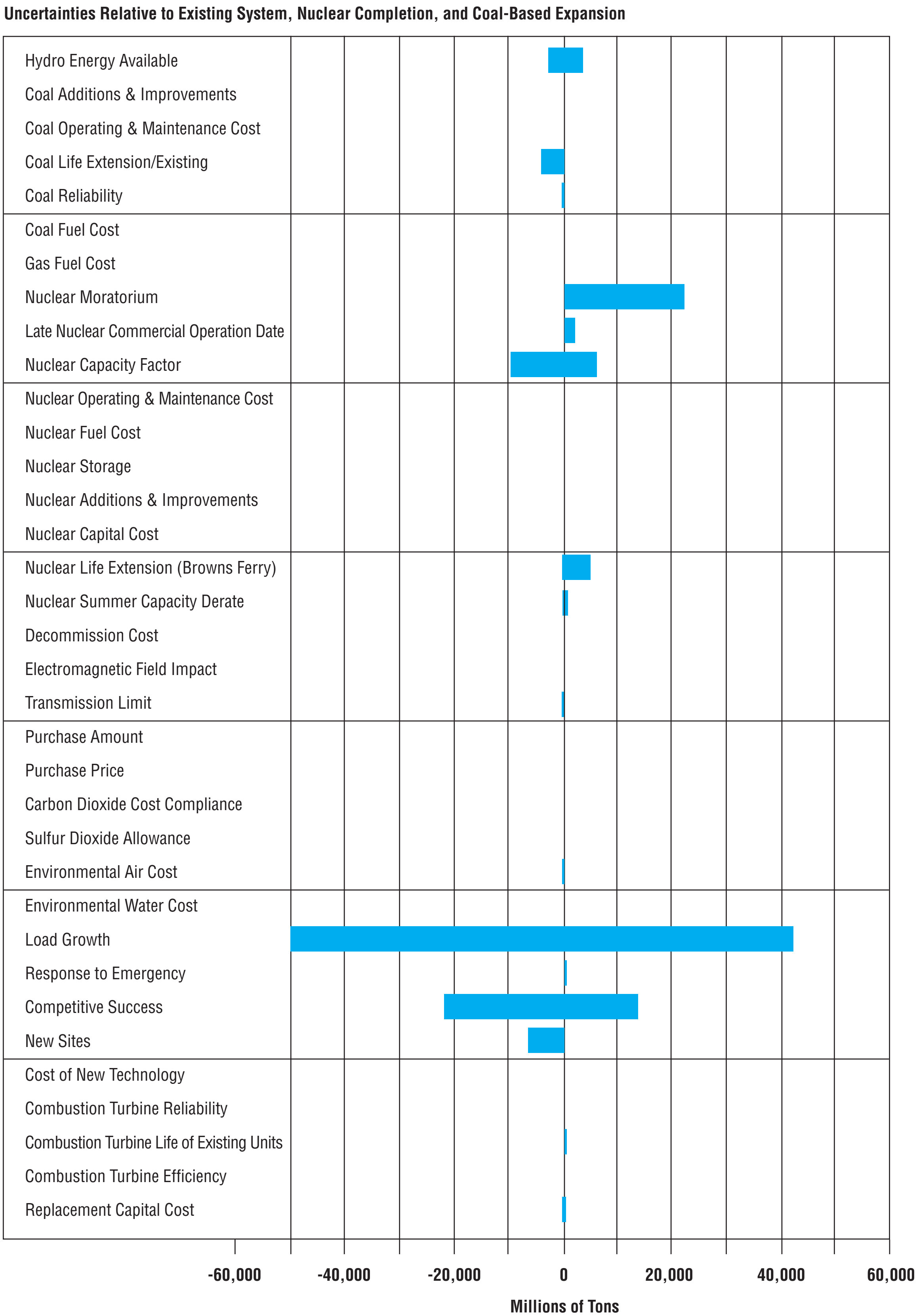


FIGURE T8-34. **Change in Total Resource Costs – Other Expansion Options**

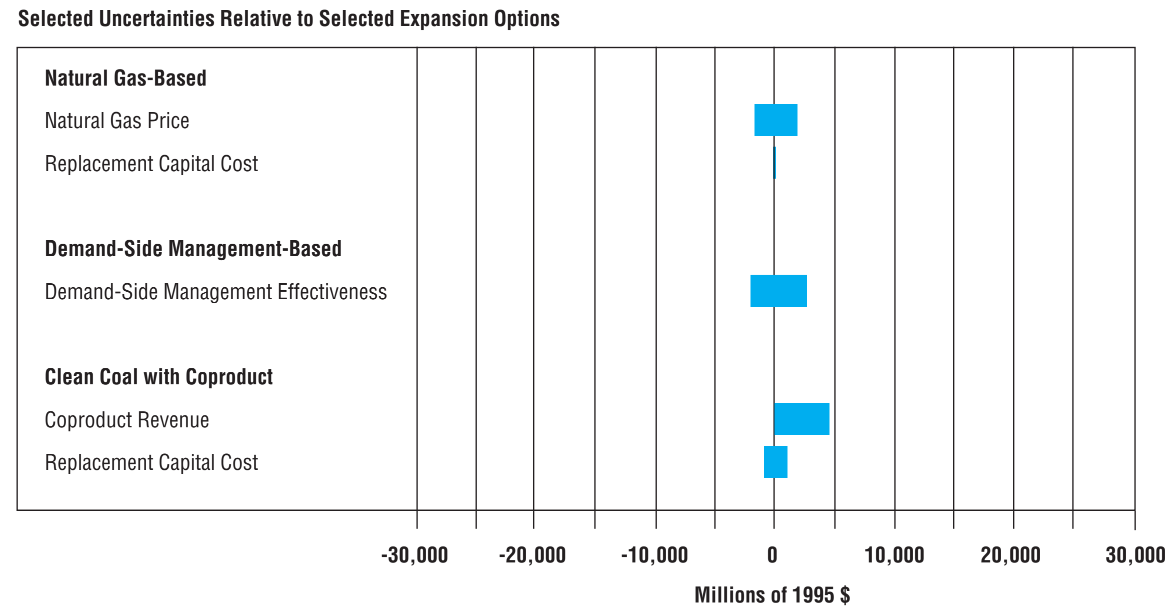


FIGURE T8-35. **Change in Electric Rates – Other Expansion Options**

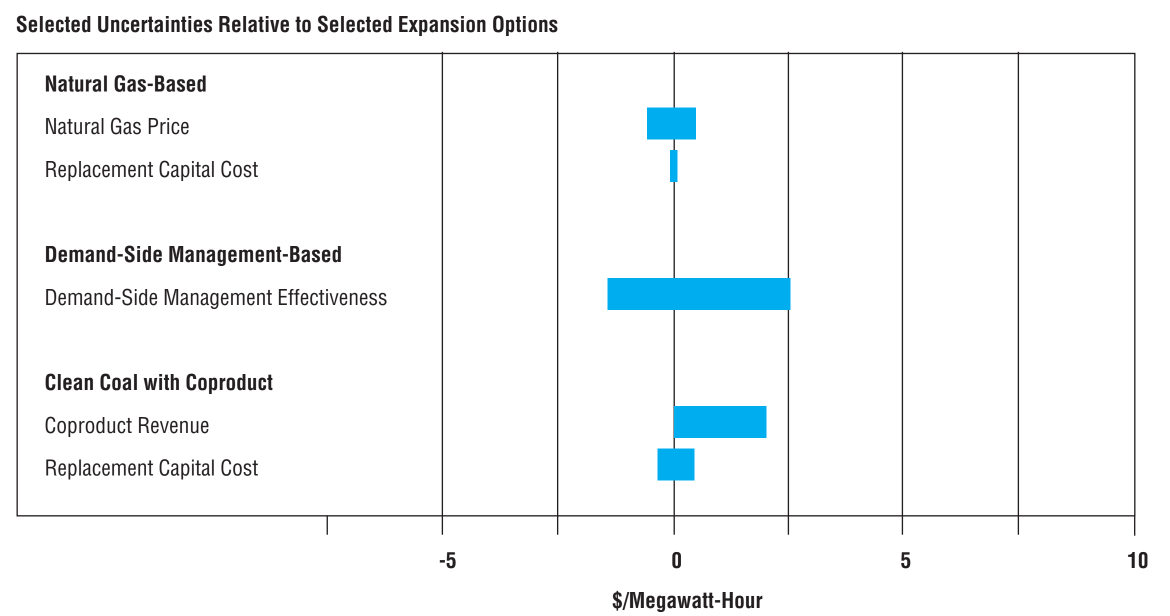


FIGURE T8-36. **Change in Debt in Year 2007 – Other Expansion Options**

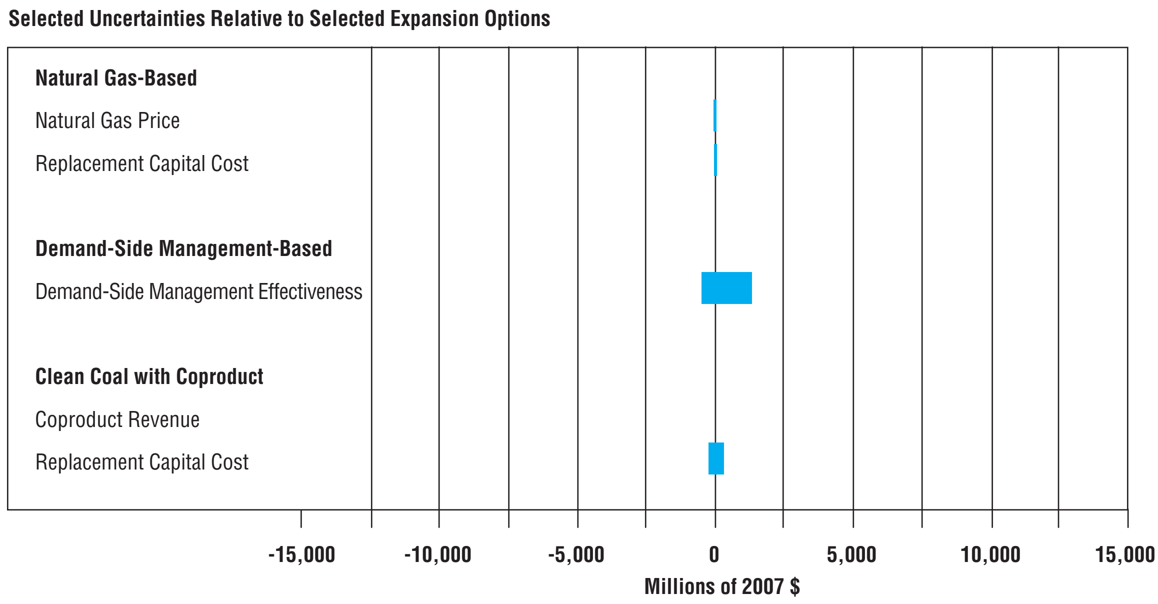
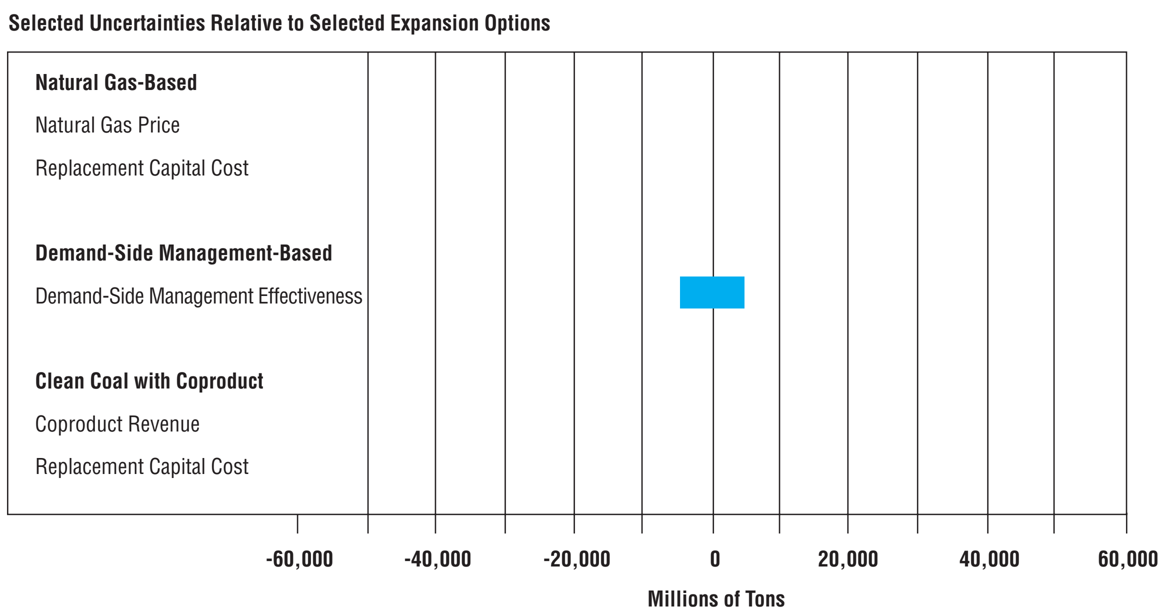


FIGURE T8-37. **Change in Average Annual Carbon Dioxide Emissions – Other Expansion Options**



ENVIRONMENTAL UNCERTAINTIES APPENDIX

Health – Air Toxics Uncertainty

Scenario 1: Utilities remain unregulated for air toxics
Impact on TVA: None
Probability of this scenario: 10 percent

Scenario 2: Environmental Protection Agency decides in 1996 to regulate air toxics from utility sources beginning in 2002. Equipment needed to control mercury will also control radioactive particulates and other heavy metals.
Impact on TVA: For Paradise 1-3, Cumberland 1-2, Widows Creek 7-8, and Allen 1-3 facilities, add wet precipitators at $50 per kilowatt. For other fossil plants, add spray dryer at $160 per kilowatt and switch to low sulfur coal of no more than 2 pounds per million Btu of sulfur dioxide emissions (some low sulfur coals are known to be low in toxic metals); add 0.4 cents per kilowatt-hour in variable operating and maintenance costs.
Probability of this scenario: 40 percent

Scenario 3: Same as scenario 2 except: Environmental Protection Agency decides in 2004 to regulate air toxics emissions beginning in 2010.
Impact on TVA: Same as scenario 2.
Probability of this scenario: 50 percent

Visibility – Acid Aerosols/Particulate Matter (PM) Uncertainty

Scenario 1: No new requirements
Impact on TVA: None
Probability of this scenario: 60 percent

Scenario 2: In 1997, visibility issues produce new regulations that require sulfate controls. TVA units put in service after 1962 are required to install Best Available Retrofit Technology (BART) by 2002. Best Available Retrofit Technology is determined to be 90 percent removal scrubbers. These are required on Bull Run, Paradise 3, and Colbert 5 plants.
Impact on TVA: Add scrubbers at capital cost of $200 per kilowatt, with increased operating and maintenance expense of 0.4 cents per kilowatt-hour.
Probability of this scenario: 30 percent

Scenario 3: In 2003, long-range transport and visibility issues produce new regulations that require sulfate and fine particulate controls by 2010. Best Available Retrofit Technology is determined to be 90 percent removal scrubbers and control of all particulates of 10 microns or less. Older units burning high or medium sulfur coal (in excess of 2.5 pounds per million Btu) are also required to reduce sulfur dioxide emissions and particulates of 10 micros or less emissions. These units add in-duct lime injection systems. (These controls will address the condensible portion of particulates of 10 micros or less. The mass portion of particulates of 10 micros or less should not affect TVA due to high efficiency of TVA's precipitators.)
Impact on TVA: Same as scenario 2. In addition, add in-duct lime injection systems at all unscrubbed units burning coal with 2.5 pounds per million Btu or greater sulfur dioxide emissions at cost of $15 per kilowatt and increased operating cost of 0.2 cents per kilowatt-hour.
Probability of this scenario: 10 percent

Health – Ozone Uncertainty

Scenario 1: No new requirements
Impact on TVA: None
Probability of this scenario: 10 percent

Scenario 2: In 1996, Nashville area is redesignated serious non-attainment for ozone, and modeling shows direct impacts due to nitrogen oxides emissions at Cumberland and Gallatin plants. Nitrogen oxides reductions are required at Cumberland and Gallatin plants by 1999. Low nitrogen oxides burners planned for installation at the Cumberland plant are judged inadequate to meet reduction requirements.
Impact on TVA: Selective non-catalytic reduction is added at Cumberland and Gallatin at cost of $20 per kilowatt. Variable operating and maintenance costs increase by 0.2 cents per kilowatt-hour at these plants.
Probability of this scenario: 30 percent

Scenario 3: In 2002, ozone non-attainment within the Great Smoky Mountains National Park forces additional nitrogen oxides reductions from sources within a 200-kilometer radius of the park. Requirements are met by adding selective non-catalytic reduc-

tion in addition to the previously installed low nitrogen oxides burners.
Impact on TVA: Additional controls are added to John Sevier, Bull Run, Kingston, and Widows Creek plants at $20 per kilowatt and 0.2 cents per kilowatt-hour variable operating and maintenance increase.
Probability of this scenario: 30 percent

Scenario 4: Combine scenarios 2 and 3
Impact on TVA: Combine impacts of scenarios 2 and 3
Probability of this scenario: 30 percent

General Air Regulation Uncertainty

Scenario 1: No new requirements that are independent of the other uncertainties described in this paper
Impact on TVA: None
Probability of this scenario: 90 percent

Scenario 2: New legislation in 2005 requires that all plants must meet all new source requirements, including new requirements for air toxics, by 2010. All plants must be equipped with 90 percent removal efficiency scrubbers and wet precipitators.
Impact on TVA: Add scrubbers to all unscrubbed units at cost of $200 per kilowatt. Add wet precipitator to all units at cost of $50 per kilowatt. Variable operating and maintenance increases at all plants by 0.4 cents per kilowatt-hour.
Probability of this scenario: 10 percent

Greenhouse Gas Emissions Uncertainty

Scenario 1: No greenhouse gas legislation
Impact on TVA: None
Probability of this scenario: 35 percent

Scenario 2: New legislation is passed in 1997 to stabilize greenhouse gas emissions at 1990 levels in the year 2002. Offsets for sequestration and "allowance trading" are allowed. Offsets are available at $3 per ton for the first million tons above 1990 levels, $5 per ton for any additional emissions.
Impact on TVA: Impose greenhouse gas emissions cap of 98 million tons of carbon dioxide equivalent beginning in 2002. Reduce value of sulfur dioxide allowances by 10 percent starting in 2002.
Probability of this scenario: 40 percent

Scenario 3: Same as scenario 2 except the emissions limit is reduced to 80 percent of 1990 levels in 2010. Needed offsets in excess of ten million tons cost $15.
Impact on TVA: Same as scenario 2 except the emissions cap drops to 80 percent of 1990 levels in 2010. The value of sulfur dioxide allowances drops 40 percent in 2010. Natural gas prices increase by 50 percent in 2010.
Probability of this scenario: 25 percent

Thermal Water Discharge Uncertainty

Scenario 1: Regulation of thermal discharges remains unchanged
Impact on TVA: None
Probability of this scenario: 80 percent

Scenario 2: All Section 316(a) variances that currently allow less stringent thermal limits are eliminated by 2002. Cooling towers operating in helper mode would be required at eight existing coal-fired plants, modifications would be required to the existing cooling towers at Sequoyah, and additional cooling towers would be required at Browns Ferry facilities.
Impact on TVA: Capital cost for cooling towers at existing coal-fired plants would be approximately $1.7 billion. Addition of cooling towers would also result in loss of 860 megawatts capacity and increased operating and maintenance cost of $3.9 million per year.
Probability of this scenario: 10 percent

Scenario 3: Mixing zones for surface water discharges are restricted to a maximum of 1,000 feet by 2002. Cooling towers operating in closed mode are required for all existing coal-fired plants and all new thermal plants to minimize mixing zone size. Modifications are required at Sequoyah and additional towers required at Browns Ferry facilities.
Impact on TVA: Capital cost for cooling towers is approximately $2.5 billion. System loses 860 megawatts capacity and annual operating and maintenance cost is increased by $13 million per year.
Probability of this scenario: 10 percent

Entrainment/Impingement Uncertainty

Scenario 1: Section 316(b) regulation, which applies to the effects of surface water intakes on aquatic biota, remains unchanged.
Impact on TVA: None
Probability of this scenario: 80 percent

Scenario 2: Section 316(b) regulations change in 1996 to require a reduction in entrainment/impingement effects at existing plants. TVA elects to comply by constructing cooling towers at existing thermal plants to reduce the volume of water taken into the plant. Towers in closed mode are added to all coal-fired plants, repairs are required at Sequoyah, and additional tower cells are required at Browns Ferry facilities.
Impact on TVA: Capital cost for cooling towers would be approximately $1.7 billion. Capacity is reduced by 860 megawatts, and operating and maintenance cost increases by $13 million per year.
Probability of this scenario: 20 percent

Toxics/Bioaccumulation Uncertainty

Scenario 1: No changes to regulations affecting surface water discharges.
Impact on TVA: None
Probability of this scenario: 75 percent

Scenario 2: Reauthorization of Clean Water Act in 2000 requires National Pollutant Discharge Elimination System permits for discharges of pollutants to groundwater which is “hydrologically connected to surface waters.” TVA complies by lining all ash ponds at existing coal-fired plants. Ash in existing ash ponds is excavated and stabilized in lined areas. Metal cleaning waste ponds are lined.
Impact on TVA: Cost for existing plants will be $1.1 billion.
Probability of this scenario: 25 percent

Flow Alteration Uncertainty

Scenario 1: No new requirements (beyond TVA commitment to policy outlined in the Final Environmental Impact Statement, Tennessee River and Reservoir System Operation and Planning Review — Lake Improvement Plan).
Impact on TVA: None
Probability of this scenario: 80 percent

Scenario 2: States require additional minimum in-stream flows downstream of new and existing TVA hydro plants by 1998. Minimum in-stream flows would be maintained downstream of hydro plants by pumping water over the dam to the tailwater to supplement turbine releases.
Impact on TVA: Requires expenditure of $180 million capital and annual operating and maintenance cost increase of $11 million per year.
Probability of this scenario: 20 percent

Toxics/Bioaccumulation and pH Uncertainty

Scenario 1: No new regulation that is not covered under the Toxics/Bioaccumulation uncertainty above.
Impact on TVA: None
Probability of this scenario: 90 percent

Scenario 2: Reauthorization of Clean Water Act in 2005 requires the elimination of discharges of all pollutants by 2010. All surface water discharges, including thermal, and discharges to groundwater that are “hydrologically connected to surface water” would be eliminated. All thermal plants would operate closed cycle. Blow down and other miscellaneous wastewater are treated on-site, primarily by evaporation and constructed wetlands. All combustion byproducts and scrubber sludges are handled dry. Existing ash in ash ponds is stabilized in lined areas to eliminate discharge to groundwater. Chemical cleaning ponds are also to be lined.
Impact on TVA: Capital cost will be $11 billion and annual operating and maintenance costs increase by $14 million per year.
Probability of this scenario: 10 percent

EVALUATION CRITERIA

The Key to Criteria is a summary of the evaluation criteria that was used to evaluate each strategy. These criteria were crucial in the analysis of the strategies as shown in the various trade-off graphs. The units and a brief description of all key criteria are given in *Figure T8-38*.

FIGURE T8-38. **Key to Criteria**

Label	Description	Units
Customer Value Test	Customer Value Test	Present Value -(1996-2030)
Total Resource Costs	Total Resource Costs (TRC)	Present Value - (1996-2030)
Electric Market	Customer Value in Electric Market	Present Value - (1996-2030)
RIM Test	Rates Impact Measure (RIM) Test	$/MWh Levelized (1996-2030)
Short-Term Rates	Short-Term Rates	$/MWh Average from (1996-2000)
Mid-Term Rates	Mid-Term Rates	$/MWh Average from (1996-2005)
Long-Term Rates	Long-Term Rates	$/MWh Average from (1996-2015)
New Mid-Term Rates	Mid-Term Rates	$/MWh (2001-2005)
Debt 2001	Total Debt in Year 2001	Millions $
Debt 2007	Total Debt in Year 2007	Millions $
Total Employment	Total Employment Per Year	
Total Income	Average Annual	Thousands $
Environmental Criteria:		
CO Emissions	Carbon Monoxide (CO) Emissions	Annual Average Tons (1996-2030)
CO_2 Emissions	Carbon Dioxide (CO_2) Emissions	Annual Average Thousands of Tons (1996-2030)
NO_X Emissions	Nitrogen Oxides (NO_X) Emissions	Annual Average Tons (1996-2030)
SO_2 Emissions	Sulfur Dioxide (SO_2) Emissions	Annual Average Tons (1996-2030)
VOC Emissions	Volatile Organic Compounds (VOCs) Emissions	Annual Average Tons (1996-2030)
TSP Emissions	Total Suspended Particulates (TSPs) Emissions	Annual Average Tons (1996-2030)
Mercury Emissions	Mercury (Hg) Emissions	Annual Average Tons (1996-2030)
Solids	Solids	Annual Average Tons (1996-2030)
Thermal Discharge	Thermal Discharges	Annual Average Quadrillion BTUs (1996-2030)
Water Usage	Water Usage	Annual Average Trillions of Gallons (1996-2030)
Water Consumption	Water Consumption	Annual Average Trillions of Gallons (1996-2030)
Coal Burned	Coal Burned	Annual Average Millions of Tons (1996-2030)

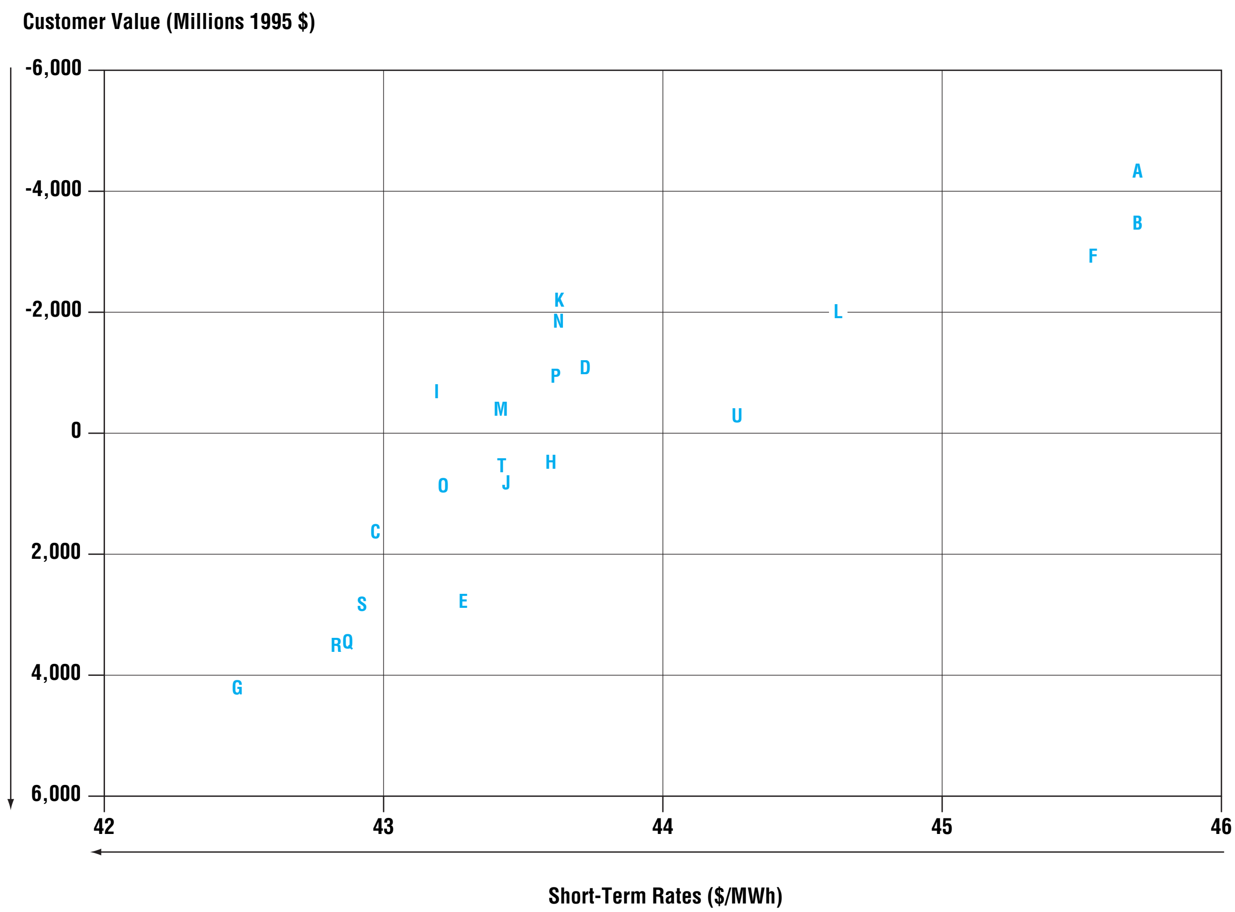
FIGURE T8-38. **Key To Criteria** *CONTINUED*

Label	Description	Units
Environmental Criteria:		
Biomass Burned	Biomass Burned	Annual Average Millions of Tons (1996-2030)
RDF Burned	Refuse-Derived Fuel (RDF) Burned	Annual Average Millions of Tons (1996-2030)
Landfill Methane Capture	Landfill Methane Capture	Annual Average Tons (1996-2030)
NG Burned	Natural Gas Burned	Millions of Standard Cubic Feet
Total Power Sales	Total Power Sales	MWh
Nuclear Power Sales	Nuclear Power Sales	MWh
Fossil Power Sales	Fossil Power Sales	MWh
Hydro Power Sales	Hydro Power Sales	MWh
Wind Capacity	Wind Capacity	MW
New Thermal Plants	New Thermal Plants	Number
Environmental Impacts:		
Air:		
Health - Inhalation	Human Health - Inhalation	Index
Visibility	Visibility	Index
Forests And Crops	Forests and Crops	Index
Materials	Materials (Structural and Cultural)	Index
Water:		
Health - Ingestion	Human Health - Ingestion	Index
Water Supply/ Assimilation	Water Supply/Waste Assimilation	Index
Aquatic/Biodiversity	Fish and Aquatic Life/ Biodiversity	Index
Other:		
Greenhouse Gases	Greenhouse Gas Emissions	Total Equivalent Carbon Dioxide (Millions of Tons)

TRADE-OFF GRAPHS

The Trade-off Graphs represent how each strategy performs given certain criteria. Specifying a particular future, some strategies were better than others for each criteria. To illustrate the evaluation of certain strategies, as well as the correlation of some of the criteria, three sets of trade-off graphs focusing on specific criteria are attached. They are cost, rates, debt, and value trade-offs, *Figures T8-39* through *T8-41*; environmental emissions trade-offs, *Figures T8-42* through *T8-48*; and environmental impacts

FIGURE T8-39. **Costs, Rates, Debt, and Value Trade-Off Customer Value vs. Short-Term Rates**

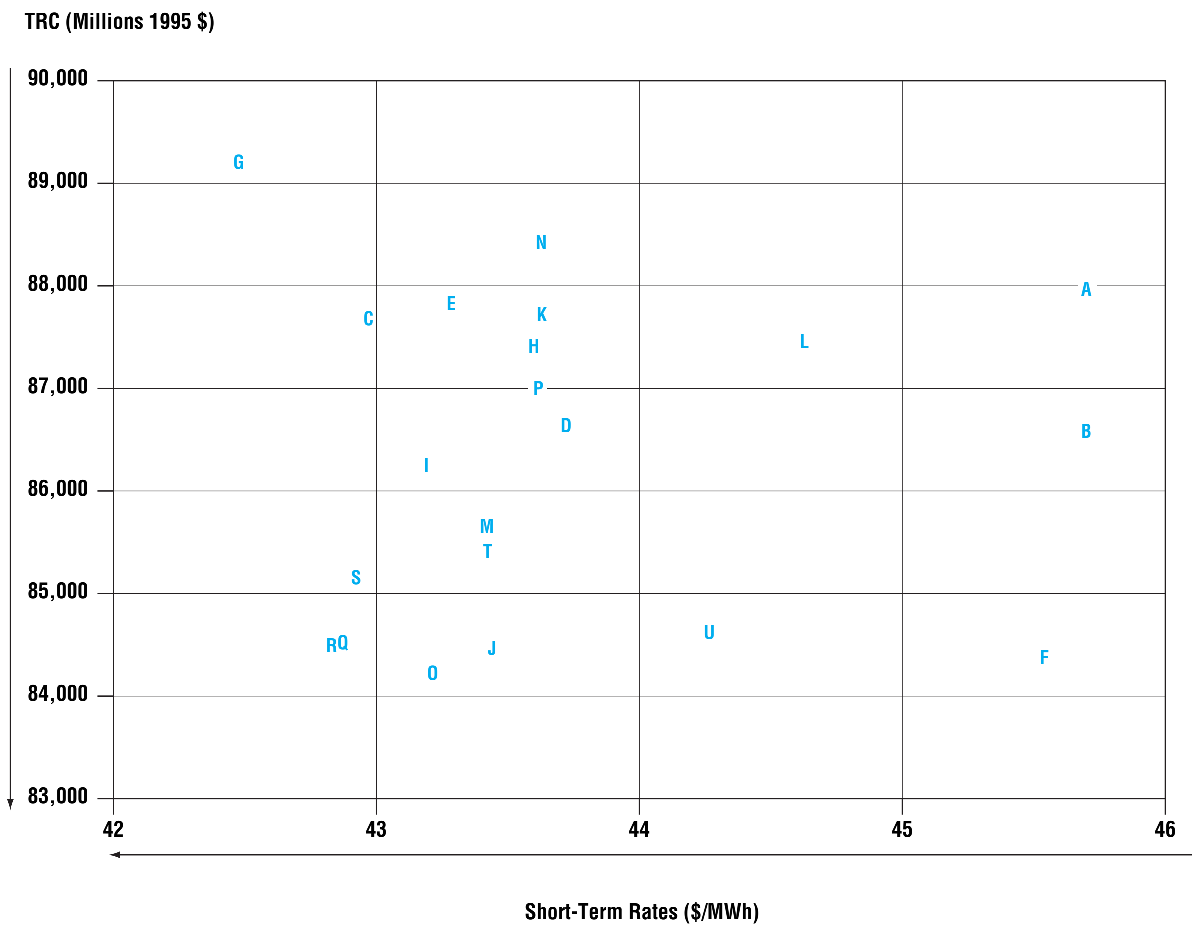


Strategy

- **A** Minimum Carbon Dioxide—Natural Gas Repowering of Existing Coal
- **B** Minimum Carbon Dioxide—Natural Gas Repowering of Existing Coal and Renewables
- **C** Low-Cost Producer (Coal-Based)
- **D** Combined Cycle, Purchased Power, Coal (Reference)
- **E** Maximum Customer Value Index—Off-System Sales, High Beneficial Electrification, Declining Block Pricing
- **F** Low Total Resource Cost, High Demand-Side Management
- **G** Maximum Sales
- **H** Maximum Capacity Diversity
- **I** Bellefonte Nuclear Partnership
- **J** Bellefonte Coproduct, Renewables, Independent Power Producers
- **K** Defer and Build Browns Ferry 1 and Watts Bar 2 with Reference Expansion
- **L** Minimum Carbon Dioxide with Less Demand-Side Management
- **M** Combined Demand-Side Management and Off-System Sales
- **N** Decentralized Generation with More Renewables
- **O** Bellefonte Coproduct, More Demand-Side Management, More Off-System Sales
- **P** Low-Cost Renewables, Low-Price Demand-Side Management, Repowering
- **Q** Flexible with External Options
- **R** Flexible with Internal Options
- **S** Low Cost, Low Rates, Improved Environment
- **T** Low-Cost Renewables, Low-Price Demand-Side Management, Repowering, Bellefonte Coproduct Partnership
- **U** Low-Cost Renewables, More Demand-Side Management, Repowering, Bellefonte Coproduct Partnership

trade-offs, *Figures T8-49* through *T8-55*. In the environmental emissions trade-offs, there is a correlation between the emission criteria. In the environmental impacts trade-offs, there is a correlation between the environmental air impact indices. As the air quality becomes better, the attributes associated with the environmental air impacts also improve. There is no true correlation between the environmental water impact indices *(Figures T8-53* through *T8-55)*.

FIGURE T8-40. **Costs, Rates, Debt, and Value Trade-Off Short-Term Rates vs. Total Resource Costs**



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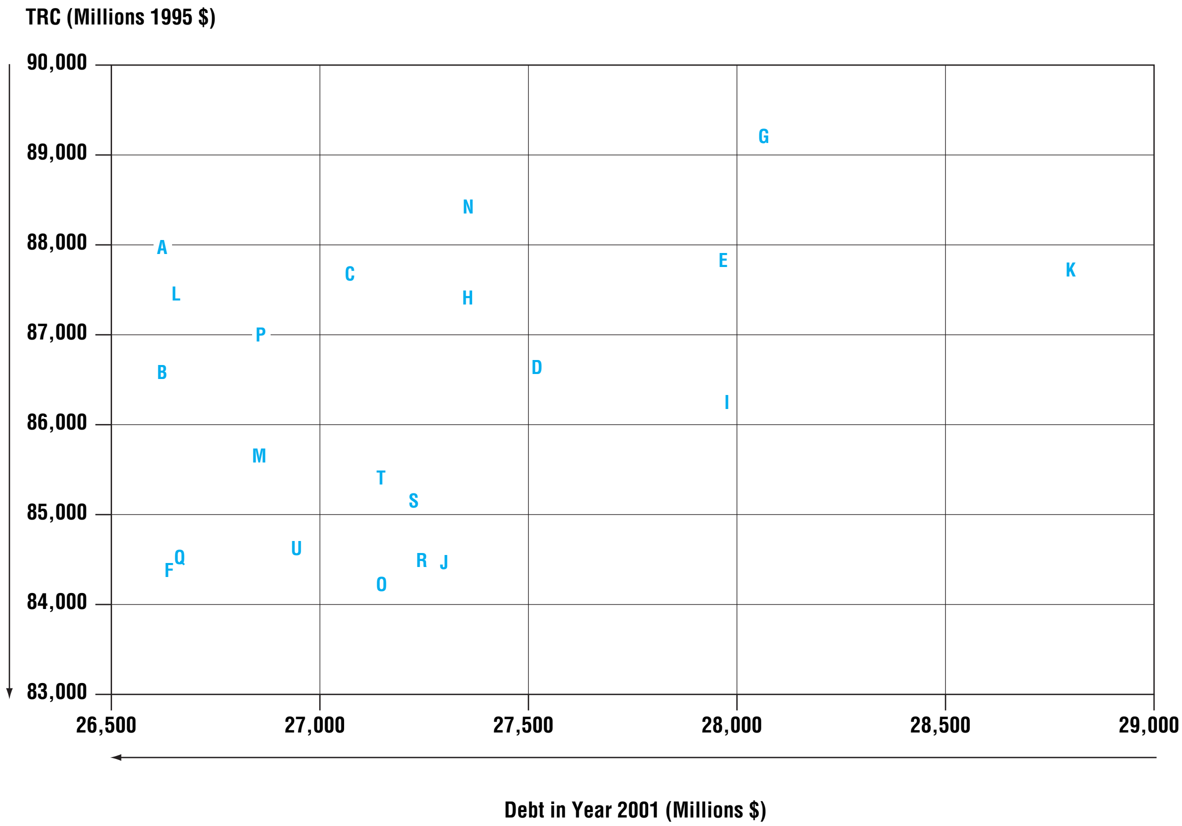
- **U** Low-Cost Renewables, More Demand-Side Management, Repowering, Bellefonte Coproduct Partnership

FIGURE T8-41. **Costs, Rates, Debt, and Value Trade-Off**
Debt in Year 2001 vs. Total Resource Costs



Strategy

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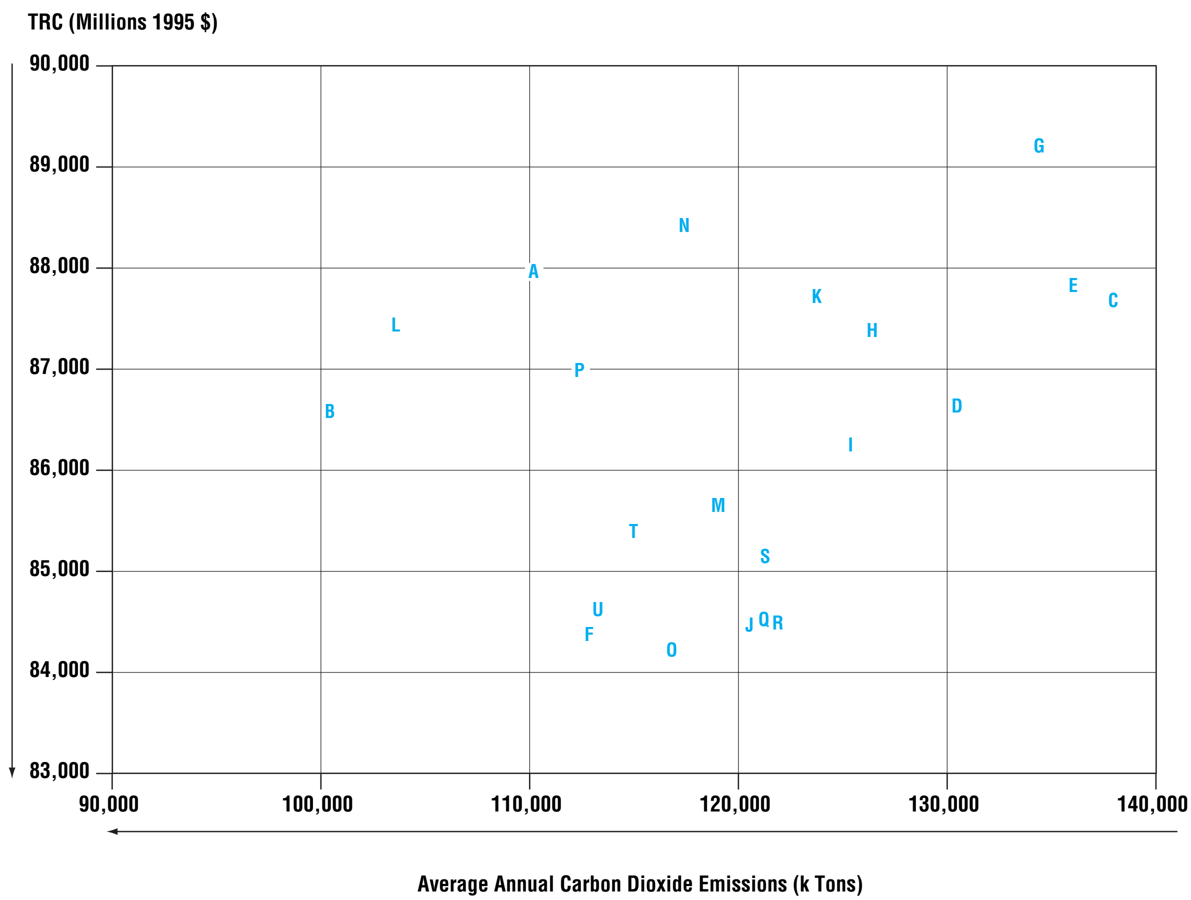
U Low-Cost Renewables, More Demand-Side Management, Repowering, Bellefonte Coproduct Partnership

FIGURE T8-42. Environmental Emissions Trade-Off
Average Annual Carbon Dioxide Emissions vs. Total Resource Costs



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- **J** Bellefonte Coproduct, Renewables, Independent Power Producers
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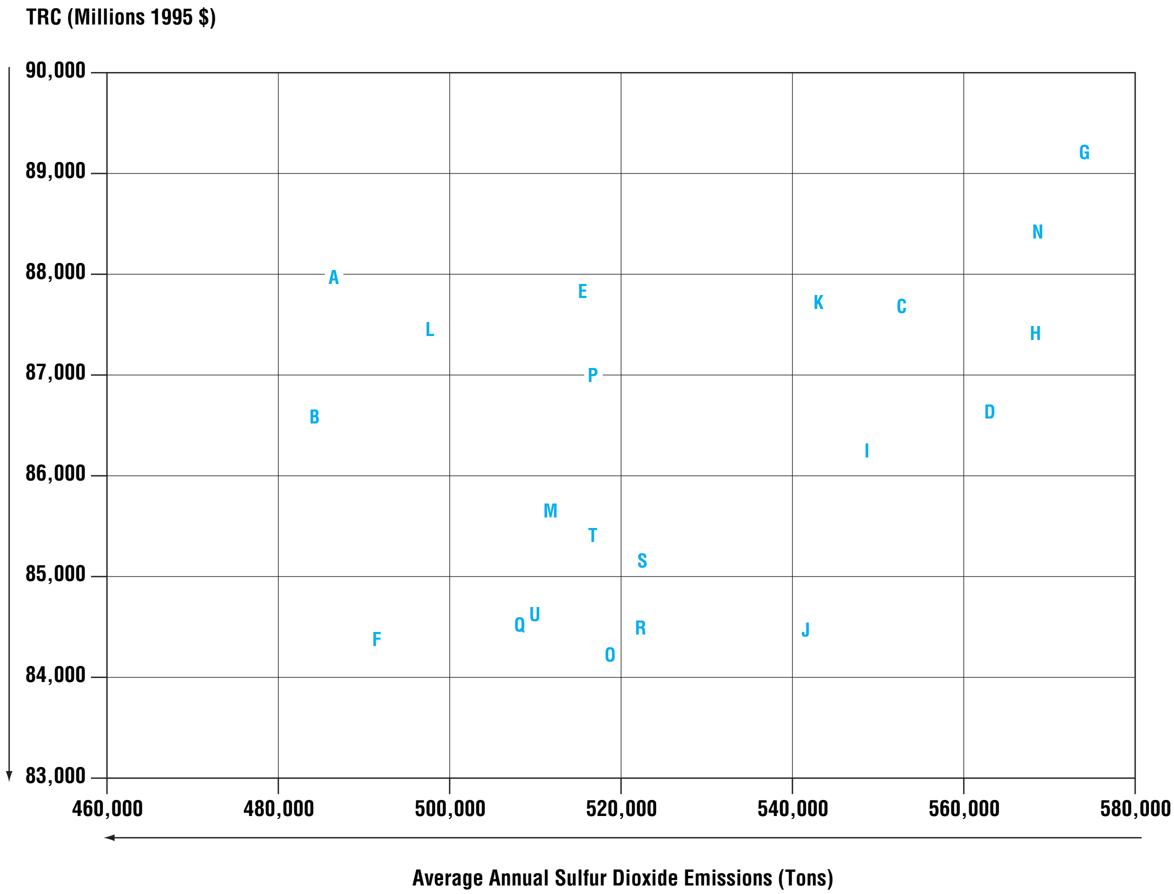
FIGURE T8-43. **Environmental Emissions Trade-Off**
Average Annual Sulfur Dioxide Emissions vs. Total Resource Costs



Strategy

A Minimum Carbon Dioxide—Natural Gas Repowering of Existing Coal
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C Low-Cost Producer (Coal-Based)
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FIGURE T8-44. **Environmental Emissions Trade-Off**
Average Annual Nitrogen Oxides Emissions vs. Total Resource Costs

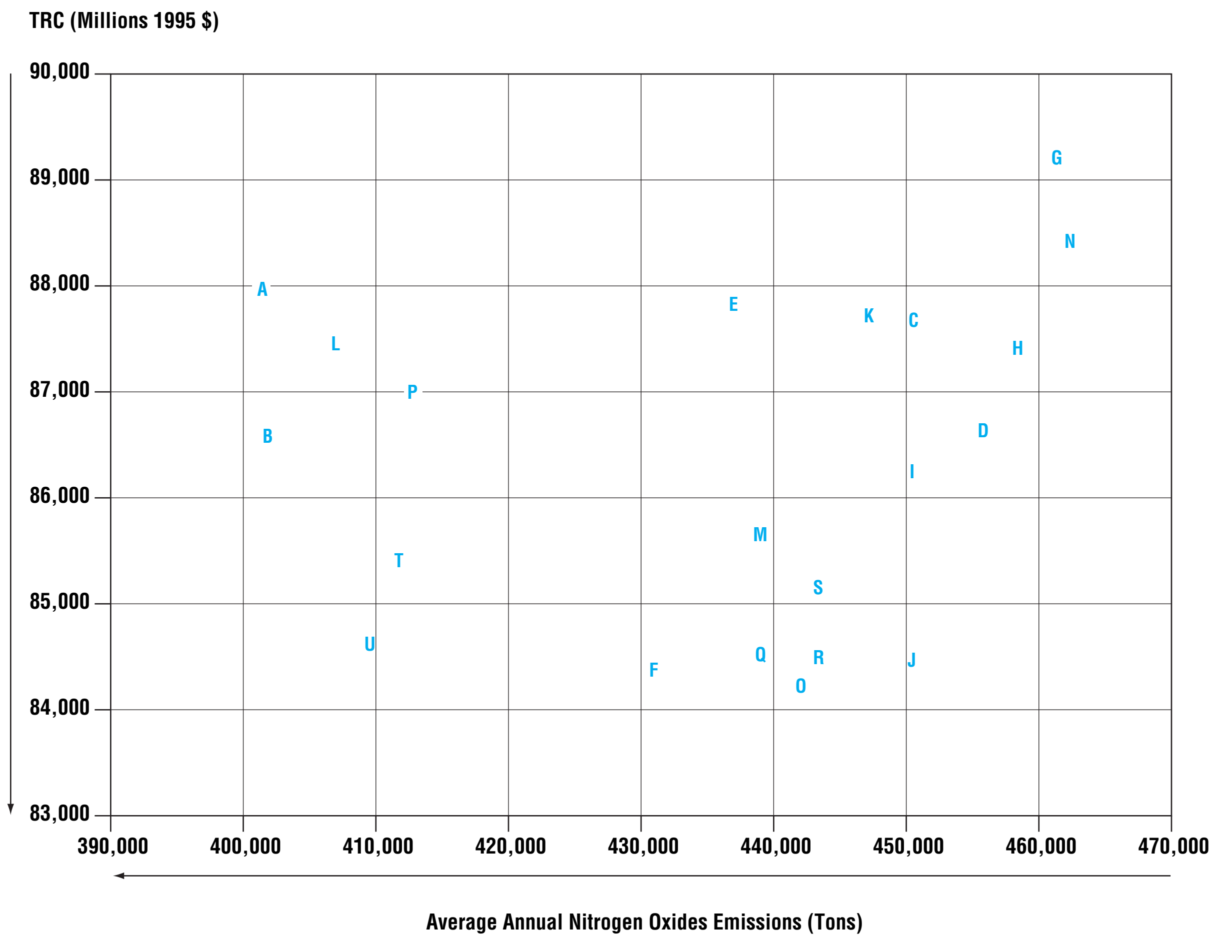

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FIGURE T8-45. **Environmental Emissions Trade-Off**
Thermal Discharge vs. Total Resource Costs

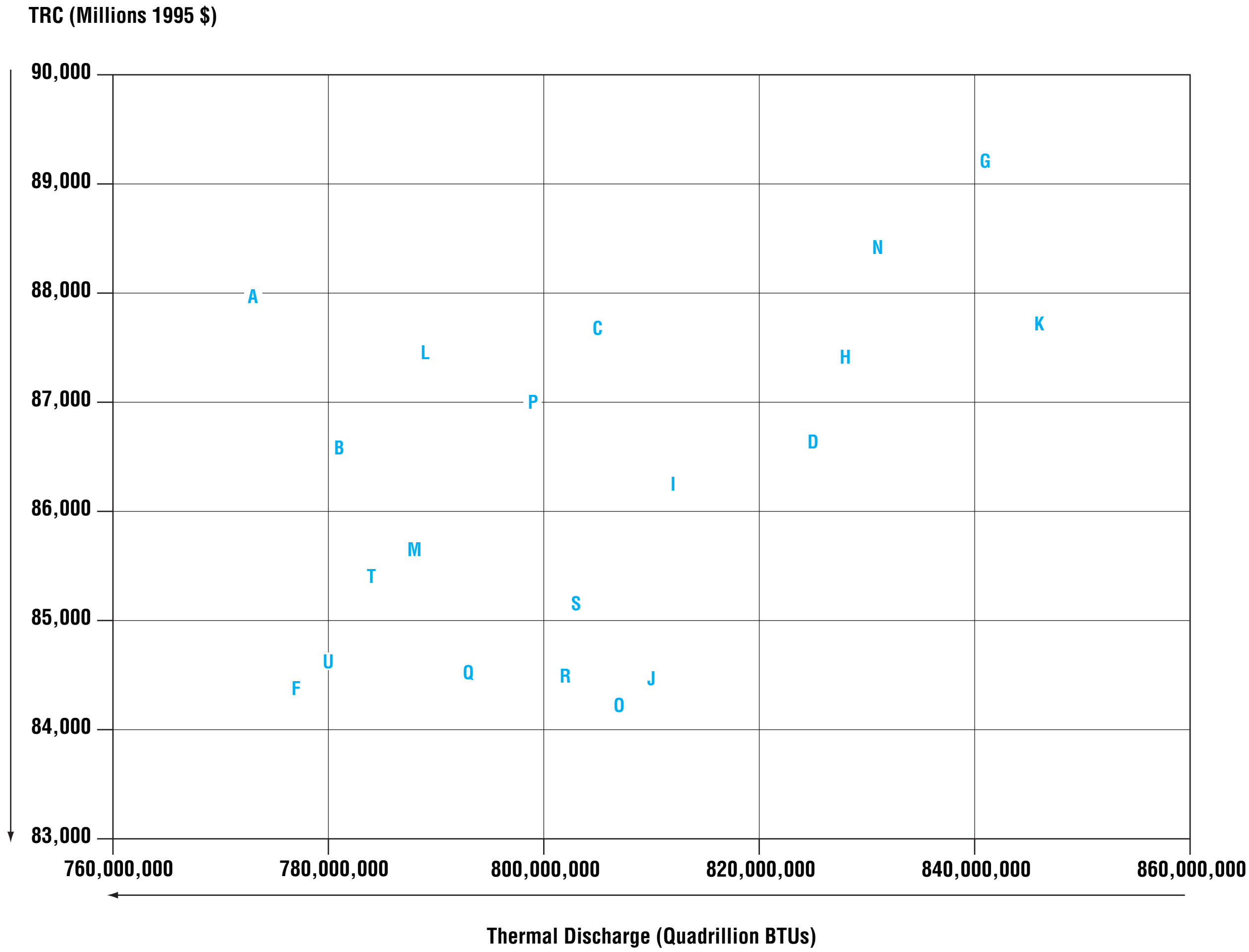

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FIGURE T8-46. **Environmental Emissions Trade-Off**
Volatile Organic Compounds vs. Average Annual Carbon Dioxide Emissions

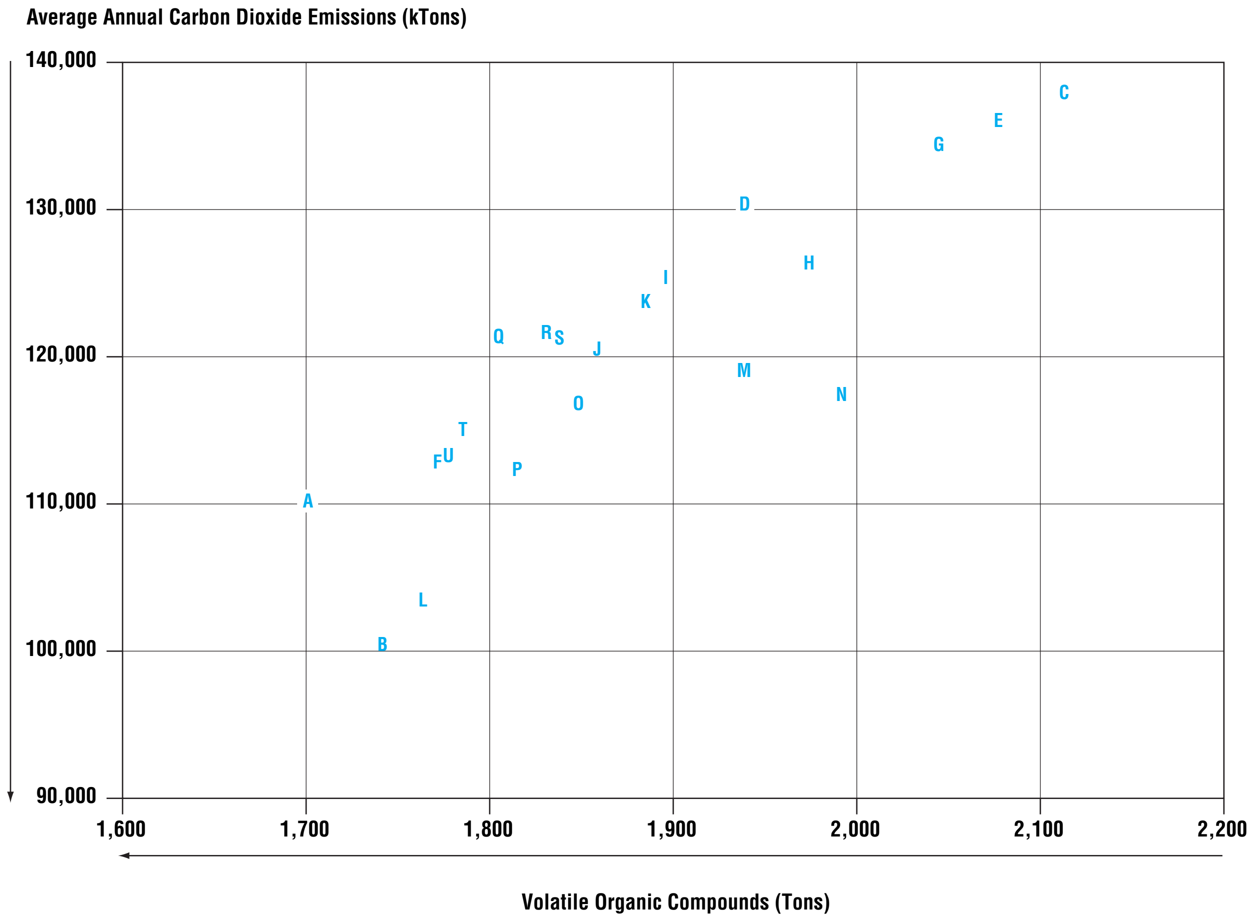

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FIGURE T8-47. **Environmental Emissions Trade-Off**
Total Suspended Particulates vs. Average Annual Carbon Dioxide Emissions

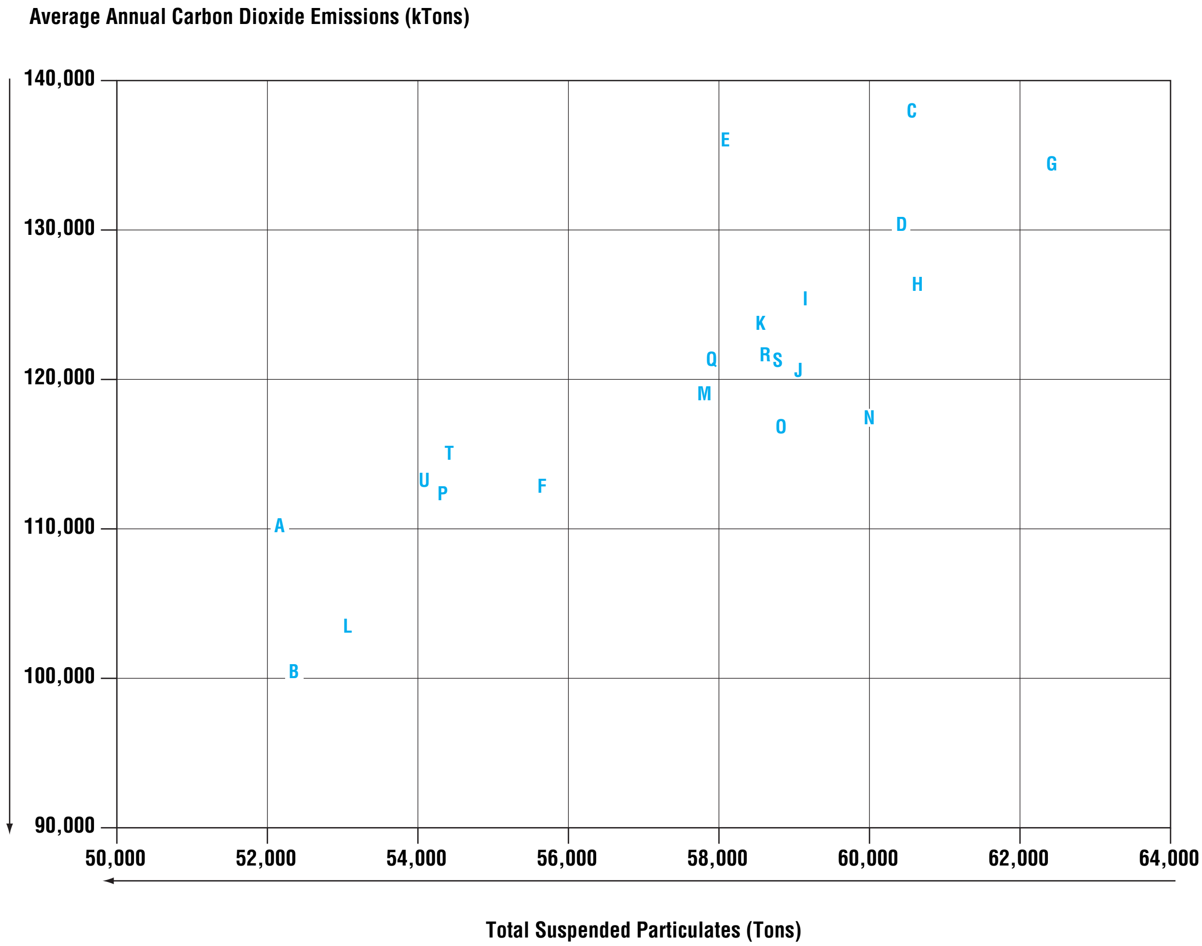

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FIGURE T8-48. **Environmental Emissions Trade-Off**
Thermal Discharge vs. Average Annual Carbon Dioxide Emissions

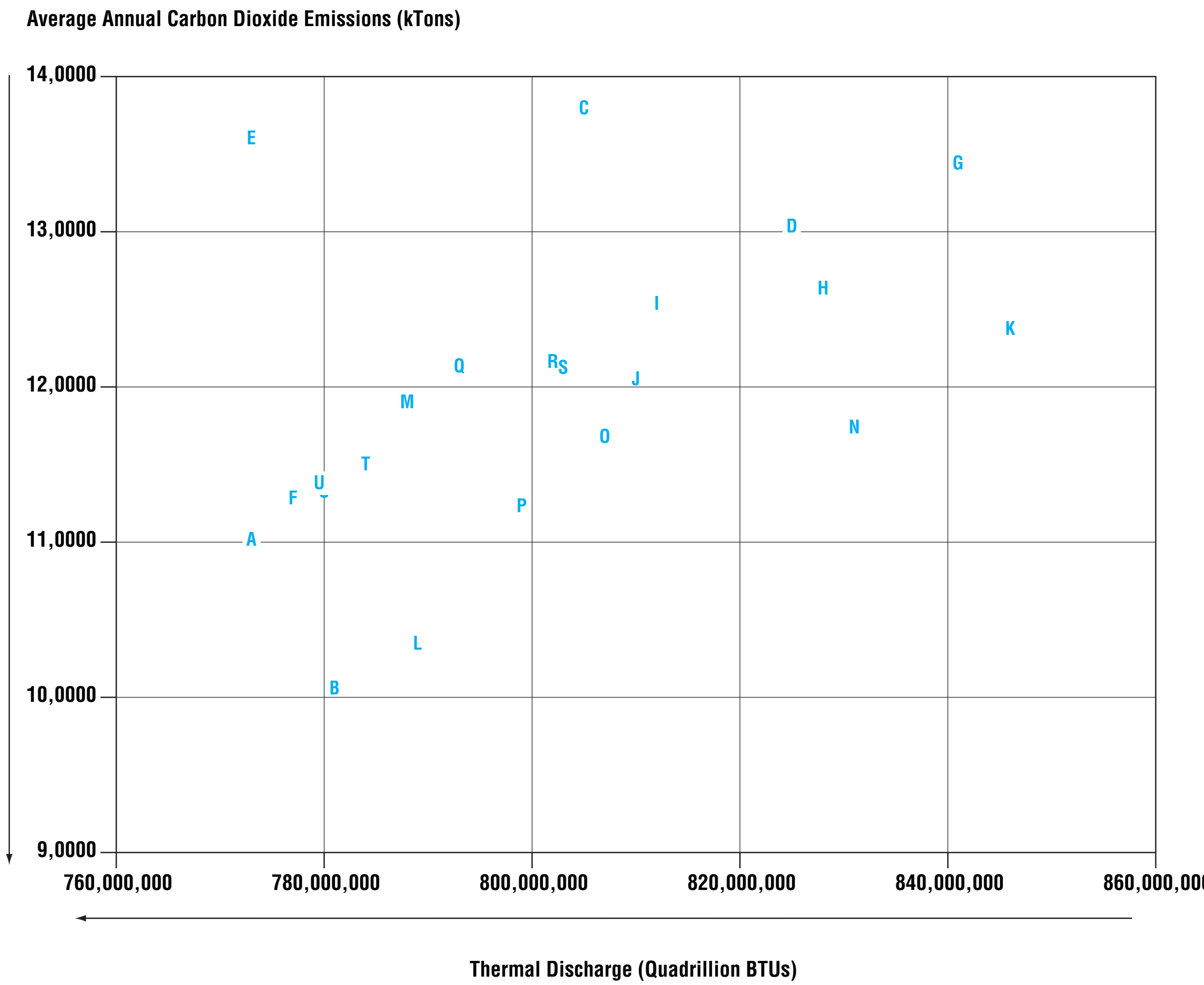

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FIGURE T8-49. **Environmental Impacts Trade-Off Greenhouse Gases vs. Health Inhalation**

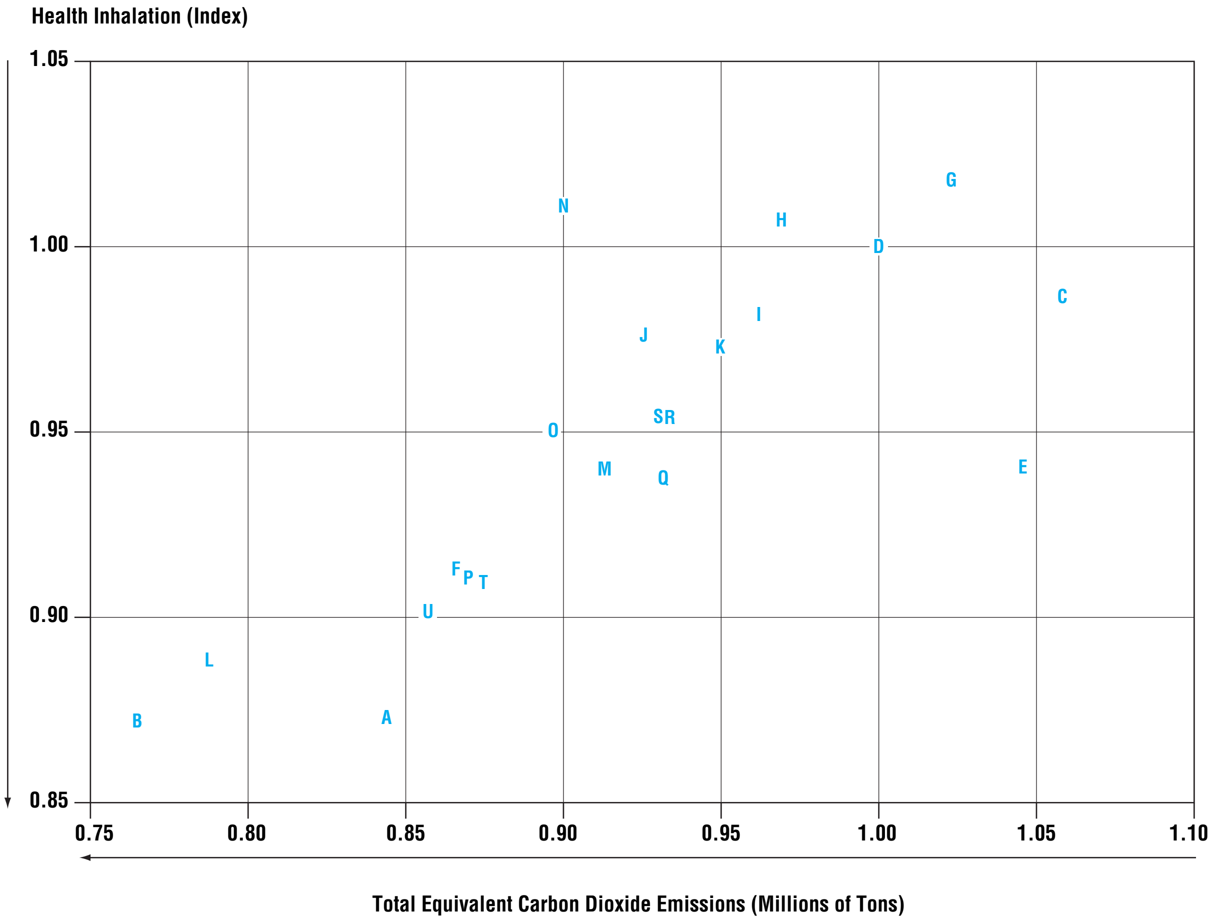

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FIGURE T8-50. **Environmental Impacts Trade-Off Visibility Impairment vs. Health Inhalation**

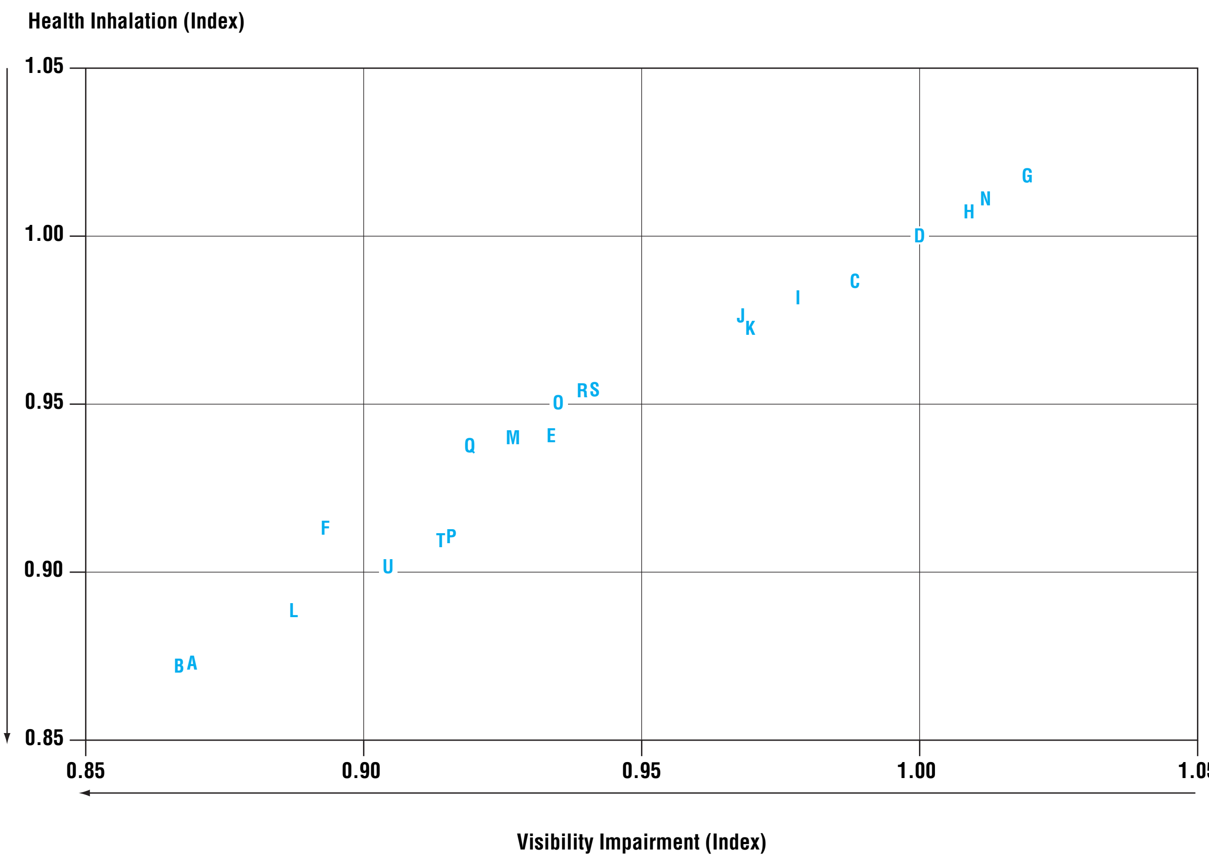

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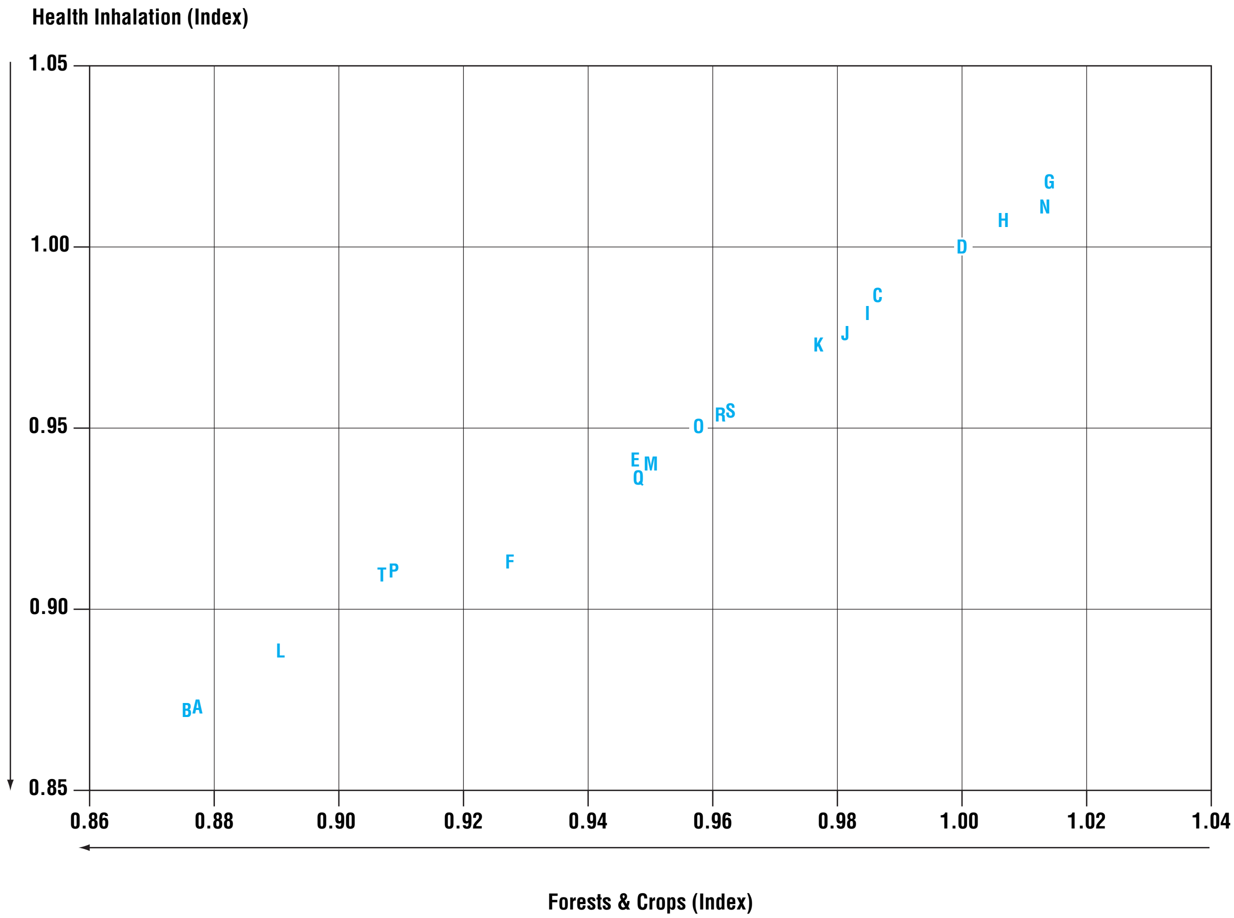
FIGURE T8-51. **Environmental Impacts Trade-Off Forests & Crops vs. Health Inhalation**



Strategy

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FIGURE T8-52. **Environmental Impacts Trade-Off Materials vs. Health Inhalation**

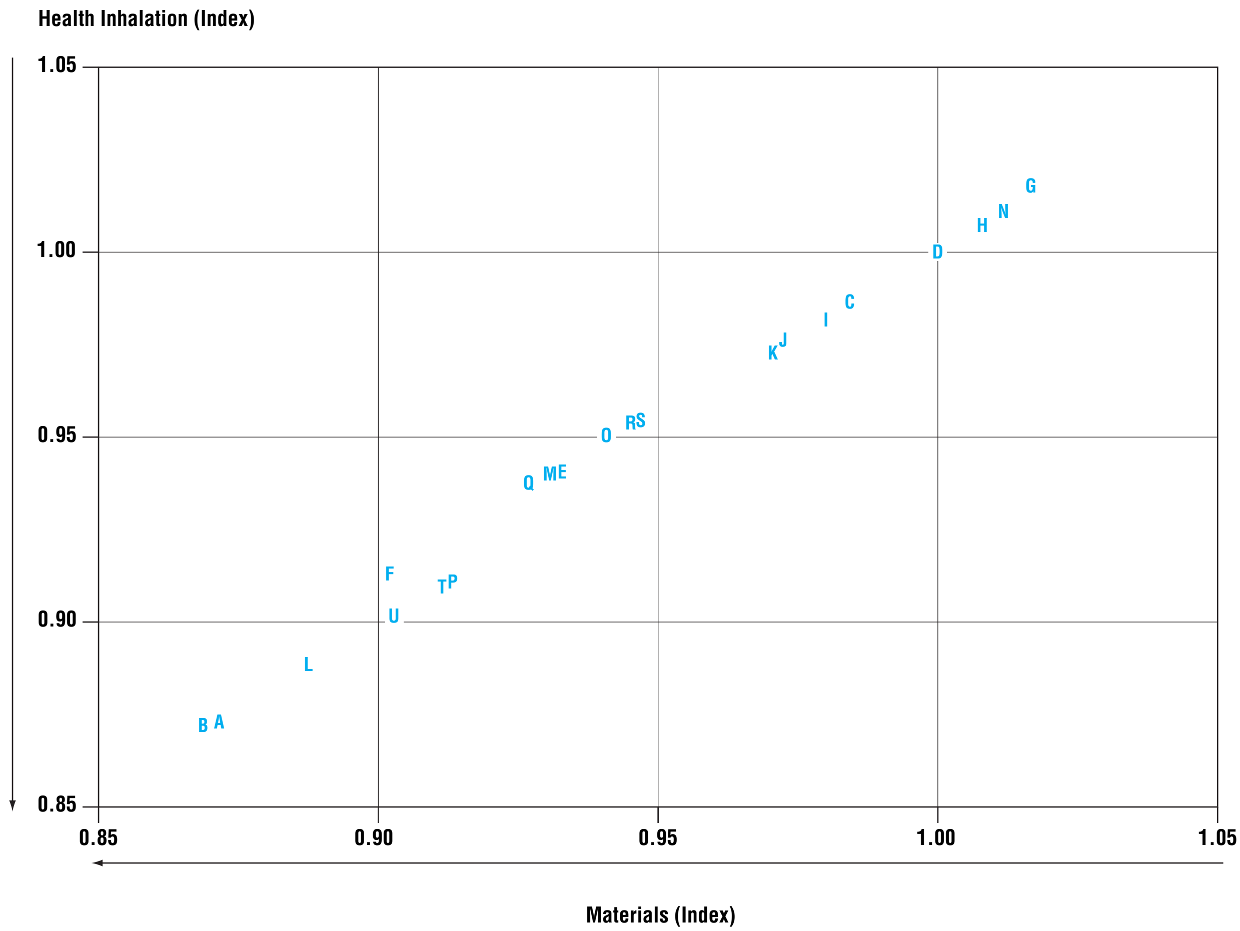

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FIGURE T8-53. **Environmental Impacts Trade-Off**
Water Supply & Waste Assimilation vs. Health Ingestion

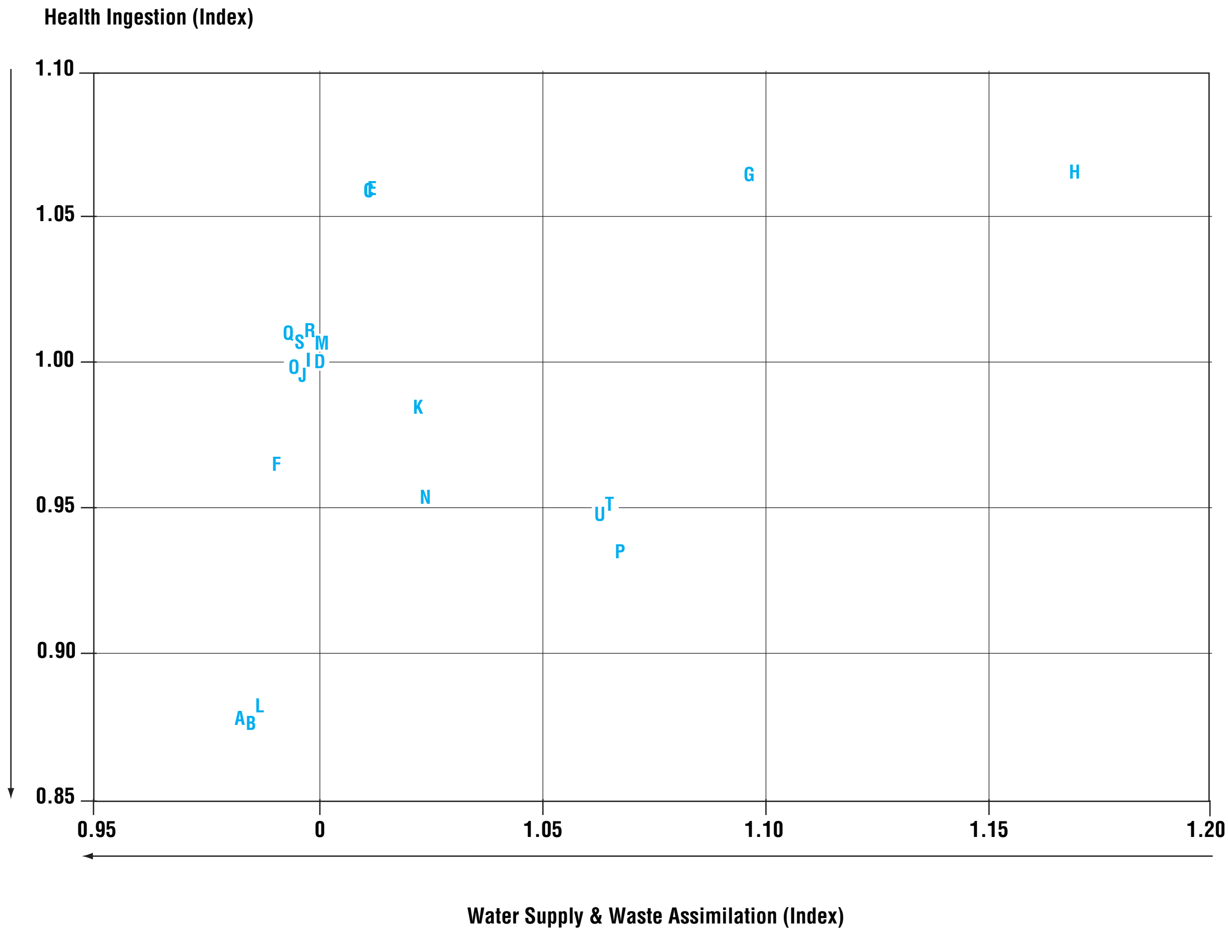

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FIGURE T8-54. **Environmental Impacts Trade-Off**
Fish & Aquatic Life vs. Health Ingestion

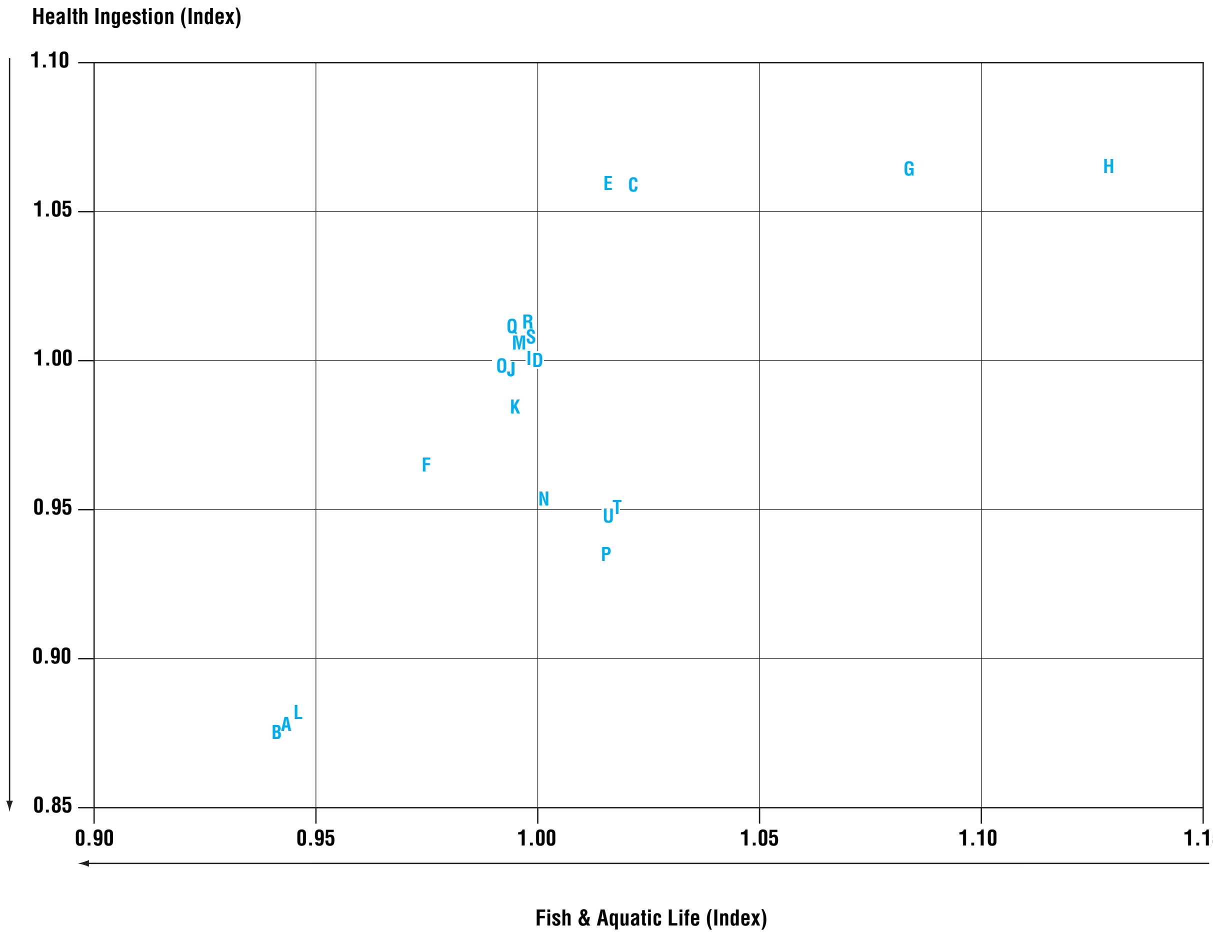

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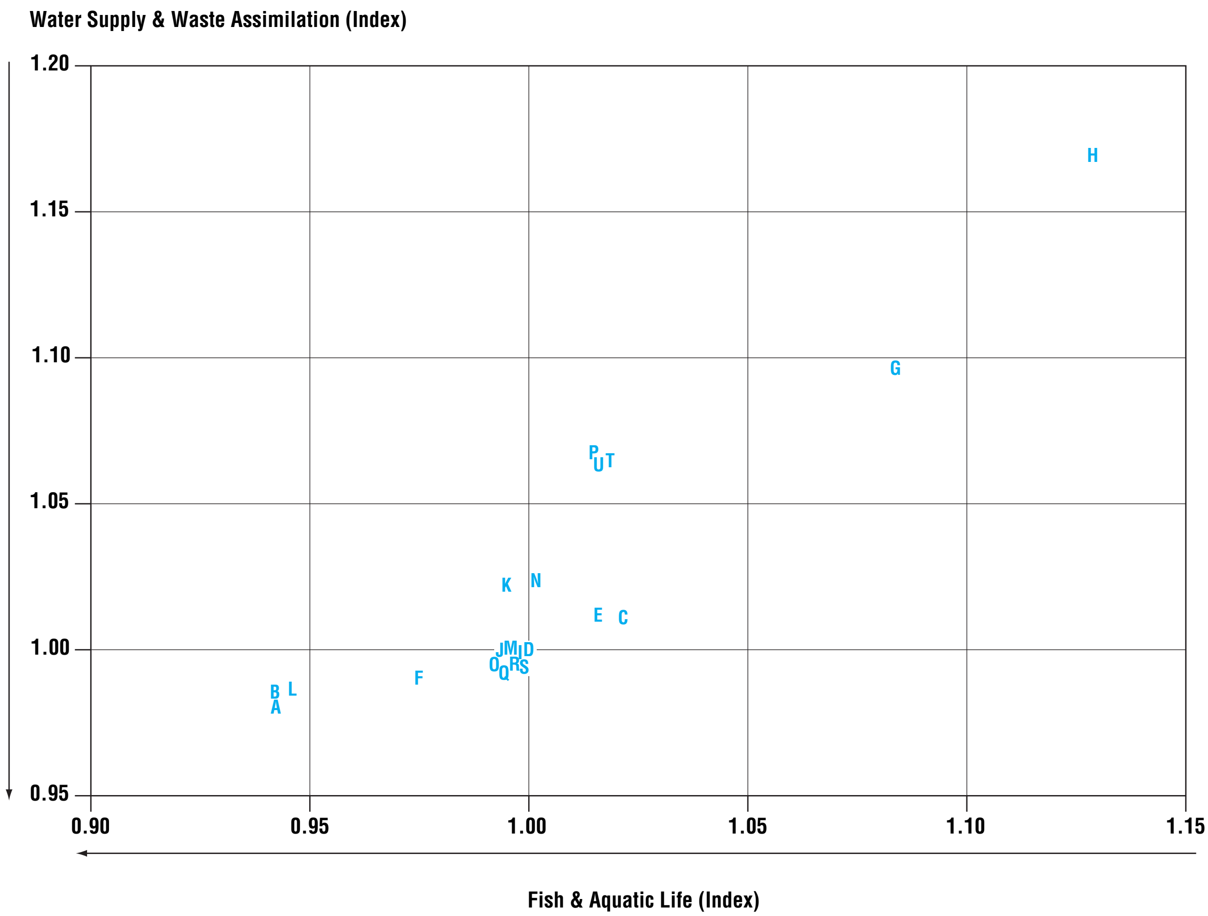
FIGURE T8-55. **Environmental Impacts Trade-Off**
Fish & Aquatic Life vs. Water Supply & Waste Assimilation



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TVA'S NUCLEAR OPTIONS

This paper is from a report, "TVA's Nuclear Options, A Report on Bellefonte Units 1 and 2, Watts Bar Unit 2, and Browns Ferry Unit 1," that was issued by TVA in December 1994.

Overview

This is an interim review of issues involving four unfinished or inoperative TVA nuclear units and their impacts on rates, debt, long-term costs and flexibility for meeting future power needs. It has been developed largely in response to concerns identified through TVA's Integrated Resource Planning (IRP) process.

The three major concerns identified in TVA's IRP to date—debt, competitiveness, and nuclear power—are interrelated. In the opinion of many TVA customers and the public, high debt is generally associated with a poor competitive position. Since the large capital expenditures necessary to complete TVA's nuclear units will increase TVA's debt, completing these units contributes to a perception that TVA's competitiveness will suffer. With this in mind, the TVA Board of Directors requested the Chief Financial Officer (CFO) to initiate a study to look at the possibility of stopping the growth of debt. A summary of the conclusion of this study is:

> "The results of this review, which has encompassed the involvement of all areas of the TVA, is that TVA can limit its level of debt to $2 billion to $3 billion below the $30 billion debt ceiling and can achieve this limitation by the end of fiscal year 1997."

Additionally, the Board of Directors is requesting that the Chief Financial Officer conduct a feasibility study of reducing future levels of debt. The internal limit on debt would be formally reviewed periodically to ensure that this limitation meets TVA's continuing business needs. The debt limit will be carefully observed in the development of TVA's Integrated Resource Plan. The IRP will examine the disposition of TVA's debt in light of an increasingly competitive business environment.

TVA has three nuclear units in various stages of construction with scheduled completion dates ranging from 2003 to 2006. These units and current estimates of the costs to complete them are:

- Bellefonte Units 1 and 2, near Hollywood, Alabama—$4.4 billion
- Watts Bar Unit 2, near Spring City, Tennessee—$2.2 billion
- In addition, one TVA nuclear unit previously licensed to operate would need major modifications and is tentatively scheduled to return to service in the year 2001:
- Browns Ferry Unit 1, near Decatur, Alabama—$2.4 billion

The question of how to proceed with these four nuclear units is of critical importance to TVA and the region it serves. The total cost to complete or restore them to service as nuclear units is estimated to be about $9 billion—unquestionably a major investment by TVA customers. But in addition to these costs, TVA must consider several other factors, such as:

- The need for power in the future
- The cost of other options that could replace the nuclear units
- Prior investment in the nuclear units
- TVA's long-term costs
- TVA's rising debt
- The impact of any decision on short- and long-term rates
- The environmental effects of various options

All of these issues are currently being addressed in TVA's IRP, a comprehensive study of future power needs in the TVA region and the various ways and costs of meeting them. The IRP will not be completed until late 1995. However, several concerns regarding TVA's nuclear construction plans have already been identified through the IRP process. It is necessary, therefore, to review the current status of these units to ensure that they are being managed in the most cost-effective and beneficial manner for TVA customers.

As a result of this review, staff recommends that over the near term TVA should not fund the completion or restoration of Bellefonte Units 1 and 2, Watts Bar Unit 2, and Browns Ferry Unit 1 as nuclear units. Instead, TVA should keep open alternatives for these units that would minimize short-term rates, increase long-term flexibility, minimize long-term costs, and limit debt.

Alternatives to completing/restoring these units as nuclear units include:

- Converting them to another technology such as natural gas
- Replacing them with different types of supply- and demand-side resource options
- Completing the construction of one or more units in partnership with others

- Maintaining the nuclear units in a "mothballed" state and deciding later whether to complete or replace them

Some options could involve limited TVA investment in the future. All options will be carefully considered in the IRP process and, ultimately, the most cost-effective long-term uses for these units will be decided by the TVA Board of Directors.

Introduction

TVA formally began its IRP process in February 1994. An IRP is a process for identifying, thoroughly evaluating, and selecting a set of resource options to meet the expected future consumer demand for electricity. TVA's IRP process is called "Energy Vision 2020."

TVA is committed to developing an energy strategy for the future with considerable input from customers and stakeholders. Decisions and recommendations for meeting future energy needs will take into account the values and expectations customers have for their energy supplier for both electrical generation and demand-side options, as well as for new energy technologies. Information TVA receives from stakeholders is being incorporated into the technical analysis process for Energy Vision 2020.

A series of open meetings provided an opportunity for TVA to both inform the public about its resource planning process and collect valuable input from the public. From July to November, TVA held 12 meetings throughout the Tennessee Valley. Approximately 300 people attended to view the Energy Vision 2020 displays, talk with TVA representatives, and provide input to the planning process. After publication of the draft IRP in July 1995, there will be another round of public meetings across the Valley. These meetings will update the public on the latest findings and provide an opportunity to review and react to TVA's draft plan.

During the summer of 1994, one-on-one interviews were conducted with about 100 opinion leaders across the Tennessee Valley and in Washington, DC. The opinion leaders represented distributors of TVA power, industrial customers, environmental advocates, government, and community leaders. A questionnaire was designed to gather opinions on the issues TVA will examine in Energy Vision 2020. The questions fell into three major areas:

- General questions about the Tennessee Valley region
- Questions about economic development and the environment
- TVA-specific questions

The Energy Vision 2020 Review Group was established in June 1994 to bring key stakeholders into TVA's energy planning process. It consists of 18 representatives from various organizations outside TVA with a wide variety of views and interests. Members of the group provide input and views on TVA's planning assumptions, new options for consideration, and issues associated with long-term energy planning. To date, the Review Group has had seven intensive, full-day sessions, performing in-depth reviews of TVA's IRP planning assumptions and the overall IRP process. Four additional meetings are scheduled.

The Tennessee Valley Public Power Association, an association of the 160 distributors of TVA power, has established a Power Supply Planning Committee. This 28-member committee provides critical reviews of TVA's IRP process and of the major issues facing TVA and the distributors. Since it was formed in May 1994, TVA has met with the committee three times to discuss energy planning issues affecting TVA's wholesale customers.

Through this interactive public participation process and internal reviews, numerous concerns have been identified. Among those most frequently voiced are:

1. TVA's competitive position
2. TVA's nuclear program
3. TVA's debt

With many of the fundamental assumptions necessary for an energy strategy already in an advanced state of review in the IRP process, TVA staff has been able to perform a preliminary analysis of these three concerns. As a result, the staff has prepared this interim report to present the latest findings to the TVA Board of Directors. It should be stressed that these are only initial findings. Taking interim action on these findings would not pre-empt the ultimate decisions to be made through the IRP process. Rather, this will enhance TVA's ability to respond to the rapidly developing competitive environment of the electric utility industry.

This report examines the question of whether TVA should fund the completion or restoration of Bellefonte Units 1 and 2, Watts Bar Unit 2, and Browns Ferry Unit 1 as nuclear units. Alternatives to TVA completing these units include:

- Converting them to another technology such as natural gas
- Replacing them with different types of supply- and demand-side resource options
- Completing the construction of one or more of the units in partnership with others
- Maintaining the nuclear units in a "mothballed" state and deciding later whether to complete or replace them

A more detailed explanation of these alternatives is described in the Nuclear Options Appendix.

Each of these alternatives will affect future costs, electric rates, debt, and environmental impacts, as well as TVA's ability to respond to an ever-changing marketplace. In this paper, we will:

- Review certain key assumptions, such as the need for power,

FIGURE T8-56. **Residential Costs – CalendarYear 1993**

Kentucky Utilities	4.4 ¢/kWh
Kentucky Power	4.9
Kingsport Power	5.1
Appalachian Power (VA)	5.7
Public Service of Indiana	5.8
TVA	**5.9**
Louisville Gas & Electric	6.0
Mississippi Power	6.2
Ohio Power	6.3
East Kentucky Power	6.4 [1]
Gulf Power	6.6
Big Rivers	6.9
South Carolina Elec & Gas	7.1
Alabama Power	7.2
Duke Power	7.3
Union Electric	7.5
Georgia Power	7.8
Louisiana P&L	7.8
Florida Power	7.9
New Orleans Pub Ser	7.9
Florida P&L	8.1
Gulf States Utilities	8.2
Carolina P&L	8.3
Virginia Power	8.6
Mississippi P&L	8.6
Arkansas P&L	9.3
Illinois Power	10.2

[1] Using South Kentucky REC Corp. as representative of East Kentucky Power Coop

Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

cost of the nuclear units, and several other key assumptions that significantly affect the alternative choices available concerning the TVA nuclear construction program.

- Evaluate the changes in costs, electric rates, and debt resulting from the different resource choices.
- Draw some preliminary conclusions upon which the TVA Board may wish to act.

TVA'S COMPETITIVE POSITION

TVA electric rates are currently competitive with other utilities. Comparisons of TVA rates with surrounding utilities for residential, commercial, and industrial customers are shown in *Figures T8-56*, *T8-57*, and *T8-58*.

TVA's residential electric rates are lower than most surrounding utilities. Of the 27 Southeastern utilities shown in *Figure T8-56*, TVA ranks sixth lowest. Likewise, TVA's commercial and industrial rates are below the median level of other utility rates shown in *Figures T8-57* and *T8-58*. The recommendations in this report are intended to improve TVA's competitive position into the future.

SELF-IMPOSED DEBT LIMITATION

The three major concerns identified in the IRP to date—debt, competitiveness, and the future of the four nuclear units—are interrelated. In the opinion of many TVA customers and members of the public, high debt is generally associated with a poor competitive position. Since the large capital expenditures necessary to complete TVA's nuclear units will increase TVA's debt, completing these units contributes to a perception that TVA's competitiveness will suffer. With the rapid evolution of the utility industry into a competitive environment, many utilities are improving their debt structure so that the pricing of electricity can be more flexible in response to future uncertainty. Clearly, with the increasing risk of TVA losing customers to other utilities, prudent business practices suggest that debt be carefully managed and controlled. With this in mind, the TVA Board of Directors requested the CFO to initiate a study to investigate the possibility of stopping the growth of debt. This study, "Report on Controlling the TVA Debt," was completed in December 1994. The following Introduction and Conclusion of the CFO study highlight several key points concerning TVA's debt:

FIGURE T8-57. **Commercial Costs – Calendar Year 1993**

Kentucky Utilities	4.3 ¢/kWh
Public Service of Indiana	4.6
Kingsport Power	5.1
Kentucky Power	5.2
Appalachian Power (VA)	5.3
Ohio Power	5.5
Louisville Gas & Electric	5.6
Gulf Power	5.6
South Carolina Elec. & Gas	5.6
Florida Power	5.8
TVA	**5.9**
Mississippi Power	6.0
Duke Power	6.0
Virginia Power	6.2
Union Electric	6.3
Florida P&L	6.8
East Kentucky Power	6.8 [1]
Big Rivers	6.9
Carolina P&L	6.9
Alabama Power	6.9
Gulf States Utilities	7.3
Georgia Power	7.4
Arkansas P&L	7.6
Louisiana P&L	7.8
Illinois Power	8.3
New Orleans Pub Ser	8.4
Mississippi P&L	8.6

[1] Using South Kentucky REC Corp. as representative of East Kentucky Power Coop

Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

"At the Tennessee Valley Authority Board of Directors meeting on September 21, 1994, the Board of Directors requested that the Chief Financial Officer undertake a study to determine if it would be possible to stop the growth of debt in TVA and, in effect, impose an internal limitation on debt below TVA's statutorily mandated limit of $30 billion. If that is possible, what should that limit be and when could it be achieved.

"The results of this review, which has encompassed the involvement of all areas of the TVA, is that TVA can limit its level of debt to $2 billion to $3 billion below the $30 billion debt ceiling and can achieve this limitation by the end of fiscal year 1997."

The internal debt limit would be formally reviewed periodically to ensure that this limitation meets TVA's continuing business needs.

Additionally, the Board of Directors is requesting that the CFO conduct a feasibility study of reducing future levels of debt.

The debt limit will be carefully observed in the development of TVA's IRP. In addition, the IRP will examine the disposition of TVA's debt in light of an increasingly competitive business environment.

I. Key Assumptions for Evaluating TVA's Nuclear Construction Program

Although many assumptions about possible futures must be made to evaluate TVA's nuclear construction program, two key assumptions are both important and highly uncertain. These are the need for power, which is largely determined by the expectations of future load growth, and the cost and performance parameters for constructing and operating TVA nuclear power plants.

NEED FOR POWER

TVA will likely require additional power beginning in 1998 and increasing to several thousand megawatts (MW) by 2005. This need is shown graphically in *Figure T8-59*.

The bars in *Figure T8-59* represent TVA's long-term forecasts of peak loads plus the necessary capacity reserves to maintain a reliable power system. TVA's peak loads are approximately 24,000 MW today and are expected to increase 1.9 percent per year from 1994 to 2020. Forecasts of future load growth are particularly uncertain, and this uncertainty is represented by low

FIGURE T8-58. **Industrial Costs – Calendar Year 1993**

Big Rivers	3.0 ¢/kWh [1]
Ohio Power	3.2
Kentucky Utilities	3.3
Kentucky Power	3.3
Public Service of Indiana	3.4
Kingsport Power	3.5
Mississippi Power	3.6
Louisville Gas & Electric	3.8
Appalachian Power (VA)	3.8
South Carolina Elec. & Gas	3.9
TVA	**3.9** [2]
Louisiana P&L	4.1
Duke Power	4.3
Gulf Power	4.3
Illinois Power	4.4
Virginia Power	4.4
Alabama Power	4.5
Gulf States Utilities	4.6
Georgia Power	4.7
Florida Power	4.8
Union Electric	5.2
New Orleans Pub Ser	5.3
Florida P&L	5.4
Carolina P&L	5.5
East Kentucky Power Coop	5.5 [3]
Arkansas P&L	6.0
Mississippi P&L	6.6

1 Non-Aluminum Industrial is 3.9 cents/kWh
2 TVA's directly served industrial cost is 3.0 cents/kWh and the distributor served industrial cost is 4.6 cents/kWh
3 Using South Kentucky REC Corp. as representative of East Kentucky Power Coop

Source: DOE 826, REA Forms 7 & 12, and TVA Electric Sales Statistics

and high forecasts of peak load, which generally bound the range of uncertainty. In the low load forecast, peak loads are expected to increase by 0.1 percent per year from 1994 to 2020, and in the high forecast by 3.3 percent per year over the same period. In *Figure T8-59*, the three segments of each bar represent TVA's low, medium, and high demand requirements for that year.

TVA currently has approximately 25,500 MW of existing capacity, with a plan to add 2,235 MW upon the completion of Watts Bar Unit 1 and the return to service of Browns Ferry Unit 3. This existing and future capacity, or supply, is shown by the solid line in *Figure T8-59.*

Matching the supply with projected future demand requirements (comparing the bars to the supply line in *Figure T8-59*) indicates that TVA's need for additional capacity will increase from 700 MW in 1998 to several thousand megawatts by 2005. It must be recognized that these capacity needs are highly uncertain. With low demand requirements, there is no need for future capacity from 1996 to 2020; whereas, with high load growth, there is an almost immediate need for additional capacity.

NUCLEAR COSTS AND PERFORMANCE

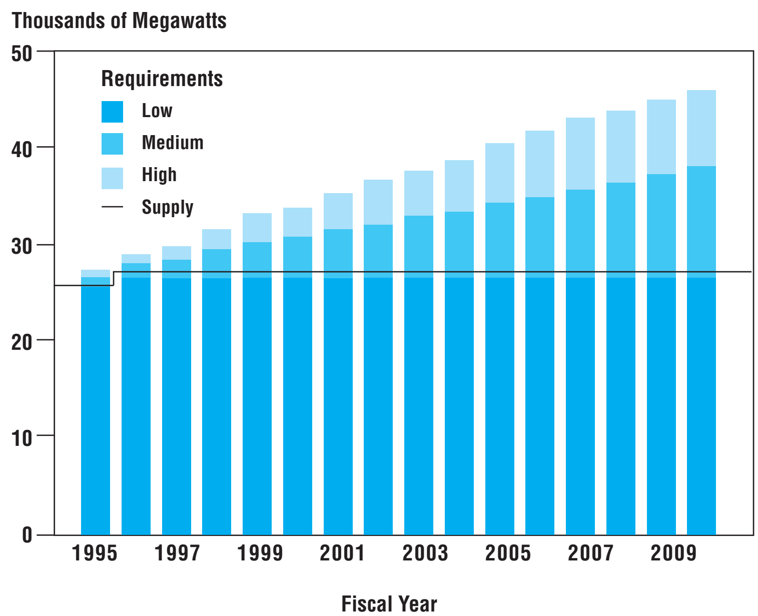
The question of whether to complete/restore the nuclear units is affected by several key assumptions about nuclear construction and operation. Most important are the cost to complete the nuclear units, the cost to operate and maintain the units, and the level of generation from the units or capacity factors. Of lesser significance are the fuel costs and costs to decommission the nuclear plants at the end of their useful lives, currently estimated to be at least 40 years. The future construction cost and operational performance of the nuclear units cannot be precisely forecast and this uncertainty in cost and performance is represented by a range of forecasts for these key assumptions.

Project Cost and Schedule Estimates

Both the expected, or medium, forecast and the low and high forecasts for the cost to complete the nuclear units are shown in *Figure T8-60.*

The medium and high-cost estimates are based on detailed engineering cost estimates plus adjustments reflecting the history of cost-estimating experience by TVA and the nuclear industry. The detailed engineering cost estimates that have

FIGURE T8-59. **Long-Term Capacity Requirements and Supply**



been developed for each of the nuclear projects serve as the "low" estimate for IRP analysis.

Capacity Factors

Capacity factor is a ratio of actual generation from a generating unit compared to its theoretical best output over a certain period of time. TVA's average annual nuclear capacity factor since restoring Sequoyah Units 1 and 2 and Browns Ferry Unit 2 to service has been 67 percent. This value is used as the medium estimate for future capacity factor for the currently operating units (Sequoyah Units 1 and 2 and Browns Ferry Unit 2), for projects under active construction or modification (Watts Bar Unit 1 and Browns Ferry Unit 3), and for the currently inactive projects (Watts Bar Unit 2, Browns Ferry Unit 1, and Bellefonte Units 1 and 2). TVA's high and low estimates for nuclear capacity factor are 86 percent and 55 percent, respectively. Industry trends have shown significant improvement in nuclear performance over the past decade.

Operating Costs

Operating costs for a nuclear unit include "operations and maintenance," "additions and improvements," and fuel. In addition, funds are accumulated for decommissioning throughout the life of the unit. These cost estimates are shown in *Figure T8-61*.

Operations and maintenance cost assumptions are based on the costs incurred by TVA for the operating units over the past five years. The range of potential costs is based on potential variations in plant staffing levels, since this is the primary driver for nuclear operations and maintenance costs.

The cost of additions and improvements has dropped significantly throughout the nuclear industry with the completion of regulation-driven modifications required after the 1979 Three Mile Island accident. TVA is assuming a level of expenditures consistent with industry experience. Replacing steam generators at Sequoyah Units 1 and 2 and Watts Bar Units 1 and 2 is an unusual addition and improvement and is considered explicitly in the IRP analysis.

Nuclear fuel costs at TVA have been higher than average because of contracts written during the 1980s. As these contracts have expired, TVA will be procuring fuel at a cost typical of the industry. Nuclear fuel is relatively abundant now, and sufficient supplies are expected to be available throughout the period of the IRP to limit cost escalation to that of general inflation.

Decommissioning costs are accrued and set aside during the operating life of the plant in accordance with rules issued by the Nuclear Regulatory Commission (NRC). Current cost estimates for decommissioning exceed these NRC requirements. TVA has identified a range of possible decommissioning costs for consideration in the IRP assumptions that use the NRC-required level as a low estimate.

FIGURE T8-60. **Nuclear Project Cost and Schedule Estimates**

	Cost Estimate (millions of 1994 dollars)			Nominal Schedule
Project	Low	Medium	High	(months)
Bellefonte Unit 1	1311	2622	3470	67
Bellefonte Unit 2	912	1824	2420	*
Browns Ferry Unit 1	1187	2374	3150	78
Watts Bar Unit 2	1097	2194	2910	62

** Approximately 18 months after Bellefonte Unit 1 is completed*

FIGURE T8-61. **Nuclear Operating Costs (in 1994 dollars)**

	Low	Medium	High
Operations & Maintenance	$55/kW/yr	$69/kW/yr	$84/kW/yr
Additions & Improvements		Approx. $15 million/unit/yr	
Incremental Fuel		$0.42/million Btu	
Decommissioning			
• Pressurized Water Reactors	$ 200 million	$ 300 million	$ 600 million
• Boiling Water Reactors	$ 250 million	$ 350 million	$ 700 million

License Extension

Operating licenses for the Browns Ferry units expire during the time period covered by the IRP. The NRC issued regulations in 1991 that allow an operator to apply for a license extension of up to 20 years. These rules are currently being revised and are not expected to be finalized until mid-1995. Consequently, the cost and schedule for obtaining a license extension cannot be defined with certainty. Technical studies, however, have not shown any "show-stoppers" that would preclude extending the Browns Ferry licenses. To accommodate this possibility, the IRP will consider both extending the operating licenses at these units and terminating their operation at the current license expiration date.

THE CONVERSION ALTERNATIVE

Figure T8-62 provides a cost and performance summary for converting the Bellefonte nuclear units to fossil-fueled units. Four alternative conversion options are considered: coal-fired plant, natural gas combined cycle, integrated gasification combined cycle, and integrated gasification combined cycle with coproduction of a chemical product such as methanol or methyl tertiary butyl ether.

THE CANCELLATION ALTERNATIVE AND REPLACEMENT WITH SUPPLY- OR DEMAND-SIDE RESOURCES

The key assumptions for supply- and demand-side alternatives that are available to replace the nuclear units are too numerous to display in this paper. However, the cost and performance characterizations for each supply option are identified in the paper, "Energy Vision 2020 Supply-Side Options." Cost and per-

FIGURE T8-62. **Cost and Performance Summary**

	Pulverized Coal, 4x616 MW	Gas-Fired Combined Cycle 10x222 MW	IGCC, 9x250 MW	IGCC with Coproduction, 9x239 MW (feasibility only)
Capacity, MW	2,464	2,220	2,250	2,151
Heat Rate, Btu/kWh	9,611	7,367	8,488	11,761
Fuel [1]	Illinois Basin 3.0 lb SO_2 Coal	Natural Gas	Illinois Basin 7.0 lb SO_2 Coal	Illinois Basin 7.0 lb SO_2 Coal
Capital Cost, [2] $/kW (1994)	$1,263 (base) $1,158 (low) $1,325 (high)	$475 (base) $442 (low) $507 (high)	$1,484 (base) $1,327 (low) $1,650 (high)	$1,730 (base) $1,530 (low) $1,942 (high)
Total Capital Cost, MM$ (1994)	$3,112 (base) $2,853 (low) $3,265 (high)	$1,054 (base) $981 (low) $1,125 (high)	$3,339 (base) $2,986 (low) $3,712 (high)	$3,721 (base) $3,291 (low) $4,177 high)
Coproduct	none	none	none	Methyl Tertiary Butyl Ether
Coproduction Rate, Tons/Day	none	none	none	4,410 tpd
Schedule, Months First Capacity Addition [3]	90 months	66 months	66 months / 81 months [4]	66 months / 81 months [4]
Last Capacity Addition	126 months	90 months	90 months / 108 months [4]	90 months / 108 months [4]

1 Fuel SO_2 is given in terms of pounds of sulfur dioxide produced per million Btus fired.
2 Base capital cost is the expected cost. The high and low ranges define the potential range of capital costs given the uncertainties that have been identified.
3 Duration to first capacity addition assumes approximately 3 years from project initiation to start of construction for environmental permitting activities. This duration may be reduced to 18 months if credit can be taken for previously collected environmental data.
4 First duration assumes phased construction with gas-fired generation coming on-line first, followed by conversion to integrated gasification combined cycle at a later date. Second duration assumes that project proceeds directly to integrated gasification combined cycle without phased construction.

formance characteristics for the demand-side options can be found in "Energy Vision 2020 Customer Service Options."

Canceling the nuclear projects also involves liquidating the asset. Past experience with nuclear project cancellations has shown that there is essentially no net recovery from the existing equipment by the time the project is closed. The IRP, therefore, assumes no net proceeds from canceling the units.

The undepreciated value of the projects, shown in *Figure T8-63*, must also be recovered following cancellation. TVA is investigating the possibility of using recovery periods of up to 30 years.

FIGURE T8-63. **Current Undepreciated Nuclear Project Investments**

	Bellefonte Unit 1	Bellefonte Unit 2	Watts Bar Unit 2	Browns Ferry Unit 1
Current Undepreciated Investment	$ 3.7 Billion	$ 0.8 Billion	$ 1.7 Billion	$ 0.7 Billion

THE DEFERRAL OPTION

The cost of maintaining a nuclear project in a condition that would permit it to be completed at a later date is approximately $10 to $20 million per unit per year. Deferring the decision to a subsequent IRP would allow additional time to acquire information regarding nuclear unit performance and economics, TVA's need for power, and the possible role of nuclear power in minimizing total environmental impacts.

II. Evaluation of Alternatives

Based on the assumptions outlined in the previous section, the alternative nuclear strategies will be evaluated against several key criteria. These criteria (and their measurements), shown in *Figure T8-64*, were developed for the IRP process.

In the full IRP process, each nuclear strategy is evaluated against the criteria in *Figure T8-64*. For example, a strategy to complete the nuclear units is compared to a strategy to replace them with other options, such as coal-fired units. This comparison or trade-off would tell us which strategy (nuclear or coal) would have the lowest costs (total resource costs), lowest rates, least impact on debt, and most flexibility.

FIGURE T8-64. **Evaluation Criteria and Measurements**

Criteria	Measurement
Long-Run Cost and Value	Total Resource Costs Rate Impact Measure Participant Test/Electric Bill Total Value
Rates/Competitiveness	Electric Rates (Cents/kWh) 1996-2000, 1996-2005
Reliability	Reserve Margin Load Not Served
Environment	Emissions (SO_2, CO_2, NO_X, VOC, TSP, etc.) MWh Nuclear Generation
Economic Development	Jobs, Total Personal Income
Financial	Borrowings, Debt, Cash Flow, Net Income
Risk Management	Robustness, Flexibility

Not all of the IRP criteria will be used for the evaluations in this report, but some will be represented as constraints in evaluating the strategies. For example, for each strategy evaluated, the reliability of the power system will be maintained, using a 13 percent capacity reserve margin. Under the environmental criteria, all strategies are evaluated assuming compliance with Phase I and II of the acid rain provisions of the Clean Air Act and compliance with the voluntary goals for greenhouse gas emissions of the Climate Challenge Program.

The criteria for economic development will not be addressed in this report but will be addressed through the IRP.

In this report, strategies will be evaluated specifically on long-term cost (total resource cost), electric rates, and total debt, reflecting the many concerns expressed about TVA's costs and flexibility.

EVALUATING NUCLEAR STRATEGIES – THE PROCESS

Many different strategies were developed as combinations of the nuclear options, supply-side replacement options, and demand-side options. For the purposes of this report, the focus has been narrowed to a few key strategies and the resulting changes in costs, rates, debt, and flexibility. (For a complete description of all strategies and their development, see TVA's Nuclear Options Appendix.)

In evaluating the strategies, the staff looked for those that will minimize long-term costs, minimize short-term rates, minimize long-term debt, and be flexible enough to adapt to an uncertain future. In particular, the staff investigated whether there are strategies better than TVA funding the completion of the four nuclear units. In the analysis, several successive strategies were evaluated—each of which improves TVA's position in one or more of the areas of cost, rates, debt, or flexibility. These strategies are grouped as:

- Completing the nuclear units, as opposed to replacing them with alternative supply- and demand-side resource options
- Converting Bellefonte to another technology

- Completing Bellefonte as a nuclear plant, but with a partner providing funds to complete the plant
- Deferring Watts Bar Unit 2 and Browns Ferry Unit 1 to provide flexibility for an uncertain future

Each of these successive evaluations results in a potential improvement in long-term costs, short-term rates, long-term debt, and flexibility compared to TVA funding completion of the nuclear units. Exactly which strategy or strategies will be pursued as an alternative to completing the nuclear units will be determined through TVA's IRP.

Completing the Nuclear Units vs. Replacement

Five specific nuclear completion strategies are evaluated in this analysis:

1. Complete Bellefonte Units 1 and 2, Watts Bar Unit 2, and Browns Ferry Unit 1
2. Complete Bellefonte Unit 1, Watts Bar Unit 2, Browns Ferry Unit 1, and replace Bellefonte Unit 2
3. Complete Watts Bar Unit 2, Browns Ferry Unit 1, and replace both Bellefonte Units 1 and 2
4. Complete Watts Bar Unit 2 and replace Bellefonte Units 1 and 2 and Browns Ferry Unit 1
5. Replace all four units: Bellefonte Units 1 and 2, Watts Bar Unit 2, and Browns Ferry Unit 1.

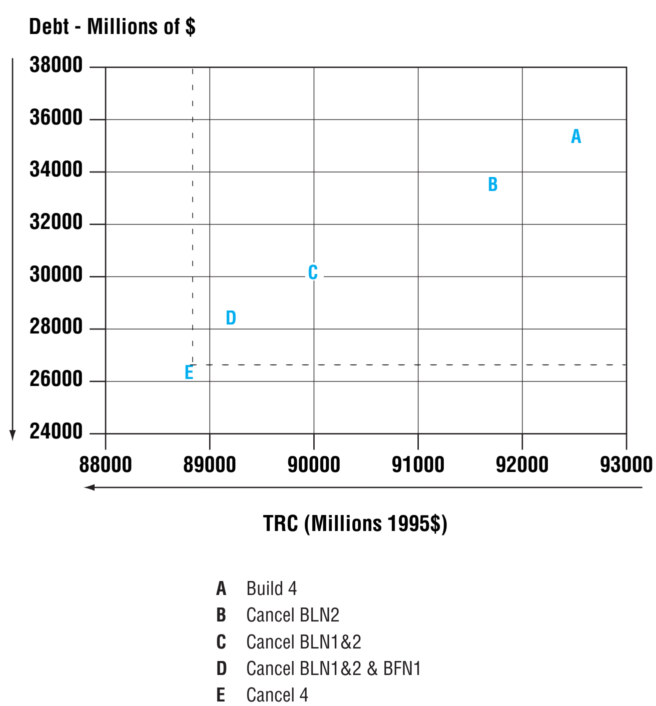
Supply-Side Options: For each of these strategies, the supply-side replacement options considered were natural gas-fired combined cycle units (CC) in the short term and, for the long term, clean coal units (advanced integrated gasification combined cycle (IGCC). Peaking capacity was supplied by combustion turbines. Many different supply-side resource options were evaluated for replacement capacity. These included coal-based capacity, natural gas-based capacity, renewables, and purchases of power from cogenerators, other utilities, and independent power producers. Some of the lower-cost options in the short term were coal-fired units and combined cycle units. In the long term, natural gas-based options, renewables, and clean coal technologies such as integrated gasification combined cycle units were lower in cost. An alternative in the short term to replacing the nuclear units with combined cycle units would be to replace the units with a combination of TVA-financed combined cycle units and purchases of power from other utilities, cogenerators, or independent power producers. Such a strategy would also produce a combination of relatively low long-term costs, low short-term rates, and lower debt.

Demand-Side Options: Several combinations of demand-side options were also evaluated. For this report, the demand-side replacement option was a 700-megawatt block of programs (installed by 2005) that is both low in long-term cost and does not increase electric rates over the short term.

In all cases, the environmental strategy for compliance with Phase II acid rain regulations is based on a combination of switching to low-sulfur coal at several plants and building a scrubber at Paradise Unit 3 and the Allen Steam Plant.

The supply-side, demand-side, and environmental strategies will be thoroughly reviewed in the IRP process.
A comparison of the five nuclear completion/replacement strategies for long-term total resource costs (TRC) and total debt in the year 2007 is represented in *Figure T8-65*.

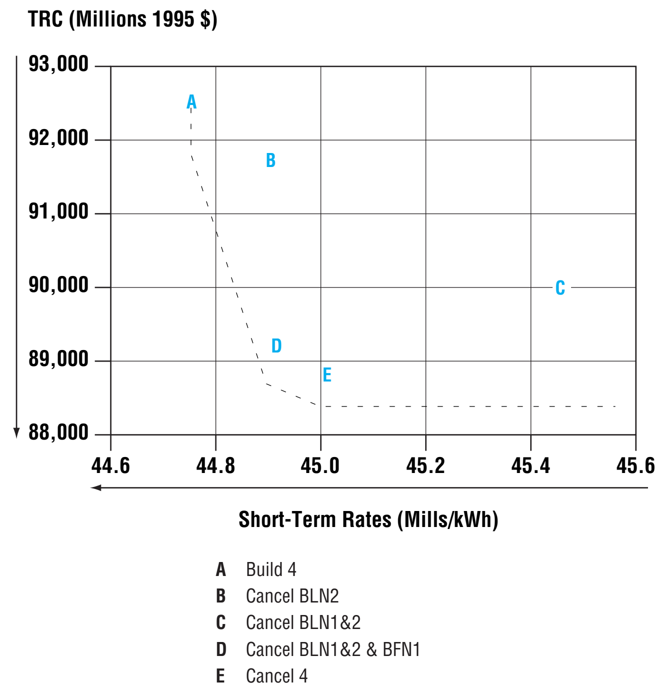
FIGURE T8-65. **Nuclear Decision Trade-Off: Low-Price DSM, Current Clean Air, CC/Coal – Total Resource Costs vs. Debt in Year 2007**



In F*igure T8-65*, the trade-off between long-term cost (TRC on the horizontal axis) and debt in the year 2007 (vertical axis) is shown for the five strategies. The results indicate that completing the four nuclear units (A) has the highest debt and highest cost compared to other strategies. The strategy that results in the lowest cost and lowest debt is to replace all four nuclear units with alternative supply- and demand-side resource options. The other strategies indicate that not completing various combinations of the nuclear units and replacing them with other resource options would result in successively lower long-term cost and debt.

A comparison of these same five strategies for long-term cost and short-term electric rates (average from 1996 to 2000) is shown in *Figure T8-66*.

FIGURE T8-66. **Nuclear Decision Trade-Off: Low-Price DSM, Current Clean Air, CC/Coal – Short-Term Rates vs. Total Resource Costs**



Long-term costs are a measure of the long-term economic efficiency of the power system and short-term rates are a measure of short-term competitiveness. Short-term viability is extremely important as the electric utility industry is deregulated and competition or competitive pressures increase. Low rates will be an important measure of success.

The comparison of the five strategies indicates a trade-off between long-term TRC and short-term rates, as indicated by the dashed trade-off line. Building all four nuclear units results in the highest cost and lowest rates, whereas replacing all four units results in lower cost and a slight increase in rates. Replacing only Bellefonte Units 1 and 2 (C) results in lower costs but increased short-term rates. The short-term rate increase would result from an increase in revenue needed to write off previously spent (sunk) capital expenditures on the nuclear units if these units are replaced.

Replacing all four nuclear units has a lower effect on rates than replacing Bellefonte Units 1 and 2 only. One might expect that replacing all four units would have a greater effect on short-term rates than simply replacing two units, since the write-off of sunk cost for four units is greater. However, the short-term rate increases are less when replacing four units because of other cost savings. The lower cost-to-complete, capital additions and improvements, and operation and maintenance costs for Browns Ferry Unit 1 offset the increase in revenue needs due to write-offs.

Converting Bellefonte to Another Technology

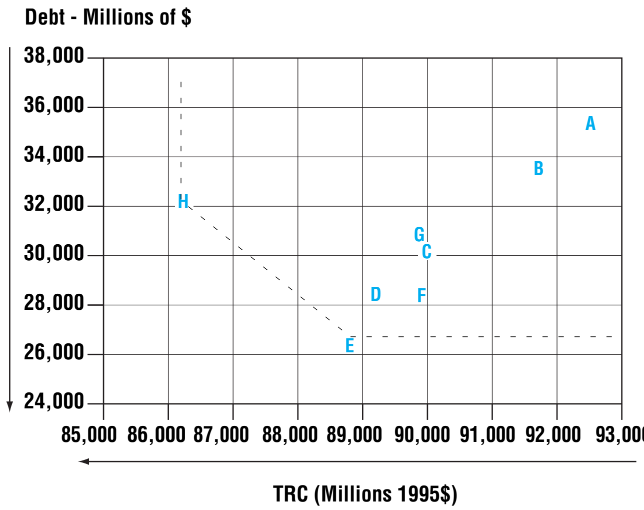
Three strategies for converting Bellefonte Units 1 and 2 to an alternative technology are:

1. Convert to a natural gas-fired combined cycle (CC)
2. Convert to an integrated gasification combined cycle unit (IGCC) in which coal is gasified and the synthesis gas is used in a combined cycle unit
3. Convert to an integrated gasification combined cycle plant where some of the synthesis gas is used to produce a chemical coproduct such as methanol (IGCC/P)

Converting Watts Bar Unit 2 or Browns Ferry Unit 1 to another technology is less feasible because there are, or will be, operating nuclear units at these sites. Although not completely infeasible, the shared systems would make conversion extremely difficult from a technical viewpoint. Thus, for this report, converting Watts Bar Unit 2 and Browns Ferry Unit 1 are not considered.

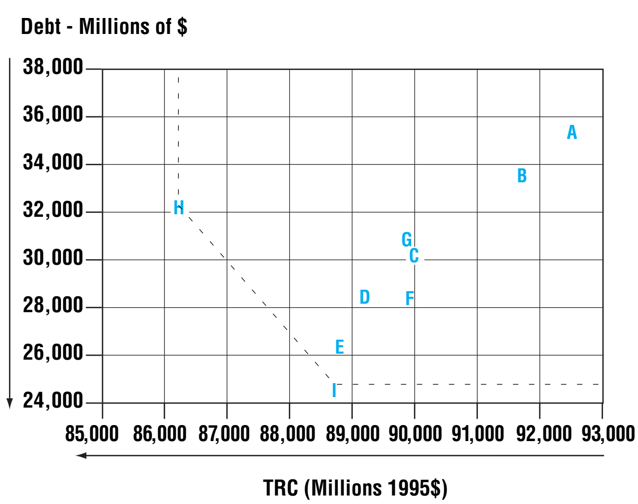
These three Bellefonte conversion strategies are compared to the completion and replacement strategies previously evaluated. For comparison purposes, all of the conversion strategies assume that Watts Bar Unit 2 and Browns Ferry Unit 1 are replaced by the same supply- and demand-side options as in the previous comparisons. The completion, replacement, and conversion strategies are shown in *Figure T8-67* for long-term costs and total debt in 2007.

FIGURE T8-67. **Nuclear Decision Trade-Off: Low-Price DSM, Current Clean Air, CC/Coal – Total Resource Costs vs. Debt in Year 2007**



- **A** Build 4
- **B** Cancel BLN2
- **C** Cancel BLN1&2
- **D** Cancel BLN1&2 & BFN1
- **E** Cancel 4
- **F** Cancel CC Conv
- **G** Cancel IGCC Conv
- **H** Cancel IGCC/P Conv

FIGURE T8-68. **Nuclear Decision Trade-Off: Low-Price DSM, Current Clean Air, CC/Coal – Total Resource Costs vs. Debt in Year 2007**



- **A** Build 4
- **B** Cancel BLN2
- **C** Cancel BLN1&2
- **D** Cancel BLN1&2 & BFN1
- **E** Cancel 4
- **F** Cancel CC Conv
- **G** Cancel IGCC Conv
- **H** Cancel IGCC/P Conv
- **I** Defer & Partner

The conversion options (F,G, and H) compared to replacing all the nuclear units (E) have higher debt associated with them. The conversion to combined cycle (F) and integrated gasification combined cycle (G) also tends to increase costs by approximately $1 billion. The conversion to an integrated gasification plant with a chemical coproduct (H), although increasing debt, does lower long-term costs by approximately $3 billion compared to replacing all of the nuclear units (E).

Although not shown in *Figure T8-67*, the conversion to combined cycle or the conversion to integrated gasification combined cycle with a coproduct (IGCC/P) have about the same effect on short-term rates as replacing all of the nuclear units.

The conclusion from this comparison is that converting Bellefonte to a combined cycle (CC) plant increases long-term cost and debt slightly compared to replacement, but appears to be a viable alternative to completing Bellefonte as a nuclear plant. The conversion to integrated gasification combined cycle with a chemical coproduct (IGCC/P) can significantly reduce long-term costs but significantly increases debt. To reduce the impact on debt for the conversion to a plant that produces a coproduct, TVA is exploring an option for a partnership to build the IGCC/P plant. This option will be fully explored in the IRP process.

Bellefonte Nuclear Partnership

Another strategy currently being explored by TVA is to enter into a partnership with another firm to complete Bellefonte as a nuclear plant. In this arrangement, the partner would complete the construction of the nuclear plant and TVA would buy a part or all of the electricity produced at predetermined prices. Any profits from the sale of electricity would be returned to TVA and the partner(s). This partnership strategy is compared to the completion, replacement, and conversion strategies in *Figure T8-68*.

The Bellefonte partnership strategy is shown in *Figure T8-68* as an 'I'. Based on preliminary assessments of the potential for a partnership arrangement, this strategy could reduce long-term cost and debt compared to replacing Bellefonte with alternative supply- or demand-side resource options. Thus, a partnership for Bellefonte will be fully evaluated in TVA's IRP.

UNCERTAINTY IN KEY ASSUMPTIONS

The strategies to complete the nuclear units, replace the nuclear units, convert Bellefonte, or enter into a partnership to complete Bellefonte as a nuclear plant have been evaluated based on a mid-range set of assumptions discussed in the previous section. All of the evaluations have been based on a mid-range future that includes:

- The mid-range load forecast
- The mid-range cost and operating characteristics for the nuclear plants
- Other assumptions necessary for the evaluations

Basing the evaluations solely on the mid-range assumptions implies that we can perfectly forecast the future. Since no one has perfect foresight, it is necessary to evaluate the nuclear strategies using different assumptions about the future. Under the IRP, over 30 different parameters already have been analyzed, as well as how variations in these parameters can change the evaluations of these strategies. From these analyses, we have identified the most important parameters or uncertainties whose variation could alter the evaluations of the nuclear strategies. These uncertainties are:

- The load forecast
- The cost to complete the nuclear plants
- The operations and maintenance cost for the nuclear plants
- The capacity factor of the nuclear plants
- Whether there will be future legislation on carbon dioxide (CO_2) emissions or greenhouse gases

Further evaluations have indicated that decisions concerning completing the nuclear units versus replacing them would not be affected by possible future legislation on CO_2 emissions. In these evaluations, CO_2 was valued at $5 and $10 per ton. Before it became a significant decision factor, CO_2 would have to be valued at approximately $30 per ton.

To examine uncertainty, the nuclear strategies have been evaluated for two alternative futures as compared to the mid-range assumptions. To derive these futures, we have varied the load forecast, the cost-to-complete, the operation and maintenance cost, and the capacity factor of the nuclear units. The first future is a "low performance" future consisting of:

- Low load growth
- High cost-to-complete the nuclear units
- High operations and maintenance costs of the nuclear units
- Low nuclear capacity factor

The second "high performance" future consists of:

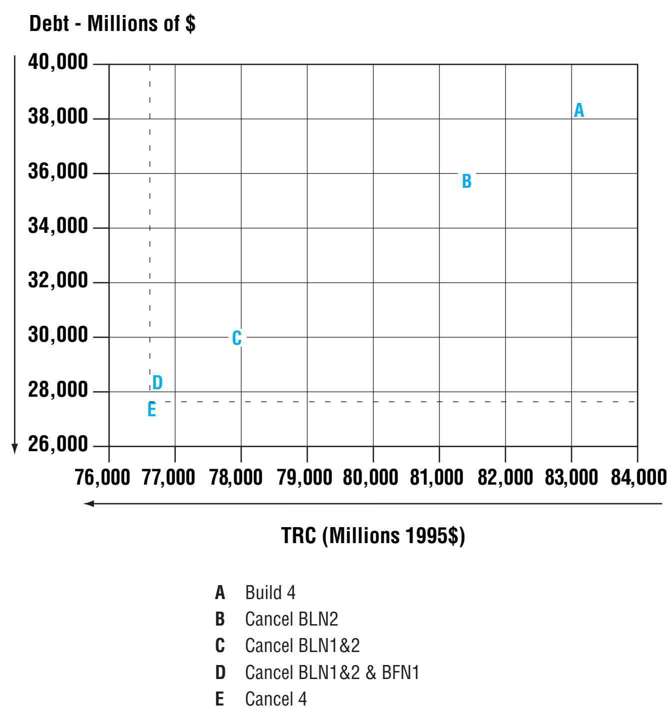
- The high load forecast
- Low cost-to-complete the nuclear units
- Low operations and maintenance costs
- High nuclear capacity factor

A Comparison of Nuclear Completion and Replacement with Alternative Futures

The effect on long-term cost and debt for the five nuclear completion and replacement strategies for the "low performance" future is shown in *Figure T8-69*.

In *Figure T8-69* the lowest cost and lowest debt option is to replace all four nuclear units with alternative supply- or demand-

FIGURE T8-69. **Nuclear Decision Trade-Off: "Low Performance" Future – Total Resource Costs vs. Debt in Year 2007**

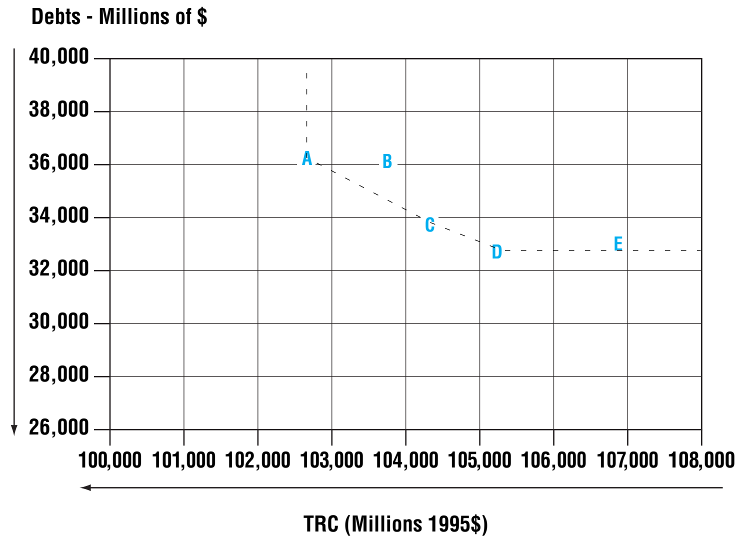


side options. This result is the same as for the "mid-range forecast" shown in *Figure T8-59* in the "Key Assumptions" section.

The same strategies evaluated with the "high performance" future are shown in *Figure T8-70*.

In *Figure T8-70*, the five nuclear completion and replacement strategies are evaluated for the "high performance" future and the resulting impacts on long-term costs and debt are represented. These results differ from previous results in that the lowest-cost option is to complete the nuclear units (A) compared to canceling the units (E). Completing the units (particularly the Bellefonte units) generally results in higher debt when compared to replacing them (A and E).

FIGURE T8-70. **Nuclear Decision Trade-Off: "High Performance" Future – Total Resource Costs vs. Debt in Year 2007**



A Build 4
B Cancel BLN2
C Cancel BLN1&2
D Cancel BLN1&2 & BFN1
E Cancel 4

SUMMARY OF ALTERNATIVE FUTURES

For the "mid-range" future and "low performance" future, the lowest long-term cost and debt strategy was the strategy to replace all four of the nuclear units. For the "high performance" future, the completion of Watts Bar Unit 2 and Browns Ferry Unit 1 could reduce costs compared to replacing the units and not significantly increase debt in 2007. Thus, if we could predict for certain that the "high performance" future would occur, costs could be reduced by completing Watts Bar Unit 2 and Browns Ferry Unit 1 compared to replacing the units.

An alternative that would allow TVA to gain additional information about load growth and nuclear performance would be to defer until a later time the decision to complete or replace the nuclear units. If, in the near future, the "mid-range performance" or the "low performance" future appears more likely, the nuclear units could be replaced. If the "high performance" future seems likely, then the nuclear units could be completed. The additional cost of such a strategy is the cost of keeping the nuclear units in a deferred status, or approximately $10 to $20 million per year per unit.

Deferral of the Decision on Watts Bar Unit 2 and Browns Ferry Unit 1

Since there are clearly several strategies available for the completion and conversion of the Bellefonte units, an attractive strategy may be to defer the decision to complete or replace Watts Bar Unit 2 and Browns Ferry Unit 1 for several years. An evaluation of a strategy to defer the decision on these units until the year 2000 is shown in *Figures T8-71* and *T8-72*.

Figure T8-71 indicates that deferral does not significantly raise long-term cost or debt compared to immediately replacing the nuclear units or replacing Watts Bar Unit 2 and Browns Ferry Unit 1.

Deferring the decision to either complete or replace these two units provides flexibility to adapt to significantly different futures. With the "medium or low performance" future, the decision can be made to replace these two units. With the "high performance future," the decision can be made to complete construction of the nuclear units. The value of this flexibility is estimated to be about $200 million more than the costs of keeping the nuclear units in a deferred status.

Deferring a decision on Watts Bar Unit 2 and Browns Ferry Unit 1 also has a favorable impact on short-term rates as shown in *Figure T8-72*.

In *Figure T8-72*, the continued deferral of both nuclear units is represented by 'D' if the deferred units are completed and by 'B' if the units are canceled at a later date. Comparing the deferral strategies to the replacement strategies (A and C) indicates that short-term rates are reduced by deferring the decision on Browns Ferry Unit 1 and Watts Bar Unit 2.

FIGURE T8-71. **Deferral of Watts Bar Unit 2 and Browns Ferry Unit 1 Decision Trade-Off – Total Resource Costs vs. Debt in Year 2007**

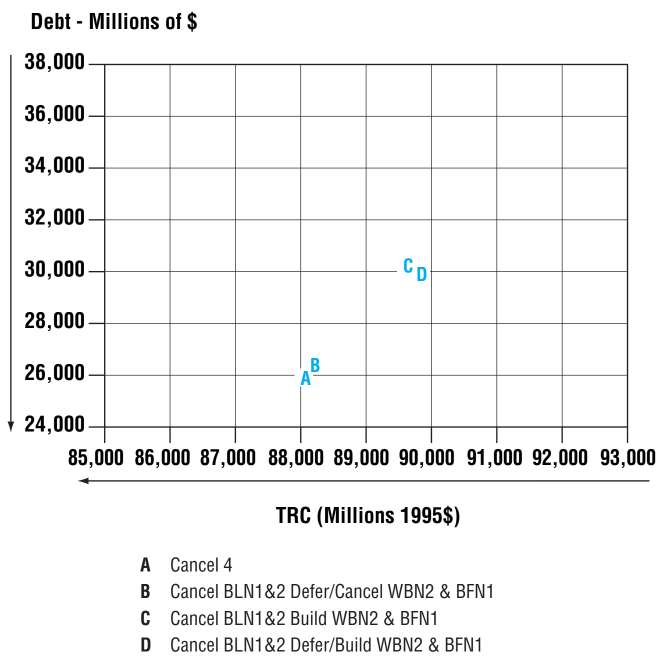
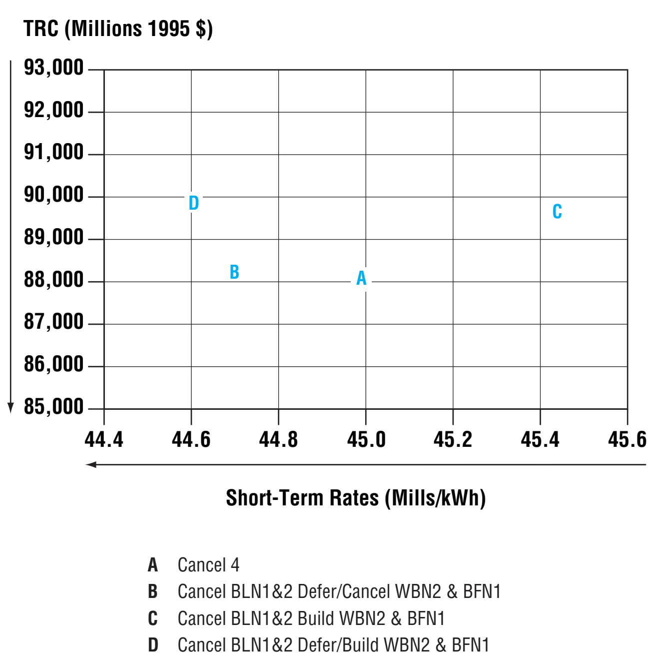


FIGURE T8-72. **Deferral of Watts Bar Unit 2 and Browns Ferry Unit 1 Decision Trade-Off – Short-Term Rates vs. Total Resource Costs**



Thus, the continued deferral of Watts Bar Unit 2 and Browns Ferry Unit 1 can provide flexibility to adapt to a highly uncertain future and reduce short-term rate changes compared to an immediate decision to either build or replace the units.

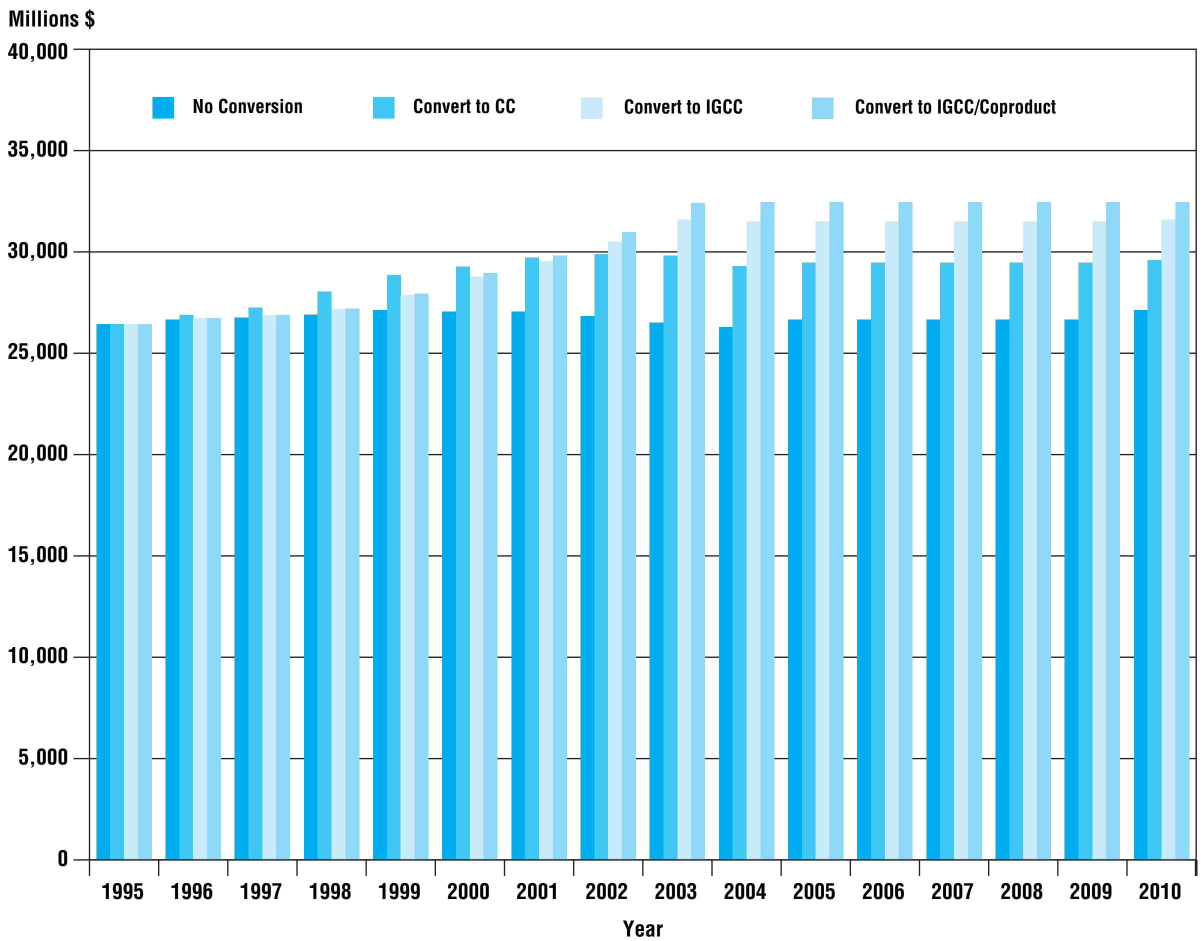
SUMMARY OF NUCLEAR STRATEGY RESULTS

Combining the different nuclear strategies is likely to produce a single strategy that minimizes debt, long-term costs, and short-term rates. Such a strategy could include:

- Completing Bellefonte as a nuclear plant with a partner
- Converting Bellefonte by TVA alone or in partnership
- Deferring a decision to complete or replace Watts Bar Unit 2 and Browns Ferry Unit 1
- Replacing capacity with combined cycle units or a combination of combined cycle units and purchases of power
- A block of demand-side management programs that minimize short-term rate changes

The change in debt from 1995 to 2010 for such a strategy is shown in *Figure T8-73*. By the end of 1995, total TVA debt will be slightly less than $27 billion. Without a conversion at Bellefonte or a conversion with a partner providing the capital funds, debt will remain slightly less than $27 billion through the year 2006. With the conversion of Bellefonte to combined cycle, debt increases to slightly less than $30 billion in the year 2002 and under the other conversion strategies, debt reaches $30 billion in the year 2002.

FIGURE T8-73. **Total Debt – Defer Browns Ferry Nuclear Unit 1 & Watts Bar Nuclear Unit 2**



Note: Expand with CC/IPP/ Coal and Low-Price DSM

III. Conclusions

Evaluations of the nuclear strategies for the long-term cost, debt, short-term rate, and flexibility criteria lead to the following conclusions:

- Continued TVA construction of Bellefonte Units 1 and 2 and Watts Bar Unit 2 as nuclear units and restoration of Browns Ferry Unit 1 lead to higher costs and prevent TVA from limiting debt.
- Alternatives which could lower costs and limit debt include:
  - Replacing the nuclear units
  - Converting Bellefonte to another technology
  - Completing or converting Bellefonte in partnership with others
- Under certain conditions in the future, nuclear generation could emerge as a low-cost option. These conditions are:
  - High load growth
  - Improved nuclear performance
- Holding the nuclear option open can lead to lower short-term rate increases and increased long-term flexibility compared to immediate decisions to either complete or replace the nuclear units. Flexibility may be enhanced by:
  - Completing Bellefonte in partnership with others ($100 million savings and reduced debt)
  - Converting Bellefonte to another technology in partnership with others
  - Deferring Watts Bar Unit 2 and Browns Ferry Unit 1 – (value of the flexibility gained by deferring these units is upwards of $200 million when compared to canceling them immediately)
- TVA should not fund the completion or restoration of Bellefonte Units 1 and 2, Watts Bar Unit 2, and Browns Ferry Unit 1 as nuclear units. Instead, TVA should keep open alternatives for these units that would minimize short-term rates, increase long-term flexibility, minimize long-term costs, and limit debt.

TVA'S NUCLEAR OPTIONS APPENDIX

Alternative Resource Strategies

Several possible strategies have been developed for the four nuclear units, Bellefonte Units 1 and 2, Watts Bar Unit 2, and Browns Ferry Unit 1. These strategies include:

1. Complete the units as nuclear units.
2. Convert them to another technology.
3. Cancel one or more of them and replace them with other supply- and demand-side technologies.
4. Defer the decision and decide at a later date either to complete, convert, or cancel the units.

Completion of the Nuclear Units

Completing the units as nuclear requires continuing the projects as currently planned with TVA performing and paying for construction. The four nuclear units are described in *Figure T8-74.*

Another option for completing the nuclear units is for TVA to enter into a partnership. Under this approach, TVA would contribute the nuclear asset as it is currently constructed to the project partnership. The other member(s) of the partnership would complete the units with non-TVA funds. The output of the plant after completion could be sold to TVA or other consumers at pre-arranged prices. Any profits from the sale of the electricity from the units would be shared by the partners: TVA and the other party(ies). TVA is currently exploring this type of arrangement for Bellefonte Nuclear Plant.

Conversion to Alternative Technologies

Alternatives for converting Bellefonte to a fossil-fueled facility have been considered since the late 1980s. The alternatives include converting the units to:

- Pulverized coal-fired units (PC)
- Natural gas-fired combined cycle (NGCC)
- Integrated gasification combined cycle (IGCC)
- Integrated gasification combined cycle with coproduction of a chemical byproduct

FIGURE T8-74. **Status of Nuclear Plant Construction**

	Bellefonte Unit 1	Bellefonte Unit 2	Browns Ferry Unit 1	Watts Bar Unit 2
Plant Location	Hollywood, AL	Hollywood, AL	Decatur, AL	Spring City, TN
Power Level	1212 MW	1212 MW	1065 MW	1170 MW
Reactor Type	Pressurized Water Reactor	Pressurized Water Reactor	Boiling Water Reactor	Pressurized Water Reactor
Nuclear Steam Supply System Manufacturer	Babcock & Wilcox	Babcock & Wilcox	General Electric	Westinghouse
Construction Permit Date	1974	1974	1967	1973
Construction Status	88%	57%	100%	61%
Current Undepreciated Investment	$ 3.7 Billion	$ 0.8 Billion	$ 0.7 Billion	$ 1.7 Billion

Cancel the Projects and Replace with Alternative Capacity

The four nuclear units could be replaced with many different types of supply- and demand-side resource options.

SUPPLY-SIDE OPTIONS

Supply-side options are drawn from a variety of sources. Some are traditional power supply technologies, such as the pulverized coal and natural gas-fired combined cycle options. Other supply-side options describe opportunities that are unique to TVA. Examples of this second group include completing or converting the Bellefonte Nuclear Units or increasing the capacity of the Raccoon Mountain pumped-storage facility. Still other options reflect ongoing research and development of new technologies including solar power, wind power, fuel cells, and some of the more advanced combustion technologies.

A challenge faced in developing the supply-side options catalog is to ensure that a sufficiently broad spectrum of options is identified while still keeping the total to a manageable number. Clearly the nuclear completion, conversion, and cancellation options had to be included since they represented near-term decisions that TVA needs to make. Traditional options are included to provide a comparison with previous work and because a number of these technologies are still viable options being constructed by other utilities today.

TVA also reviewed 20 other utility IRPs to determine if we had left out any important options. Comparing TVA's option list to the list extracted from the review provides some indication of reasonableness. *Figure T8-75* illustrates this comparison. With the exception of geothermal (which is not available to a significant degree in the TVA region), large solar collectors (which do not appear to be economical as compared to other solar options), and diesel generators (which are covered better as customer service options), the TVA list spans the range covered by other IRPs.

Obtaining power supply from cogenerators and independent power producers (IPPs) has become common in the utility industry. Generally, contracts for this kind of power supply are obtained through a bidding process after a utility defines its needs (in terms of capacity type, power level, and need dates). TVA has issued a request for proposals on options for future power purchases.

TVA also can buy power from other utilities. In the near term, some utilities in the region have excess generating capacity. This excess capacity is expected to be consumed by the early 2000s, however. In the longer term, power purchases from other

FIGURE T8-75. **Comparison with Options Cited in 20 Other Integrated Resource Plans**

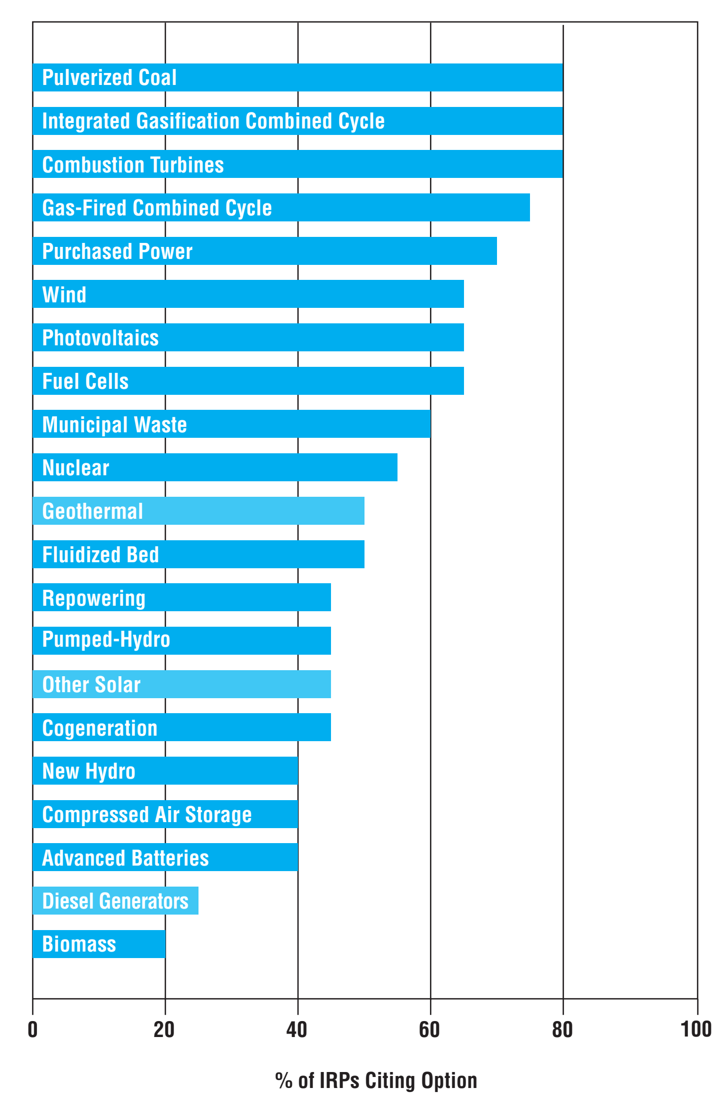


FIGURE T8-76. **Customer Service Options – Summary Impacts**

		IMPACTS IN THE YEAR 2005	
Area	**Options**	**MW**	**GWH**
Energy Efficiency	30	2,780	12,455
Self-Generation	3	146	575
Beneficial Electrification	14	-397	-1,931
Rates	3	670	-1,533

utilities will still be possible, but will likely have higher prices that reflect their cost of adding new capacity.

DEMAND-SIDE MANAGEMENT

In addition, there are over 50 different demand-side options which could be used to replace all or a part of the nuclear units. The demand-side options cover several different technologies including load management, energy efficiency, and renewables. Demand-side options have been developed for residential, commercial, and industrial customers.

TVA's customer service options were developed in four key areas:

- Energy efficiency, including conservation and load management options
- Self-generation
- Beneficial electrification
- Pricing or rate incentives

Figure T8-76 provides a summary of all options that have been developed by TVA to date for consideration in the IRP. Thirty options (17 residential and 13 commercial and industrial) have been developed in the energy efficiency classification. Three general options have been identified for the cogeneration classification. Fourteen options spanning all sectors of the economy, including the transportation sector, have been developed for beneficial electrification. These options affect both the need for new generating capacity, in terms of megawatts (MW), and the level of electricity sales, in terms of gigawatt-hours (GWH) that TVA would be required to provide. Thus, *Figure T8-76* shows that in 2005, over 2,500 megawatts of capacity savings are contained in the proposed energy efficiency options. Further, small-scale self-generation would reduce the direct demand on the TVA system by almost 150 megawatts. Time-of-day rates for the residential, commercial, and industrial sectors would reduce demand by 616 MW; however, energy use would increase by 1,533 GWH. Finally, beneficial electrification options represent an increase in the demand for electric capacity by almost 400 megawatts.

FIGURE T8-77. **IRP Strategy Development – Option Choices**

Short-Term Decisions (1996-1999)

SUPPLY
- Build Bellefonte
- Convert Bellefonte
  - -Coal
  - -Combined Cycle
  - -Integrated Gasification Combined Cycle (IGCC)
  - -IGCC w/Coproduction
- Cancel Bellefonte
- Cancel Bellefonte/ Browns Ferry Unit 1
- Cancel Bellefonte/ Browns Ferry Unit 1, Watts Bar Unit 2
- If Cancellation, Replace with
  - -Combustion Turbines (CTs), Coal
  - -CTs, Combined Cycle
  - -CTs, IGCC with or without Coproduction
  - -Purchased Power, Cogeneration, IPPs
  - -Phased CT, CC, IGCC
  - -Repower Fossil Units
  - -Market-Based Options
- Hydro Modernization
- Storage Options
- Defer Nuclear Units

ENVIRONMENT
- Phase II Acid Rain
  - -Reference Case (Low Cost)
  - -Minimum Debt
  - -Minimum CO_2
  - -Advanced Technology
- Wood Cofiring

Long-Term Decisions (2000-2020)

SUPPLY
- For Build, Cancel or Convert, Options Are:
  - -CTs, Coal
  - -Gas-Based
  - -Clean Coal (IGCC)
  - -Renewables
- Then (after Defer Nuclear Units):
  - -Build Nuclear
  - -Cancel Nuclear
  - -Convert Nuclear

ENVIRONMENT
- Phase II Acid Rain
- CO_2 Offsets

Defer the Decision to Complete the Nuclear Units

Another option is to defer the decision to either build, cancel, or convert some of the nuclear units to a later time period. This option has been specifically considered for Watts Bar Unit 2 and Browns Ferry Unit 1. For this preliminary analysis, the decision to build or cancel the nuclear units could be deferred to the year 2000. The deferral of the Bellefonte plant was not considered since the partnering option and conversion option are being considered at Bellefonte.

FIGURE T8-77. **IRP Strategy Development – Option Choices** *CONTINUED*

Short-Term Decisions (1996-1999)	Long-Term Decisions (2000-2020)
MARKETS	
• DSM -Low Rates -Low Cost -Low Penetration -High Penetration -Renewables -Low Income	• DSM • Beneficial Electrification
• Beneficial Electrification -Low Penetration -High Penetration • Off-System Sales • Distributed Generation • Fuel Switch to Natural Gas	
PRICING	
• Price Levels -Higher -Lower • Pricing Structure -Current Practice -Time-of-Day -Real Time -Block Structure	
TRANSMISSION	
• Efficiency Improvements • East-West Transmission -Capability	

Resource Strategies

The numerous nuclear, conversion, and supply- and demand-side resource options may be categorized into several different groups as outlined in *Figure T8-77*.

In *Figure T8-77*, options have been categorized according to those which can be implemented in the short term and those for the long term. The options have also been grouped by type, such as supply, environment, market, pricing, and transmission.

Strategies Evaluated

For this study, options have been chosen from *Figure T8-77* in order to develop strategies. The possible strategies are shown in *Figure T8-78*.

FIGURE T8-78. **Prospective Strategies in the IRP**

SUPPLY OPTIONS - NUCLEAR

- Build Bellefonte (BLN) Units 1 and 2, Browns Ferry (BFN) Unit 1, and Watts Bar (WBN) Unit 2
- Build BLN 1, BFN 1, WBN 2, and Cancel BLN 2
- Build BFN 1, WBN 2, and Cancel BLN 1 and 2
- Cancel All Four Units
- Convert BLN, Cancel WBN 2, BFN 1
  - -Combined Cycle (CC)
  - -Integrated Gasification Combined Cycle (IGCC)
  - -IGCC with Coproduction of Chemical Product (IGCC/P)
- Defer WBN 2, BFN 1
  - -Cancel BLN 1 and 2
  - -Convert BLN to CC
  - -Convert BLN to IGCC
  - -Convert BLN to IGCC/P
  - -Nuclear Partnership at BLN 1 and 2

OTHER SUPPLY OPTIONS

Short-Term	Long-Term
• Combined Cycle	• Clean Coal (IGCC)
• Coal (Shawnee II)	• Renewable (Wind,Biomass)
• Purchased Power, Cogeneration, Independent Power Producers (IPP)	• IPPs

DEMAND-SIDE MANAGEMENT (DSM)

- No DSM
- Low-Cost DSM Block (1000 MW)
- Low-and Medium-Cost Block (2000 MW)
- Low-Price Block (700 MW)

ENVIRONMENT

- Phase II Acid Rain Strategy
- Fuel Switch and Scrubber at Paradise Unit 3
- All Fuel Switch Strategy

Energy Vision 2020

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List of Preparers

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List of Preparers

Contents

List of Preparers

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Position: Manager, Transmission Planning, (Retired)
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Experience: 9 years of experience in planning; 39 years at TVA.

HAROLD M. DRAPER
Position: National Environmental Policy Act Specialist
Education: B.S., Botany
B.S., Conservation
M.S., Engineering and Policy
D.Sc., Engineering and Policy
Experience: 5 years of experience in TVA environmental impact assessment. Previous experience in state bioenergy and renewable energy program development, Florida Governor's Energy Office and Mississippi Energy and Transportation Division.

JUDY G. DRIGGANS
Position: Power Supply Engineer
Education: B.S., Engineering
Experience: 2 years of experience in TVA demand-side planning; 9 years with TVA solar and conservation programs. Registered Professional Engineer.

RICHARD L. DRIGGANS
Position: Manager, Strategic Processes & Planning, Resource Group
Education: B.S., Engineering
M.B.A.
Experience: 18 years of experience in TVA research and development for electric transportation, communications, and expert systems; strategic planning; and technology planning activities. Registered Professional Engineer.

JOSEPH P. FRUEH
Position: Manager, Special Studies
Education: B.S., Mathematics
Experience: 15 years of experience in TVA load forecasting and power resource planning.

GARY P. GARRETT
Position: Manager, Energy Resource Planning & Engineering
Education: B.S., Electrical Engineering
M.S., Electrical Engineering
Experience: 22 years of experience in TVA power resource planning.

LARRY L. GAUTNEY, JR.
Position: Systems Analyst/Environmental Modeler
Education: B.S., Physics
M.S. Ed., S. Physics
Experience: 20 years of experience with TVA developing and applying atmospheric dispersion models to support TVA's fossil program.

JERRY L. GOLDEN
Position: Manager, Advanced Production and Environmental Technology
Education: B.S., Mechanical Engineering
M.S., Engineering
Experience: 22 years of experience in TVA engineering design and project/program management for air pollution control projects; member of Acid Rain Advisory Committee, Climate Challenge Steering Committee.

JUAN E. GONZALEZ
Position: Senior Economist for Economic Forecasting
Education: B.A., Economics, Political Science, and Mathematics
M.A., Economics
A.B.D., Economics
Experience: 17 years of experience in TVA economic forecasting and economic development. Previous experience includes research in economic forecasting and utility economics at the University of Florida.

CHARLES H. GOODHARD
Position: Manager, Technical Analysis (Acting)
Education: B.S., Economics
M.S., Economics
Experience: 3 years of experience in fuel supply planning. Previous experience includes financial analysis and forecasting, market research, and load analysis.

J. BENNETT GRAHAM
Position: Senior Archaeologist
Education: B.A., English
M.A., Anthropology
Experience: 21 years of experience for TVA in archaeological site identification, evaluation and analysis, and cultural resource compliance. Previous experience includes teaching anthropology at Wright State University and the University of Alabama; archaeological research in Southeast/Midwest United States, Costa Rica, and South Africa.

ANDREW GROTH
Position: Economist
Education: B.A., Economics
M.A., Economics
A.B.D., Economics
Experience: 9 years of experience in TVA regional economic forecasting and research.

JAMES A. HALL
Position: Specialist, Generation Technology
Education: B.S., Mechanical Engineering
Experience: 17 years of experience in TVA Research and Development, Power Supply, and Fossil & Hydro Power; principal investigator for repowering study of TVA power plants.

GARY H. HARRIS
Position: Manager, Services Education, Training & Development
Education: B.S., Business Administration
Experience: 3 years of experience in TVA education, training and development. Previous experience includes crude oil, natural gas, and electricity production at Chevron U.S.A. Oil Company.

MARY JANE HEAVENER
Position: Manager, Market Research
Education: B.S., Business Administration
Experience: 25 years of experience in TVA market research.

KATHY A. HECK
Position: Manager, Public Participation
Education: B.S., Education
M.S., Industrial/Organizational Psychology
Experience: 4 years of experience in TVA Nuclear Mechanical Quality Control; 9 years of experience in Individual and Organizational Development.

MARK K. HILL
Position: Specialist, Generation Technology
Education: Bachelor of Mechanical Engineering
Experience: 16 years of experience in TVA Research and Development, Fossil & Hydro Power, and fluidized bed combustion; principal investigator for TVA's greenhouse gas emissions reduction activities.

JOHN W. HUTTON
Position: Staff Support Manager, TVA Nuclear
Education: B.S., Mechanical Engineering
Experience: 20 years of TVA experience in nuclear power plant operations, engineering, planning, and licensing.

ROBERT E. IMHOFF
Position: Systems Analyst/Atmospheric Modeler
Education: B.S., Engineering Science
M.S., Environmental Engineering
Experience: 20 years of experience in measuring and modeling atmospheric concentrations due to emissions from TVA sources.

WILLIAM F. IRISH
Position: Manager, Specialist in System Business Planning
Education: B.S., Economics
M.S., Economics
Ph.D., Economics
Experience: Experience in TVA risk management, evaluations of call and put option proposals, and system forecasting. Previous experience as staff economist for the North Carolina Utilities Commission.

PHILIP H. IVEY
Position: Area Communications Manager, TVA Energy Communications Staff
Education: English and Social Studies
Experience: 16 years of experience in business communications; 9 years of experience in print and broadcast media.

GARY L. JACKSON
Position: Manager, Bulk Power Marketing
Education: B.A., Mathematics
Ph.D., Economics
Experience: 15 years of experience in TVA load forecasting, generation planning, strategic planning, business evaluation, and competitive market assessments. Previous experience includes teaching at the University of Tennessee at Chattanooga.

SCOTT C. JONES
Position: Power Supply Engineer
Education: B.S., Electrical Engineering
Experience: 4 years of experience in TVA power resource planning. Previous experience includes working in System Engineering at Watts Bar Nuclear Plant. Registered Professional Engineer.

JOHN D. JOSLIN, JR.
Position: Environmental Scientist
Education: B.A., Psychology
M.S., Human Development
M.F., Forestry
Ph.D., Forestry
Experience: 12 years of experience at TVA in research on air pollution effects on forests, soils, and streams. Previous experience in teaching, soil mapping, and horticulture.

EDWARD L. JULIAN
Position: Fuel Supply Analyst
Education: B.S., Geology
M.S., Geology
Ph.D., Mineral Economics
Experience: 15 years of experience in TVA fuel market analysis, price forecasting, and fuel supply planning. Previous experience includes teaching and research in geology and industrial and resource economics at North Carolina State University and Pennsylvania State University.

HANK E. JULIAN
Position: Hydrogeologist/Civil Engineer
Education: B.S., Civil Engineering
M.S., Civil Engineering
Experience: 6 years of experience in hydrogeologic characterization studies, groundwater modeling, and research. Previous experience includes technical consulting as an environmental engineer.

J. MICHAEL KELLY
Position: Senior Technical Specialist
Education: B.S., Biology
M.S., Plant and Soil Science
Ph.D., Forest Ecology/Soils
Experience: 25 years of experience in research and analysis of air pollution impacts on terrestrial ecosystems. Certified Professional Soil Scientist and Fellow of the Soil Science Society of America.

DAVID B. LAMB
Position: Manager, Marketing Product Development
Education: B.S., Agricultural Engineering
Experience: 27 years of experience in energy end use applications, program development, implementation, and evaluation.

ALAN L. LARSON
Position: Quality Manager
Education: B.A., Economics
Ph.D., Economics
Experience: 15 years of experience in TVA load forecasting and planning. Previous experience includes teaching and research in economics at the University of Tennessee at Chattanooga.

JON M. LONEY
Position: Manager, Environmental Management
Education: B.S., Geography
M.S., Geography
Experience: 23 years of experience in environmental planning, review, and management related to energy, natural resources, and economic development.

JILL S. LUEDTKE
Position: Demand-Side Planning Specialist
Education: B.A., Economics
Experience: 2 years of experience in demand-side planning at TVA. Previous experience in demand-side planning and integrated resource planning with the Public Service Commissions of Michigan and Maryland.

STEVEN K. MACEY
Position: Power Supply Engineer
Education: B.S., Mechanical Engineering
Experience: 22 years of experience in TVA environmental engineering and demand-side and resource planning. Previous experience as design engineer on Skylab and Space Shuttle. Registered Professional Engineer.

ROBERT A. MARKER
Position: Recreation Specialist
Education: B.S., Outdoor Recreation Resources Management
Experience: 24 years of experience in recreation planning and management.

SCOTT P. MARTELLO
Position: Economist
Education: B.A., Economics
M.S., Economics
Experience: One year of experience in TVA load forecasting.

RICHARD M. MARTIN
Position: Manager, Cost and Rate Analysis
Education: B.B.A., Economics
M.A., Economics
Experience: 18 years of experience in electric utility cost-of-service and rate design. Previous experience includes research in fossil fuel supply and transportation.

LYNN C. MAXWELL
Position: Manager, System Integration and IRP Technical Manager
Education: B.A., Economics
M.A., Economics
Ph.D., Economics
Experience: 20 years of experience in TVA load forecasting and power resource planning. Previous experience includes teaching and research in economics at the University of South Dakota and the University of Wyoming.

MAJOR C. R. MCCOLLOUGH
Position: Project Engineer, Geographic Information and Engineering
Education: B.S., Chemistry
M.A., Anthropology
Ph.D. Anthropology (Archaeology)
Experience: 17 years of experience in cartography.

BERT A. MCDOWELL
Position: Electrical Engineer
Education: Bachelor and Masters of Electrical Engineering
Experience: 9 years of experience in planning, 15 years at TVA.

ALEXANDER IAN MCLEOD
Position: Environmental Coordinator, Customer Group & Transmission/Power Supply
Education: B.A., English Language and Literature
Experience: 4 years of experience in environmental planning and oversight. Prior experience includes 12 years in TVA Corporate Communications with focus on power resource planning and environmental issues.

JAMES F. MEAGHER
Position: Manager, Atmospheric Sciences
Education: B.S., Chemistry
Ph.D., Physical Chemistry
Experience: 20 years of experience in air quality research at TVA. Previous experience includes research and teaching experience in atmospheric chemistry and physical chemistry at Pennsylvania State University and University of Washington.

ROBERT L. MERRING
Position: Manager, Utility Planning
Education: Bachelors and Masters of Electrical Engineering
Experience: 22 years experience in power plant operation, maintenance and management; 3 years experience in power system planning.

ROBERT G. MILLARD
Position: Manager, Specialist in Load Forecast and Analysis
Education: B.S., Economics
M.B.A.
Experience: 14 years of experience in TVA load forecasting and power resource planning.

E. CHERI MILLER
Position: Market Development Specialist in Fuel By-Products
Education: B.S., Biology
Experience: 15 years of experience in TVA environmental assessments, ground water quality, permitting, and site development work for coal combustion by-product utilization and disposal projects.

PATRICIA H. MILLER
Position: Senior Strategy Advisor
Education: B.S., Mathematics
M.S., Mathematics
Education: 26 years of experience in utility operations, including analysis of utility industry restructuring, budgeting, and long-range planning.

JACK D . MILLIGAN
Position: Environmental Engineer
Education: M.S., Environmental Engineering
Experience: 20 years of experience with TVA in water quality.

COLLEEN M. MOORE
Position: Power Supply Analyst
Education: B.S., Electrical Engineering
Experience: 12 years of experience in TVA power resource planning and system power marketing. Previous experience in Engineering at Sequoyah Nuclear Plant.

STEPHEN F. MUELLER
Position: Senior Environmental Scientist
Education: M.S., Meteorology
Experience: 16 years of experience in TVA air quality analysis and research. Certified Consulting Meteorologist.

LEONARD J. MUZYN
Position: Senior Financial Analyst
Education: B.S., Electrical Engineering
M.B.A.
Experience: 5 years of experience in TVA finance organizations. Previous experience as electronic design/project engineer.

NIKI STEPHANIE NICHOLAS
Position: Forest Ecologist
Education: B.A., Biology
M.S., Ecology
Ph.D., Forestry
Experience: 12 years of experience in forest ecology. Previous experience in science division of National Park Service and on research faculty at Virginia Tech.

DAVID E. NICHOLS
Position: Chemical Engineer
Education: B.S., Chemical Engineering
M.S., Chemical Engineering
M.B.A.
Experience: 25 years of experience in TVA engineering and management including preparing Title V permit applications for TVA fossil plants and research and development for chemical processes.

CHARLES P. NICHOLSON
Position: Zoologist
Education: B.S., Wildlife and Fisheries
M.S., Wildlife Management
Experience: 16 years of experience in TVA wildlife and endangered species management and assessment.

NORRIS A. NIELSEN
Position: Meteorologist
Education: B.S., Meteorology
M.S., Meteorology
Experience: 20 years of experience in TVA applied meteorology for power programs and environmental assessments. Previous experience as Meteorology Group Leader at Radian Corporation; and as National Weather Service weather observer.

BARBARA O. NIERI
Position: Manager, Special Projects and IRP Coordinator
Education: B.S. and M.S., Interdisciplinary
Ph.D., Human Ecology, Planning, and Housing
Experience: 16 years of experience in TVA demand-side management, strategic, and system planning. Previous experience includes teaching and extension service at the University of Tennessee at Knoxville.

PATRICIA NORTHCUTT
Position: Team Leader, Mapping and GIS Services, Geographic Information and Engineering
Education: B.S., Geoscience, Remote Sensing
M.A., Environmental Monitoring
Experience: 3 years of experience in TVA Remote Sensing and GIS. Previous experience includes remote sensing, GIS, and software design and development at Intergraph Corporation.

PENNY K. O'DELL
Position: Manager of Electronic Media
Experience: 18 years of experience in graphics and graphic design.

AMY T. PARKER
Position: Manager, Fuel Supply Analysis
Education: B.S.B.A., Accounting
Experience: 3 years of experience in oversight related to TVA's fossil fuel supply requirements; fuel accounting/financial functional areas of TVA. Licensed Certified Public Accountant.

BEVERLY J. PATTERSON
Position: Computer Graphics Technician, Geographic Information and Engineering
Education: A.A., Graphic Arts/Drafting
Experience: 10 years of experience in TVA cartographic production. Previous experience in cartographic work with government contractors.

LAURIE SHERMAN PEARL
Position: Recreation Planner
Education: B.S., Forestry and Wildlife
Experience: 17 years of experience in TVA recreation resource planning and management.

SAMUEL C. PERRY
Position: Landscape Architect – Technical Supervisor
Education: B.L.A.
Experience: 25 years of experience in TVA Reservation and Site Planning.

PAUL A. PIER
Position: Environmental Scientist
Education: B.A., Forest Science
M.S., Forest Physiology
Ph.D., Crop Physiology
Experience: 7 years of experience in TVA biological research on air pollution effects and trace gas emissions.

M. WALTON POWERS
Position: Power Supply Engineer
Education: B.S., Mathematics
M.S., Mathematics
Ph.D., Mathematics
Experience: 15 years of long-range planning experience including power resource planning and fuel supply planning.

F. RUSSELL ROBERTSON
Position: Manager, Commercial and Industrial Marketing
Education: B.S., Electrical Engineering
M.S., Electrical Engineering
Experience: 15 years of experience in TVA market planning and delivery of utility programs to the marketplace; test and evaluation of solar and renewable technologies.

SUSAN HUMBER ROSS
Position: Manager, Specialist in System Integration and IRP Coordinator
Education: B.A., Economics and English
Experience: 15 years of experience in TVA energy efficiency and marketing programs.

MARK O. SANFORD
Position: Manager, Nuclear Corporate Licensing and Generation Planning
Education: B.S., Nuclear Engineering
M.S., Chemical Engineering
Experience: 4 years of experience with TVA in developing and evaluating new electricity generation options. Previous experience in design, construction, operation, and maintenance of nuclear power plants.

STEVEN C. SETTLE
Position: Fuel Supply Analyst
Education: B.B.A., Business Management
M.S., Industrial Organizational Psychology
Experience: 12 years of experience in oil and natural gas fuel market procurement and market analysis. Previous experience in other procurement fields.

RICHARD A. SHINN
Position: Manager, Transmission Development
Education: B.S., Electrical Engineer
Experience: 24 years of experience in TVA transmission planning and development.

JOHN W. SHIPP, JR.
Position: Manager, Environmental Services
Education: B.S., Civil Engineering
M.S., Civil Engineering
Experience: 20 years of experience in TVA environmental services, including water resources, hazardous materials handling, and emergency operations. Registered Professional Engineer. Certified Hazardous Materials Manager.

ROY E. SIEBER
Position: Project Manager
Education: Aeronautical Design
Experience: 15 years of experience in TVA industrial marketing, new product development, and demand-side planning. Previous experience includes resource planning at the New York Power Pool and Long Island Lighting Company.

R. CRAIG SMITH
Position: Manager, Conservation and Load Management
Education: B.A., Urban Studies and Planning
Experience: 3 years of experience in TVA demand-side planning and program implementation. Previous experience includes DSM program implementation at Pacific Gas and Electric and Pacific Power and Light Companies; regulatory experience at Michigan Public Service Commission.

MICHAEL CHARLES SMITH
Position: Senior Economist
Education: B.A., Mathematics
M.A., Economics
Experience: 15 years of experience in TVA economic development research and forecasting. Previous experience includes energy demand forecasting at Oak Ridge National Laboratory and teaching and research in economics at the University of Tennessee at Knoxville.

MEREDITH H. SNYDER
Position: Power Supply Analyst
Education: A.S., Mechanical Engineering
B.S., Mathematics
M.Ed., Education
Experience: 9 years of experience in load forecasting and nuclear operations. Previous experience includes teaching in Hamilton County and at Chattanooga State Technical Community College.

JOANNE V. SWANSON
Position: Decision Analysis Specialist
Education: B.S., Business Administration
M.B.A.
Experience: 20 years of experience in TVA power resource planning.

BYRON D. STEWART
Position: Manager, Bulk Transmission Planning
Education: B.S., Electrical Engineering
Experience: 24 years of experience at TVA in planning.

ROBERT E. TAYLOR
Position: Specialist, Peaking and Energy Storage
Education: B.S., Engineering Science
M.S., Aerospace Engineering
Experience: 23 years of experience in TVA power plant engineering and research and development.

R. LARRY TAYLOR
Position: Manager, Electric System Operations
Education: B.S., Electrical Engineering
M.B.A.
Experience: 2 years of experience in TVA in areas of power system operation, bulk power marketing, and interchange operations. Previous experience includes consulting for the electric power industry; Vice President, Power Delivery at Florida Power & Light Company.

J. DANIEL THOMAS
Position: Project Leader, Forest Resources Information System
Education: B.S., Forest Management
M.S., Forestry
Experience: 12 years of experience in TVA Forest Resources Inventory and Analysis Project; 2 years Forest Inventory, TVA.

TOMMY R. THOMPSON
Position: Specialist, Generation Technology
Education: B.S., Mechanical Engineering
M.S., Mechanical Engineering
Experience: 18 years of experience at TVA in fossil-fired power plant engineering, including conceptual design, detailed design, contract management, technical supervision, and project management. Previous experience includes nuclear power plant engineering. Registered Professional Engineer.

FRANK C. THORNTON
Position: Specialist, Atmospheric Sciences
Education: B.S., Environmental Sciences
M.S., Forestry
Ph.D., Forest Soils
Experience: 9 years of experience in air pollution effects at TVA. Previous experience includes post-doctoral work in mineral nutrition of woody plants and metal toxicity in United States and abroad; agricultural consultant.

CHARLES R. TICHY
Position: Historical Architect
Education: B. Architecture
M.A., Historic Preservation
Experience: 16 years of experience as TVA Historical Architect. Previous experience includes State of New Jersey Office of Historic Preservation; historic architect for Nassau County, New York.

EDDIE TRAMEL
Position: Johnson City Customer Service Center Manager
Education: B.S., Electrical Engineering
Experience: 26 years of experience in TVA working with customers and distributors in marketing, conservation, rate and contract administration, and program development and management.

RALPH J. VALENTE
Position: Project Engineer
Education: B.S., Meteorology
M.S., Engineering
Experience: 15 years of experience in TVA air quality research. Extensive experience in ground-based and airborne monitoring and model evaluation studies.

L. CHRISTY VALERIO
Position: Economist
Education: B.S., Agricultural Economics
M.S., Agricultural Economics
M.S., Public Policy and Public Administration
Ph.D., Economics
Experience: 4 years of experience in TVA regional economic forecasting. Adjunct Professor at Tusculum College.

CAROLINE M. WALLER
Position: Computer Graphics Technician, Geographic Information and Engineering
Education: High School Diploma
Experience: 18 years of experience in graphics composition and computer graphics.

BARRY B. WALTON
Position: Assistant General Counsel, Environmental
Education: B.A., Political Science
J.D., Law
Experience: 22 years of experience in TVA's General Counsel's Office practicing environmental and natural resource law.

JOHN WATKINS
Position: Economist
Education: B.S., Math
Experience: 25 years of experience in TVA load forecasting and 15 years in revenue forecasting.

FRANCES P. WEATHERFORD
Position: Senior Environmental Scientist
Education: B.A., Biology
Experience: 20 years of experience in air quality research, monitoring, and other technical services related to air quality compliance.

KATHY S. WHITAKER
Position: Manager, Transmission, Distribution and End-Use
Education: B.S., Civil Engineering
M.S., Engineering
Experience: 12 years of experience in TVA engineering disciplines; special assignment serving as the Public Participation Manager for TVA's Integrated Resource Planning development.

JAMES O. WHITE
Position: Project Manager, Industrial Marketing, and IRP Coordinator
Education: B.S., Geography/Biology
M.S., Planning
Experience: 20 years of experience in TVA regional development studies, and project management and evaluation. Previous experience includes community land use planning.

JAMES T. WHITEHEAD
Position: Manager, Reliability Analysis
Education: B.S., Electrical Engineering
Experience: 26 years of TVA experience, primarily in planning.

DALE V. WILHELM
Position: National Environmental Policy Act Liaison
Education: B.S., Mathematics
M.S., Meteorology
Experience: 20 years of experience in interdisciplinary environmental review. Previous experience as Agency NEPA Advisor.

JAMES F. WILLIAMSON, JR.
Position: Environmental Scientist
Education: B.S., General Science/Zoology
M.S., Wildlife Ecology
Ph.D., Fisheries and Wildlife Sciences
Experience: 4 years of experience in environmental reviews and preparing environmental documentation. Previous experience in forest and wildlife-related software and database development and forest biometrics.

NEIL M. WOOMER
Position: Senior Limnologist
Education: B.A., Botany
M.S., Biology
Ph.D., Limnology
Experience: 15 years of experience in TVA aquatic monitoring and assessment. Previous experience as chief ecologist for water quality studies, Arkansas Department of Pollution Control and Ecology.

B. J. WRIGHT
Position: Manager, Customer Communications
Education: B.S., Communications
M.B.A., Marketing
Experience: 12 years of experience in TVA employee, marketing, and strategic communications; visitor relations; speechwriting; and advertising.

CASSANDRA L. WYLIE
Position: Statistician
Education: B.S., Forestry
M.S., Forest Biometry
Experience: 10 years of experience in TVA data analysis of atmospheric effects on forests.

DENNIS H. YANKEE
Position: Programmer/Analyst
Education: M.S., Geography
Experience: 7 years of experience with Geographic Information Systems.

TVA Consultants

CLINTON J. ANDREWS
Position: Assistant Professor of Public and International Affairs, Princeton University
Education: Sc.B., Mechanical Engineering
S.M., Technology and Policy
Ph.D, Regional Planning
Experience: 17 years of experience in energy sector including integrated resource planning methods. Author of more than a dozen refereed articles on IRP, contributions on related topics, including *Regulating Regional Power Systems* (Quorum/IEEE, 1995).

JOHN R. BROOKS
Position: Principal, Brooks Jenkins (Communications and Design Agency)
Education: B.A., Journalism
Experience: 25 years of experience in corporate communications and agency management. Extensive experience in the transportation and energy fields, including a ten-year assignment at the Institute of Nuclear Power Operations. Accredited by the International Association of Business Communicators.

LORI CLEGHON
Position: Art Director, Graphic Advertising, Inc.
Education: A.S., Advertising Arts
Experience: 6 years of experience in graphic design and print media.

MAXIM R. DUCKWORTH
Position: Research Analyst, Energy Group, Tellus Institute
Education: B.S., Physics
M.A., Physics
Experience: Experience in electric power system modeling and planning analysis at Tellus Institute. Involved in TVA project to investigate potential level of competition from other electricity providers over the next 25 years.

LOIS HOGAN
Position: Senior Counselor, Jackson Jackson & Wagner
Education: B.S., Journalism
M.A., Holistic Education
Experience: Specializes in organization development, group acilitation, management training, development and production management of graphic systems, and community relations and public participation groups. Contributor, *pr reporter*, the international weekly professional newsletter; Contributor, *Public Relations Practices, Managerial Case Studies and Problems,* Center and Jackson, 1989, 1995. PSRA National Conferences, Council on Advancement and Support of Education (CASE) Community Relations Conference, and American Institute of Cooperatives. Accredited by the Public Relations Society of America. Certified in Group Facilitation, Interface Foundation, Boston.

JOHN I. JAMES
Position: President, The Cube, Inc.
Education: B.F.A., Graphic Design
Experience: 5 years of experience in management; 5 years in information technology; and 10 years graphic design.

HEIDI KROLL
Position: Research Associate, Energy Group, Tellus Institute
Education: B.A., Economics
Experience: Experience in the acquisition and analysis of economic, energy use, and conservation-related data underlying integrated resource planning research in utility and regulatory settings; tracking development of TVA's first comprehensive Integrated Resource Plan, on which Tellus is advising the TVA's Board of Directors. Participated in a comprehensive survey of utility and regulatory Integrated Resource Plan practices throughout the United States and helped draft proposed Integrated Resource Plan rules for the Kansas Corporation Commission and the Colorado office of Energy Conservation.

BRUCE LANDREY
Position: Principal, Landrey & Hunt, Inc.
Education: B.S., Journalism
Experience: 20 years of experience in public relations, investor relations, advertising, media and community relations, and government affairs. Previous experience includes vice president of public relations for TVA, director of investor relations for Portland General Corporation, director of corporate communications at Portland General Electric Company, and strategy development at Edison Electric Institute, the Electric Power Research Institute, and the U.S. Committee for Energy Awareness.

CHAS LAW
Position: Owner, Chas Law Design
Education: A.A.S., Communications Graphics Technology
Experience: 4 years of experience in publication design. Previous experience includes teaching computer graphics, graphic design, and photography at Pellissippi State Technical Community College.

RICHARD B. MCLEAN
Position: Principal/NEPA Manager, PTRL Environmental Services
Education: Ph.D., Marine Biology
Experience: 21 years of experience in environmental assessment.

ISOBEL PARKE
Position: Senior Counselor, Jackson Jackson & Wagner
Education: B.A., History
M.A., History
Experience: Specializes in strategic planning, crisis communication, emerging issues, environmental and waste disposal issues, coalition and consensus building, and naming strategies and graphic concepts. President, New Hampshire Timberland Owners Association, 1986-87; President, Rockingham County Woodland Owners Association, 1987. Contributor, *Public Relations Practice, Managerial Case Studies and Problems*, Center and Jackson, 1989, 1995. Accredited by and a Fellow of the Public Relations Society of America.

GABRIELLE RATLIFF
Position: Database Administrator, Geophex Ltd.
Education: B.S., Computer Science
Experience: 2 years of experience in computer programming.

MARY REVENIG
Position: Graphic Designer, DesignWorks
Education: B.F.A., Painting and Drawing
Experience: 26 years of experience in publication design.

RICHARD A. ROSEN
Position: Executive Vice-President, Director and Senior Scientist, Energy Group, Tellus Institute
Education: B.S., Physics and Philosophy
M.A., Physics
Ph.D., Physics
Experience: Research on integrated resource planning energy conservation; electric generation planning issues; and modeling studies of long-range energy demand, utility system reliability, energy demand curtailment, and environmental externalities and energy planning. Experience in integration of supply-side and DSM options into integrated resource planning, including consideration of the costs of environmental externalities.

RICHARD M. SANDVIK
Position: Energy-Related Projects Consultant
Education: B.A., Economics
J.D.
Experience: Experience in consulting for such firms as Bonneville Power Administration, U.S. Generating Company, and TVA. Previous experience includes General Manager and Director, Legal Department and Director of Strategic Issues Management for Portland General Corporation, and Senior Assistant Attorney General for the Oregon Department of Justice.

RICHARD E. SAYLOR
Position: Program Manager, Geophex Ltd.
Education: M.S., Environmental Science
Experience: 16 years of experience in environmental and safety assessment.

KATHY L. SHASSERE
Position: Database Administrator, PTRL Environmental Services
Experience: 15 years of experience in computer science.

DALJIT SINGH

Position: Research Associate, Energy Group, Tellus Institute

Education: B.Tech, Electrical Engineering
M.S., Electrical Engineering (Power Electronics)
M.S., Electrical and Computer Engineering (Computer Systems Engineering)
M.S., Technology and Policy

Experience: Experience in electric system planning, including power plant performance assessment, evaluation of power supply technologies, transmission and distribution, cost/benefit analysis, and emission control technologies. Also worked on resource bidding and evaluation of qualifying facilities and independent power producing facilities.

STEPHEN L. THUMB

Position: Partner, Energy Ventures Analysis

Education: B.S., Chemical Engineering
M.B.A., Finance

Experience: 7 years of experience directing oil and natural gas practice. EVA senior financial analyst for natural gas procurement, natural gas/oil industry analyses, forecasting, acquisition and divesture analysis. Previous experience includes over 15 years in related industry positions.

DOUGLAS H. WALTERS

Position: Senior Consultant, Strategic Decisions, Inc.

Education: B.S., Electrical Engineering
M.S., Industrial Engineering
Ph.D., Industrial Engineering

Experience: 22 years of electric utility planning experience with TVA, primarily in economic analysis and decision and risk analysis.

CHRIS WATTS

Position: Contractor, Operations Simulation Associates, Inc. (OSA)

Education: B.S., Engineering

Experience: 9 years of experience in resource planning at a utility. Previous experience as utility consultant.

THOMAS A. WINDHAM

Position: Cartographic Design Specialist

Education: B.F.A., Graphic Arts

Experience: 5 years of experience in cartographic design and production.

Review Group Consultants

STEPHEN R. CONNORS

Position: Director, M.I.T. Electric Utility Program, Director, M.I.T. Analysis Group for Regional Electricity Alternatives

Education: B.A., Anthropology
B.S., Mechanical Engineering
S.M., Masters in Technology and Policy

Experience: Participant of the Massachusetts Institute of Technology Energy Laboratory's Analysis Group For Regional Electricity Alternatives (AREA). Worked with New England's electric utilities, regulatory agencies, and business, consumer and environmental concerns to identify long-range strategies. Experience includes a broad range of energy and environmental issues ranging from electricity planning and regulation to identification of cost-effective emissions reductions, domestic and international.

BARBARA A. MACMULLAN

Position: Senior Analyst, National Economic Research Associates, Inc.

Education: B.S., Natural Resources
M.A., Economics

Experience: Experience in research and analysis for the electric utility industry, including comparing cost of electricity from nuclear and coal plants, statistical analyses of nuclear and coal capital and operating costs and analysis of utility conservation programs. Assisted clients in all aspects of regulatory proceedings, including reviewing expert testimony, preparing cross-examination of opposing witnesses, and testifying on behalf of electric utilities in regulatory and other proceedings concerning the economics of nuclear power plants. Previous experience as a consultant evaluating economic losses in wrongful death and accident cases.

GEORGE M. MCCOLLISTER

Position: Principal, Spectrum Economics, Inc.

Education: B.A., Mathematics and Chemistry
M.A., Mathematics
Ph.D., Economics

Experience: Specializes in econometric and statistical analysis for energy supply planning and calculation of economic damages in civil litigation. Applied these skills for ten years as a consultant, and for several years as a staff economist at two large investor owned utilities. Examples of projects include energy demand forecasting, probabilistic energy supply planning, conservation and load management program savings evaluation, econometric modeling to value natural resources, statistical hypothesis testing in discrimination cases, expert testimony and management of economic experts in civil litigation.

JOHN H. WILE

Position: Vice President, R. J. Rudden Associates, Inc.

Education: B.A., Economics
Ph.D., Economics

Experience: 20 years of diversified experience in the practice areas of utility pricing, electric generation and transmission planning, financial and economic analysis, strategic and resource planning, regulatory policy analysis, and related management and organizational consulting.

Energy Vision 2020

VOLUME THREE, RESPONSES TO PUBLIC COMMENTS

Integrated Resource Plan
Environmental Impact Statement

TVA

Energy Vision 2020

VOLUME THREE, RESPONSES TO PUBLIC COMMENTS

Integrated Resource Plan Environmental Impact Statement

Tennessee Valley Authority
December 1995

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Volume 3, Responses to Public Comments

INTRODUCTION

This volume of TVA's Energy Vision 2020 contains responses made to public comments on the draft integrated resource plan. Some 275 individuals and organizations made approximately 2,000 comments during the 81-day comment period, which followed the release of the draft on July 26, 1995. The public made many of its comments at nine public meetings held at different locations throughout the TVA region. Both oral and written comments were received.

Due to the volume of these comments and their frequent similarity, TVA has summarized all of them. The summarized comments—approximately 875 of them—and responses have been categorized for easier public review.

In some cases, Volumes 1 and 2 of Energy Vision 2020 have been changed in response to comments, and this has been noted in this volume.

TVA has identified, when possible, those individuals and organizations that made similar comments after each summarized response. Because the comments were summarized, the precise wording of the comments was not always used. Also, in some cases, the identified commenters did not individually raise every point or element within a summarized comment.

For example, a number of commenters urged TVA to support or invest more in renewable energy resources, such as wind or solar power. Some of those making this comment thought that such resources were environmentally cleaner; others supported such investment as a means of mitigating the risk to fossil energy resources of more stringent environment controls. Still others supported the investments because of concerns about global climate change. Because "Jane Doe" supported one of the reasons, she was identified as a supporter of renewable resources in the context of a summarized comment that lists all three reasons.

In summarizing and categorizing comments, TVA tried to retain all important nuances or differences among similar comments. Consequently, a number of summarized comments may appear repetitious. Further refinements, although more reader friendly, would risk losing a possibly important nuance. A few comments were voluminous and identified a number of sub-issues or elements in connection with the major points made in the comment. Not all of these sub-issues or elements were separately answered when the primary response adequately encompassed them.

The public comments spanned a variety of issues. However, a number of commenters addressed three issues: (1) the merits of starting up Watts Bar Nuclear Plant Unit 1 and its treatment in Energy Vision 2020, (2) the merits of using more demand-side management options in the final plan, and (3) the merits of using more renewable energy options in the final plan. To avoid repetition and to ease the burden on readers, TVA has prepared a comprehensive response for each of these three comment categories.

To help the reader in finding comments and responses about a particular subject, this volume is organized in the sections listed below. In addition, an index follows the comments and responses. This index shows the name of each commenter followed by the numbers of the summarized comments that were made by that commenter.

TVA Overview and Actions

This section includes comments and responses about:

- the changing electric industry and the potential effect of competition on TVA
- TVA's vision and statutory mission as a regional resource development agency
- historical TVA activities including the areas of safety and resource protection
- the qualifications and compensation of TVA managers
- TVA's responsibilities as a Federal agency and its public accountability
- the potential consequences if TVA were privatized.

The Plan
This section includes comments and responses about:
- how well information has been presented in Energy Vision 2020 and the format of the document
- the goals and objectives of Energy Vision 2020
- the appropriateness of the evaluation criteria used in Energy Vision 2020 and the desirability of additional or different criteria
- the monetization of externalities
- the use of biomass and refuse-derived fuel in the plan
- the merits of the use of coal-fired units in the plan
- the treatment of debt and TVA's electric rates in Energy Vision 2020
- the treatment of various uncertainties, including competition in the electric utility market, load growth, natural gas prices, environmental regulations, and nuclear performance and costs
- the evaluation methods used in Energy Vision 2020

The Process
This section includes comments and responses about:
- the overall Energy Vision 2020 process
- the public participation process used in Energy Vision 2020

Existing System
This section includes comments and responses about:
- TVA's debt
- TVA's existing electric rate structure and its effect on energy use
- the operation of TVA's existing generating units, including its coal-fired, hydroelectric, and nuclear units
- the merits and economics of Watts Bar Nuclear Plant Unit 1, and other issues (assumptions, safety and health) related to start-up and operation of Watts Bar Nuclear Plant Unit 1 and restart of Browns Ferry Nuclear Plant Unit 3

This section includes a comprehensive response for a number of comments about the economics of operating Watts Bar Nuclear Plant Unit 1.

Long-Term Plan
This section includes comments and responses about:
- the energy resource strategies considered in Energy Vision 2020
- the process TVA used to develop strategies
- the merits of various supply-side resource options contained in Energy Vision 2020 strategies, including the conversion of Bellefonte to a gasification plant with a chemical coproduct, nuclear units, renewable energy resources such as wind, and emerging or new technologies
- TVA's decision to cease constructing Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2
- the role of demand-side management resources in Energy Vision 2020
- TVA's strategy for complying with the 1990 Clean Air Act Amendments, including the role of scrubbers and the use of sulfur dioxide allowances

Short-Term Action Plan
This section includes comments and responses about:
- the merits of proposed actions
- the details of Energy Vision 2020's short-term action plan
- the merits of using more demand-side management options in the plan
- the merits of using more renewable energy options in the plan, including the recommendations of the National Renewable Energy Laboratory
- the purchase of options to purchase energy resources
- the investigation of and research into various options

This section includes two comprehensive responses to a number of comments about the merits of using more demand-side management and renewable options in the plan.

Load Forecast and Need for Power
This section includes comments and responses about:
- the accuracy and range of TVA's load forecasts, including the assumptions and methodology used in forecasting future demands for Energy Vision 2020
- the need for power in the future in the TVA region

Customer Service Options
This section includes comments and responses about:
- the development and characterization of customer service options in Energy Vision 2020
- the merits of beneficial electrification
- the role of education in demand-side management
- the effect of electric rates on energy conservation
- the merits and effect of interruptible rates
- the merits of various end-use renewable energy options
- the importance of promoting energy efficiency, low income energy conservation and energy efficiency programs

Supply-Side Options

This section includes comments and responses about:

- the identification and characterization of supply-side options in Energy Vision 2020, including coal-fired, gas-fired, and hydroelectric resource options
- the merits of nuclear generation options
- the Kenetech wind farm project
- the merits of large photovoltaic and wind stations
- the effect of various options on global climate change or the greenhouse effect
- the merits of purchased power options, including the purchase of call options
- smaller-scale distributed generation options

Affected Environment and Environmental Consequences

This section includes comments and responses about:

- various aspects of the environmental quality of the TVA region
- the effect of coal combustion on air quality related problems, including acid rain, visibility, adverse effects in the Great Smoky Mountains National Park, forest health impacts, and global climate change
- water quality in TVA reservoirs and the TVA region
- socioeconomic conditions
- the treatment of environmental consequences in Energy Vision 2020, including the impact of radioactive wastes

Transcripts of the public meetings and all original comments are available for review at TVA's offices.

TVA OVERVIEW AND ACTIONS

This section includes comments and responses about:

- the changing electric industry and the potential effect of competition on TVA
- TVA's vision and statutory mission as a regional resource development agency
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- the potential consequences if TVA were privatized

The Changing Electric Industry (Competition)

1

Comment: *With utilities competing for customers and Congress demanding change from agencies, TVA faces tough challenges. In the last few years it has trimmed its work force, refinanced its debt, and eliminated unnecessary programs to become more competitive. We applaud these efforts.*

Comment by: Tennessee Valley Industrial Committee

Response: Energy Vision 2020 is expected to help TVA's efforts to remain competitive in the future.

2

Comment: *As deregulation occurs, utilities that have prepared early will be better prepared to respond to deregulation. TVA has made significant efforts in this regard and the Tennessee Valley Industrial Committee wants to work with TVA to continue these efforts.*

Comment by: Tennessee Valley Industrial Committee

Response: TVA will continue its efforts to improve its competitive position as deregulation continues and is eager to work with its customers in developing new products and services.

3

Comment: *TVA should work with distributors to better understand end-use customers in order to be ready for competition. TVA needs to allow greater choice. TVA thinks its customers are just distributors and direct-served industries, but they are really the residential customer.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA works with distributors of TVA power to better understand end-use customers. TVA and distributors survey end-use customers to identify electricity and appliance consumption patterns. TVA's customer service managers also work with distributors on a daily basis. A major part of this relationship involves identifying new end-use customers and customer needs.

4

Comment: *TVA's history does not justify removing the fence.*

Comment by: Ann Harris

Response: Restructuring of the electric utility industry is increasing competition among electric utilities. Recognizing the trends in the utility industry, the TVA Board of Directors asked a utility consulting firm, Palmer Bellevue, to examine TVA's competitiveness. This study, "The Ties That Bind: TVA in a Competitive Electric Market," has concluded that the fence provisions should be changed in two phases. Phase 1 would allow TVA to conduct all conventional types of wholesale business with utilities bordering TVA and beyond. During Phase 1, TVA would not be allowed unbalanced access to traditional non-profit wholesale customers of neighboring utilities with which TVA's relationship has been severely restricted since 1959 and which cannot be served in the TVA territory under the TVA Act. Phase 2 would remove the fence entirely, giving TVA's current wholesale customers in the Valley free market access to other suppliers of power and, at the same time, permitting TVA to seek markets outside the Valley on the same basis that competitors could enter the Valley to provide service.

5

Comment: *We do not have true open market competition in this region because TVA's distributors are locked into long-term contracts.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: True open market competition does not yet exist anywhere in this country. TVA has contracts with most of the distributors of its power that require the distributors to give TVA at least ten years' notice before meeting their power needs from other sources. It is one of TVA's goals to maintain itself as a low-cost and preferred supplier of electric energy and services for its distributors and others in the future.

6

Comment: *The people of the Valley should be preparing for the day when the TVA power program becomes investor-owned and the region will have to compete economically without the assistance of TVA.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: Currently, TVA's electric rates are very competitive with those of other utilities. In looking toward the future, the TVA Board of Directors has established a new vision for TVA that calls for the corporation to be the recognized world leader in providing energy and related services, independently and in alliance with others, for society's global needs. The recommendations in Energy Vision 2020 will help position TVA to continue to be competitive in the future.

7

Comment: *TVA lacks the data on end-users to adequately respond to a competitive environment where knowledge of one's customers could mean the difference between maintaining or losing an individual customer or market segment. Given the size and resources of*

TVA and the impending changes in the competitive environment, it is surprising that they have very little data on distributors' retail customers.

Comment by: Tennessee Valley Public Power Association

Response: TVA works with distributors of TVA power to better understand end-use customers. TVA and distributors survey end-use customers to identify electricity and appliance consumption patterns. TVA's customer service managers also work with distributors on a daily basis. A major part of this relationship involves identifying new end-use customers and customer needs.

8

Comment: *TVA should consider "lobbying" for legislation that would prevent environmentally unfriendly competitors from being allowed to sell power to its customers.*

Comment by: Elizabeth Garber

Response: The commenter is free to seek such legislation in Congress. TVA has prepared itself and continues its efforts to prepare itself to meet competition. Although it would be helpful if TVA's competitors were held to the same environmental standards and requirements that TVA is, TVA expects to be successful without such environmental parity.

TVA's Mission/Vision

9

Comment: *TVA can serve a valuable purpose for both the region and the nation.*

Comment by: Mary English (University of Tennessee)

Response: TVA serves a number of valuable purposes for the region and the nation. Maintaining and enhancing its ability to compete as a low-cost energy supplier, serving as a steward of the environment, and working toward the best quality of life for the region will be some of the ways that TVA will continue to serve a valuable purpose both in the Tennessee Valley region and the nation.

10

Comment: *TVA has a tremendous potential for leadership in the utility industry and for doing what is good for the Valley in the long run without much interference.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: TVA has historically been a leader in the utility industry in a number of different ways. It pioneered large central generating stations and large-capacity transmission lines. It also conducted some of the basic research into air pollution control equipment for coal-fired power plants. In the late 1970s and early 1980s, TVA initiated energy conservation programs that have become models for the utility industry. The Energy Vision 2020 process has employed cutting-edge analytical methods and integrated resource planning techniques. The process to purchase options on energy resources that TVA has initiated

in tandem with Energy Vision 2020 has attracted widespread industry attention because of its innovative nature.

Although TVA is not subject to the authority of state public utility commissions, it is subject to the authority of the United States Congress, and its activities are scrutinized by Congress. Both as a matter of policy and law, TVA also provides numerous opportunities for public input into its decision-making processes such as those used for Energy Vision 2020.

11

Comment: *TVA should return to its original mission of regional economic development, rural electrification, and protecting natural resources. Electric power is only one component of that mission. There is more to TVA than just selling cheap power. It should be a leader in sustainable energy.*

Comment by: Michelle Carratu, Martha McGill, Richard Simmers, Fred Wright, Alan Ball, Sheilla Cheyenne, Mary Ellen Bowen, Bruce Wood, Howard Switzer (Sun/Earth Tempered Organic Architecture), Michelle Neal (Tennessee Valley Energy Reform Coalition), Ann Harris, Alan Jones (Tennessee Environmental Council), Nancy Bell, Edward Smeloff (Sacramento Municipal Utility District), Debra Jackson, David Bowman (Huntsville News), Stephen Smith (Tennessee Valley Energy Reform Coalition), Retha Ferrell, Eileen McIlvane (Coalition for Jobs and the Environment), Robert Schreiber (Common Sense), Sharon Fidler (League of Women Voters), Alexander Dewey, Steven Walsh

Response: Under the TVA Act, TVA is charged with conducting a broad program directed toward development of the natural resources of the Tennessee River drainage basin and of such adjoining territory as may be related to or materially affected by the development consequent to this Act all for the general purpose of fostering an orderly and proper physical, economic, and social development of said areas. TVA has never deviated from this mission. TVA agrees that its electric power program is simply one component of its regional resource development program; albeit, a very important component in the success that TVA has achieved in fostering improvements in the region's social and economic well-being.

TVA's first effort toward meeting the energy needs of the region occurred in the context of the development of most of its hydroelectric units, which exemplify sustainable energy. TVA's hydroelectric system continues to be a very important part of the TVA power system and, as part of Energy Vision 2020, TVA has proposed enhancing the use of its hydroelectric units. In its long-term portfolio of energy resource options, it has also included biomass, end-use solar photovoltaics, demand-side management, and wind turbines. The flexibility of the Energy Vision 2020 plan will allow TVA to appropriately consider and implement other sustainable energy resource options as they become available in the future. (See Volume 1, Chapter 9, Figure 9-23.)

12

Comment: *As a public entity TVA has the responsibility to offer energy services that benefit the public and the environment.*

Comment by: Alan Ball, John Noel, Linda Cataldo Modica, Robert Schreiber (Common Sense)

Response: TVA agrees. Accomplishing this, however, is difficult, as reflected by the kind of trade-offs identified in Energy Vision 2020. (See, for example, Volume 1, Chapter 9, Figures 9-4 to 9-9.) The Energy Vision 2020 long- and short-term action plans recommend several customer service options and supply-side resource options that perform

well across all evaluation criteria including environmental quality, economic development, and rates. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

13

Comment: *TVA as a federal agency has the luxury to invest in things that monetarily responsible utilities could not do.*

Comment by: Maggie Kalen (Tennessee Valley Energy Reform Coalition)

Response: TVA, especially in this era of increasing competition, must make responsible monetary decisions. Its status as a federal agency does not change this.

14

Comment: *TVA is commended for generating electricity.*

Comment by: Julian McManus (Cherokee Lions Club)

Response: Your comment has been reviewed and noted.

15

Comment: *Because TVA is just in the business of pushing electricity, a quote that needs to be added to the record is "if electricity is just another commodity, then oxygen is just another gas."*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition)

Response: TVA is not just in the business of pushing electricity. The recommendations in the long-term plan and short-term action plan in Energy Vision 2020 are based on consideration of a number of criteria. These criteria include long-term costs, customer value, short- and long-term electric rates, environmental quality, economic development, debt, and risk management. Many of these criteria were suggested to TVA by the public.

16

Comment: *TVA should be asking the question "How do we meet the energy needs of the Valley?" and not "How should we generate more power?" The answer to the first question is conservation and renewables, and the answer to the second question is fossil and nuclear electric power.*

Comment by: Fred Wright

Response: Energy Vision 2020 asks how the energy needs of the Valley can be met and does not ask how should we generate more power. Energy Vision 2020 first determines the energy needs of the Valley and then determines the best way of meeting those needs. In Energy Vision 2020, the long-term plan and short-term action plan (see Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1) identify both demand- and supply-side resource options for meeting customer needs. This includes renewables and energy conservation.

TVA Actions and History

17

Comment: *I am impressed with the work done to improve the efficiency of TVA.*

Comment by: Ann Lamb

Response: Your comment has been reviewed and noted.

18

Comment: *TVA has been a major force in economic development since its inception.*

Comment by: William Bowker (Kentucky Coal Marketing and Export Council)

Response: TVA's broad mission is to foster the social and economic welfare of the TVA region. Accordingly, one of the criteria used to evaluate Energy Vision 2020 strategies is economic development.

19

Comment: *TVA's early television ads showing the state of the Valley before TVA were good ads because they show people the way things were.*

Comment by: Alexander Dewey

Response: Your comment has been reviewed and noted.

20

Comment: *TVA should continue to discourage chip mills.*

Comment by: Dennis Haldeman, Richard Simmers, Elizabeth Garber

Response: It is not TVA's intention to encourage or discourage chip mills. As appropriate, it looks at the ramifications of allowing chip mills to use property under TVA control or of approving water use facilities associated with chip mills.

21

Comment: *I admire TVA for its efforts to control soil erosion and bring electricity to the Valley. TVA has done some incredibly good things in the past such as stopping chip mills.*

Comment by: Marjorie Raines, John Noel, Alexander Dewey, John van der Harst

Response: Your comment has been reviewed and noted.

22

Comment: *Historically TVA's policies have shifted back and forth from resource conservation to resource exploitation.*

Comment by: Bruce Wood

Response: TVA's mandate is to manage the natural resources of the Tennessee Valley in a manner that fosters the social and economic welfare of the TVA region. The emphasis that TVA has given to the conservation of natural resources has varied over the years and

has included elements of both preservation and wise use. This has in part reflected the desires and needs of the public served by TVA, as well as the evolving role of other public and private entities in the conservation and protection of natural resources.

23

Comment: *TVA has reversed its former position of stewardship and enhancement of degraded lands by setting up an infrastructure that permits degradation of natural resources by private companies.*

Comment by: Dennis Haldeman

Response: As a regional resource development agency, TVA is broadly responsible for managing the natural resources of the Tennessee Valley in a manner that fosters the social and economic well-being of the TVA region. It has not deviated from or shirked this responsibility, although it recognizes that others may have a different view, depending on their own perceptions and goals. One of TVA's primary mandates in the TVA Act is to improve the navigability of the Tennessee River and to provide for flood control on the Tennessee River and its tributaries. TVA does not consider the fulfillment of this mandate to be inconsistent with TVA's stewardship of the region's natural resources. TVA has developed the infrastructure to achieve this mandate and continues its efforts to appropriately maintain that infrastructure. Inherent in the concept of navigation is the ability of people and business entities to use the Tennessee River for economic purposes, whether those purposes are recreation-related or related to the movement of natural resources into and out of the region.

24

Comment: *TVA has not been responding to hundreds of Freedom of Information Act requests on Watts Bar Nuclear Plant Unit 1 which makes people think TVA is hiding something.*

Comment by: Beth Zilbert (Greenpeace)

Response: As of October 1, 1995, no pending Freedom of Information Act requests on Watts Bar Nuclear Plant Unit 1 are outstanding. All requests for the last 10 years have been handled in accordance with standard Freedom of Information Act practices.

25

Comment: *My comments on the Nuclear Regulatory Commission Environmental Impact Statement for Watts Bar were illegible when photocopied and included in that document. Simple citizens just cannot figure out how TVA can blow such things.*

Comment by: John van der Harst

Response: TVA was not responsible for photocopying and including comments on the supplemental environmental impact statement which the Nuclear Regulatory Commission prepared for TVA's Watts Bar Nuclear Plant. The Nuclear Regulatory Commission was responsible for this. One of the drawbacks of including actual copies of the comments received in environmental impact statements is the occasional difficulty encountered in reproducing fully legible copies in the environmental impact statement, either due to the poor quality of the incoming document received or the reproduction process itself.

26

Comment: *TVA represses and punishes those seeking to speak to the Board in opposition to decisions they make.*

Comment by: Beth Zilbert (Greenpeace)

Response: TVA welcomes comments from the public and makes time to hear them at its Board meetings. In order to ensure that everyone who wishes to address the Board has an opportunity to do so, it is important that an orderly process be adhered to.

27

Comment: *TVA spends hundreds of thousands of dollars harassing and terrorizing employees and people who oppose it.*

Comment by: Beth Zilbert (Greenpeace)

Response: TVA does not harass or terrorize its employees. It provides many opportunities for employees to express concerns.

28

Comment: *The appalling history of TVA has been that not only were nuclear whistle blowers not promoted but they were harassed and fired. I have personally known many TVA workers at all levels who were forced by their supervisors to sign off on shoddy work and undone testing. The judge at the Sixth Circuit of Appeals in Cincinnati agreed with the allegations in nuclear engineer Jim Jones' harassment suit but did not find them "outrageous." Any reasonable unbiased person would find them outrageous. I have talked to the Nuclear Regulatory Commission inspectors about the fact that discovery of faults and shoddy workmanship by workers was punished rather than rewarded, and they acknowledged that they knew it.*

Comment by: Fred Wright

Response: TVA employees are our most important asset and provide valuable information concerning all aspects of our nuclear program. Therefore, it is TVA policy that intimidation, harassment, discrimination, or retaliation will not be tolerated. TVA is committed to ensuring an environment where employees feel free to express their concerns and ensuring that their concerns are properly addressed.

TVA has established two programs to assure that employee concerns have been, and will continue to be, properly addressed and resolved. The ongoing Concerns Resolution Program, put in place on February 1, 1986, was established to encourage the prompt and effective resolution of employee concerns through the normal line management process, as well as provide an alternate avenue for concerns that cannot be effectively resolved that are similar to and under the oversight of the Concerns Resolution Staff. Employees and line management are the key building blocks of this program; however, the Concerns Resolution Staff and contractor programs are available on-site as alternate avenues for employees to raise and resolve concerns. Concern programs are made known to employees in General Employee Training, site bulletins, and postings on bulletin boards. In addition, employees leaving the site participate in an exit interview with the Concerns Resolution Staff or their contractor concern program to specifically identify

any unresolved safety issues they are aware of. These programs have been successful. The number of issues expressed to concern programs TVA-wide has consistently trended downward from 1,298 in 1986 to 77 in 1995 (through October). Nuclear Regulatory Commission reviews in 1993 and 1995 of the programs revealed the site-wide employee concerns programs are being effectively implemented. Employee interviews conducted by the Nuclear Regulatory Commission during their 1993 and 1995 inspections of the programs, and by the TVA Office of the Inspector General in 1994 and 1995 were very positive and indicated that the vast majority of employees will report nuclear safety or quality problems by some available avenue, have confidence in line management to resolve issues, and will, if needed, use the concern programs as an alternative avenue to raise issues.

The second program, known as the Employee Concerns Special Program was established to resolve concerns expressed prior to February 1, 1986. The Employee Concerns Special Program made use of an independent contractor in 1985 and early 1986 to interview all employees associated with Watts Bar Nuclear Plant to make sure all employee concerns were identified. Over 5,800 employees associated with Watts Bar Nuclear Plant (not necessarily on-site) were interviewed which resulted in over 5,000 employee concerns being identified by approximately 1,850 employees. Hot lines for all employees and the public were also established. Due to the large number of concerns expressed, TVA established Employee Concern Task Groups to categorize and investigate the concerns. The Employee Concern Task Groups issued 1,591 Corrective Action Tracking Documents for issues that were validated and required further corrective actions. All 704 Corrective Action Tracking Documents that are applicable to Watts Bar Nuclear Plant Unit 1 have been closed.

29

Comment: *TVA is marketing electricity to feed its dying nuclear monsters.*

Comment by: Retha Ferrell, Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: In Energy Vision 2020, TVA has considered many different customer service options, including marketing options. Some decrease electricity consumption; others increase consumption. But all increase customer value. The choice of these customer service options is not dictated by TVA's nuclear program.

TVA's Organization/Work Force

30

Comment: *What are the qualifications of TVA's energy program senior leadership?*

Comment by: Robert Nash

Response: TVA's Board of Directors exercises ultimate management authority over all of TVA's programs, both its energy or power programs and its natural resource management programs. In addition, there are two other managers who collectively are responsible for all aspects of TVA's energy programs and who report to the Board. These individuals and their principal occupations in recent years are:

Craven Crowell, TVA Board Chairman since July 1993 —
Chief of Staff to Senator Sasser (1989-1993)
Vice President of TVA's Office of Governmental & Public Affairs and TVA Director of Information (1980-1988)

Johnny H. Hayes, TVA Board Director since July 1993 —
Tennessee State Commissioner of Economic and Community Development (1992-1993)
Tennessee State Commissioner of Employment Security (1991-1992)

William H. Kennoy, TVA Board Director since April 1991 —
President, Kennoy Engineers (1966-1991)

Joseph W. Dickey, Chief Operating Officer since February 1994 —
Senior Vice President of TVA's Office of Fossil & Hydro Power (1991-1994)
Vice President of Florida Power & Light Company's Power Resources Division (1988-1991)

Oliver D. Kingsley, Jr., President of TVA Nuclear and Chief Nuclear Officer since February 1994 —
President of TVA's Generating Group (1991-1994)
Senior Vice President of TVA's Office of Nuclear Power (1988-1991)
Vice President of Mississippi Power and Light Company's Nuclear Power Division (1985-1988)

31

Comment: *TVA needs more enlightened, accountable management that will restore its leadership in energy conservation and demonstrate commitment to a clean energy future.*

Comment by: John Johnson (Earth First), Linda Cataldo Modica, Robert Schreiber (Common Sense)

Response: In Energy Vision 2020, hundreds of supply- and demand-side management options were carefully developed and evaluated using a multi-attribute criteria process. A number of demand-side management options have been recommended either for implementation or further investigation in the short-term action plan. These options were selected by balancing the multiple evaluation criteria. Additional demand-side management options could be implemented in the future as identified in the short-term and long-term plans. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) TVA thinks that the Energy Vision 2020 process and its recommendations demonstrate a commitment to energy conservation and to a clean energy future.

32

Comment: *TVA needs to reduce its expenses in such areas as high managers getting unwarranted and illegal bonuses that exceed the federal pay cap.*

Comment by: Jeannine Honicker, Frank Holm

Response: TVA's compensation policies, including supplementary compensation, are well within the law. Supplementary compensation contributes to TVA's ability to recruit and retain top management talent in a competitive environment. The benefit for TVA customers is a nine-year track record of stable electricity rates, made possible because TVA's management team has been able to reduce costs and interest expense.

33

Comment: *TVA should have an annual report that identifies what TVA employees, contractors, and consultants get paid.*

Comment by: Frank Holm

Response: As appropriate, TVA makes available such information, but this is not included in TVA's annual reports to Congress.

TVA's Accountability/Possible Privatization

34

Comment: *I do not want to see TVA split up, but if it is going to stay whole, it needs to be more responsive to the public.*

Comment by: Debra Jackson, John Noel

Response: TVA makes a concerted effort to be responsible to the public. The public participation effort made as part of the Energy Vision 2020 process is an example of this. (See Volume 1, Chapter 1.)

35

Comment: *There needs to be a larger TVA Board with a citizens' representative or the creation of a public oversight panel. This may prevent TVA from repeating its dramatic mistakes from the past.*

Comment by: Myles Jakubowski (Sunbeam Household Products)

Response: The idea of increasing the size of the TVA Board of Directors has been raised over the years, but has not been widely supported. The law calls for the TVA Board to be appointed by the President with the advice and consent of the Senate. Congress, made up of the elected representatives of the people, has the responsibility to oversee TVA. It is unclear how a larger board would be more responsive to the public or provide significantly more effective leadership.

36

Comment: *Although Duke Power and Southern Company can do a better job of pushing electrons through a meter, the benefits of TVA's broad mission, such as serving rural or low income customers, could be lost if TVA is privatized. It is more cost-effective to serve urban areas. TVA must be kept strong and viable and as a yardstick against which other utilities can be measured.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA is able to fully compete with Duke Power and Southern Company in the electric market. However, TVA agrees that both the cost and reliability of electric energy services provided to many of the ultimate users of TVA-provided energy would likely be adversely impacted if TVA is privatized. As a federal power provider, TVA's mission and requirements are generally broader than those of private utilities. TVA's mission also includes economic development, management of the Tennessee River system, and environmental stewardship. TVA's development of new technologies has been and is expected to be an important means of accomplishing its broad mission.

37

Comment: *We want to see TVA survive. There are thousands of employees who are counting on this. There are also millions of customers counting on TVA to be responsible with how they generate energy and manage their resources. We want TVA to remain a public power firm because of the vital role it used to play.*

Comment by: Beth Zilbert (Greenpeace)

Response: We agree that TVA's role as a non-profit power supplier is very important to the social and economic well-being of the region.

38

Comment: *The Tennessee Valley Energy Reform Coalition is advocating a more environmentally and economically responsible agency.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA certainly shares these goals. In Energy Vision 2020, a number of criteria were used to evaluate strategies. These include environmental quality, economic development, and rates.

39

Comment: *The impacts on the costs of power to the TVA distributors and their customers from privatization would likely be substantial.*

Comment by: Tennessee Valley Public Power Association

Response: We agree. Privatizing TVA would result in major changes in TVA's capital structure, resulting in increased electric rates for TVA customers. There are no sound business reasons for privatization.

40

Comment: *If the final Energy Vision 2020 report includes a resource strategy with projected debt that exceeds the limitations, there could be significant direct increases on TVA's cost of providing service. Obviously, TVA would have to get legal authority to raise its total debt above $30 billion. This would be very difficult to accomplish and an attempt by TVA to convince Congress to adjust the debt ceiling may expedite the privatization of the TVA system.*

Comment by: Tennessee Valley Public Power Association

Response: Energy Vision 2020 supports the internal ceiling on debt. As shown in Energy Vision 2020, Volume 1, Chapter 9, Figure 9-4, Strategy Trade-Off for Debt in Year 2001 vs. Total Resource Costs, all seven of the key strategies remain well below the internal debt ceiling. In addition, the short-term action plan (see Volume 1, Chapter 10, Figure 10-1) results in debt in the year 2001 less than the internal debt ceiling (see Volume 1, Chapter 10, Figure 10-7). Past the year 2001, the long-term resource plan includes recommendations for unique energy supply arrangements such as partnerships with investors supplying capital as well as options to purchase power which have no effect on debt while providing the needed generating capacity.

41

Comment: *TVA needs to consider having private industry generate power and TVA becoming the broker of energy transmission lines and dam operators. This will be the cheapest way in the future to hold down electricity costs.*

Comment by: C. L. McKinney (Creret, Inc.)

Response: In Energy Vision 2020, several supply-side options (generation) proposed by private industry have been considered. In the short-term action plan, TVA has identified up to 3,000 megawatts of option purchase agreements for purchase from private industry.

TVA's Energy Vision 2020 recognizes that the electric industry is becoming increasingly competitive. As electric utility industry restructuring continues, many different utility structures may occur. TVA's generation resources may have to compete in an open market against other generators while TVA's transmission system takes on more of the status of a common carrier. However, TVA's current or existing generating units are expected to be able to compete in this competitive market.

42

Comment: *If TVA is going to behave like an investor-owned utility, why should TVA not be privatized? The draft Energy Vision 2020 ignores TVA's unique mission as a federal corporation.*

Comment by: Alexander Dewey, Eric Hirst (Oak Ridge National Laboratory), Stephen Smith (Tennessee Valley Energy Reform Coalition), Linda LaForest (Tennessee Citizens for Wilderness Planning), Robert Schreiber (Common Sense), Michelle Neal (Tennessee Valley Energy Reform Coalition)

Response: TVA is making a strong effort to operate more efficiently and to reduce costs in order to keep rates low and be better able to compete in the sale of electric energy. This is fully in keeping with TVA's historical mission as a federal agency and corporation. Efficient, cost-effective operations should not be attributes of only investor-owned utilities. Efficiently producing and selling competitively priced electricity has long been one

of the cornerstones of TVA's regional resource development mission. In fact, its ability to compete with investor-owned utilities in the sale of electric energy has been one of the things that has characterized TVA as a unique federal agency.

The Energy Vision 2020 plan is one of the ways TVA is preparing for an increasingly competitive utility industry while serving as a steward of the many natural resources of the region.

43

Comment: *TVA's lack of accountability must be addressed. Its actions must be subject to closer public review to protect consumers against abuses. TVA has a politically appointed Board, and stakeholders do not have a say in who governs TVA. There is no public oversight of TVA. The plan should provide for this.*

Comment by: Stan Gloeckner (Sierra Club), Robert Schreiber (Common Sense), Beth Zilbert (Greenpeace), John Johnson (Earth First), Nancy Bell, Powell & Sharon Foster

Response: TVA is subject to public accountability and scrutiny in a number of different ways. The three members of its Board of Directors are appointed by the President, with the advice and consent of the United States Senate. As a federal agency, TVA's activities are scrutinized by Congress, and TVA officials appear before congressional committees to testify about TVA activities.

As a regional resource agency whose headquarters and personnel are located in the area served by the agency, the public has access to TVA's senior officers and management to a much greater degree than almost any other federal agency. TVA's management and employees live and work in the communities served by the agency. Notice of TVA Board meetings is provided in advance. Board meetings are open to the public, and members of the public are given an opportunity to address the Board. Board meetings are held at different locations in the TVA region throughout the year in order to facilitate attendance of interested members of the public in those locales.

TVA activities are also subject to a number of external review processes, including the National Environmental Policy Act. The Energy Vision 2020 process has been conducted in conformity with the National Environmental Policy Act's environmental impact statement procedures. Substantial opportunities for public input and scrutiny have been provided throughout the entire Energy Vision 2020 process.

In light of the existing opportunities for public scrutiny and involvement, there is no need to create additional opportunities in the context of TVA's energy resource planning efforts.

44

Comment: *By 2020 TVA should be administered by an elected body and overseen by financial and environmental experts who are dedicated to the original purpose of TVA to benefit the region.*

Comment by: Retha Ferrell

Response: Such a change would require congressional legislation and is not being proposed as part of Energy Vision 2020.

45

Comment: *TVA is keeping rates artificially low to stall the movement toward privatization.*

Comment by: Steven Walsh

Response: TVA's electric rates are not artificially low. TVA's electric prices that it charges all of its customers cover all the costs of operation plus the cost of servicing TVA's debt. It is a benefit to the region to provide low-cost power to customers.

46

Comment: *TVA's plan should address the consequences of privatization.*

Comment by: Nancy Bell

Response: Energy Vision 2020 assumes that TVA will continue as a federal government agency and TVA will not be privatized (see Volume 1, Chapter 1). A privatized TVA would likely have goals and objectives radically different than TVA's current goals which account for TVA's mission as a federal regional resource agency.

THE PLAN

This section includes comments and responses about:

- how well information has been presented in Energy Vision 2020 and the format of the document
- the goals and objectives of Energy Vision 2020
- the appropriateness of the evaluation criteria used in Energy Vision 2020 and the desirability of additional or different criteria
- the monetization of externalities

Presentation of Information

47

Comment: *TVA's development, analysis, display, and discussion of various resource portfolios, alternative futures, and uncertainties demonstrated a high degree of technical competence and communication skills.*

Comment by: TVA Retirees Association, Eric Hirst (Oak Ridge National Laboratory)

Response: In addition to internal resources, TVA had the assistance of other experts and stakeholders throughout the process.

48

Comment: *We commend TVA for making a long-range plan. The plan is well laid out and shows a lot of work.*

Comment by: Ken Wheeler (Midland Enterprises)

Response: TVA made a concerted effort to produce a good, readable integrated resource plan.

49

Comment: *TVA's draft is well organized, well written, logically structured, comprehensive, and the easiest to read integrated resource planning report ever.*

Comment by: TVA Retirees Association, Mary English (University of Tennessee), Eric Hirst (Oak Ridge National Laboratory)

Response: TVA made a concerted effort to produce a good, readable integrated resource plan.

50

Comment: *In my opinion, the beauty of these documents is the degree to which they are readable and yet technically convincing. The use of graphs, maps, charts, and tables is superb.*

Comment by: Tom Forsythe

Response: TVA made a concerted effort to produce a good, readable integrated resource plan.

51

Comment: *The report is not written so that it is user-friendly to the average person. It should clearly explain what the situation is, what the goal is, and how to achieve it.*

Comment by: Dolores Howard, John van der Harst

Response: TVA has endeavored to write the Energy Vision 2020 in a user-friendly manner, but we realize that much of this material is technical in nature.

52

Comment: *The format of the document indicates insensitivity to environmental issues because of the glossy conventional public relations style of the document.*

Comment by: Howard Switzer (Sun/Earth Tempered Organic Architecture)

Response: The document was purposely formatted to promote clarity, understanding, and ease of reading. The document is printed on recycled paper.

53

Comment: *A section with the traditional environmental impact statement title of "Alternatives" does not appear in the Table of Contents of Energy Vision 2020. This may be confusing to some reviewers. We note, however, that alternatives are covered in Chapter 9, which is listed as "Resource Integration" in the Table of Contents. We recommend that the full title of Chapter 9 (i.e., "Resource Integration/Alternative Strategy Comparisons") be included in the Table of Contents in order to signify an alternatives analysis.*

Similarly, the section on "Environmental Consequences" is difficult to find (Chapter 9) in the Table of Contents of Volume 1. This may also be confusing to some reviewers. However, Environmental Consequences is covered in detail and clearly listed in Volume 2, technical Document 2.

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: As recommended, the full title of Chapter 9, Resource Integration/Alternative Strategy Comparisons has been included in the Table of Contents for Volume 1 of the final Energy Vision 2020.

54

Comment: *The discussion of the "preferred bundle of resource options" is somewhat confusing. TVA may wish to consider minor language changes to clarify that the goal of the preferred bundle of resource options is to develop a preferred set of resource options (portfolio). (See Executive Summary, page 14, Figure 2.) This is better explained in Volume 1, Chapter 9, page 9.34 and in Volume 2, Technical Document 2, page T2.51.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: This has been changed in the final Energy Vision 2020.

55

Comment: *TVA's Energy Vision 2020 document is extensive, descriptive, and well referenced. However, detailed descriptions of each strategy evaluated in the Energy Vision 2020 process are not included. Memphis Light, Gas and Water requests a detailed description of each strategy.*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: Detailed descriptions of each strategy have been provided to Memphis Light, Gas and Water.

Goals and Objectives/Evaluation Criteria

GENERAL

56

Comment: *The long-term strategy appropriately emphasizes flexibility and seeks to balance the goals of economic growth and environmental quality.*

Comment by: TVA Retirees Association, Eric Hirst (Oak Ridge National Laboratory)

Response: Through Energy Vision 2020, TVA developed a comprehensive evaluation system that reflects TVA's goals and objectives, as well as the concerns and values of the public. Some of TVA's evaluation criteria include risk management, flexibility, economic development, and environment. These criteria and other measures became the quantitative basis for ranking supply-side and customer service options. They were used to develop the long-term plan and the short-term action plan. In addition to these quantitative criteria, TVA took into account other qualitative factors such as some environmental concerns.

57

Comment: *The plan balances energy, policy, and environmental issues with practical business considerations that are necessary if TVA is to continue serving the needs of both the region's power consumers and its growing economy. If implemented, it should provide a sound framework for TVA to achieve its goals for economic development of the Valley, combined with high-level environmental stewardship.*

Comment by: TVA Retirees Association

Response: Your comment has been reviewed and noted.

58

Comment: *There should be a renewables portfolio standard by which there is a set amount of renewable investment that is uniform throughout the industry.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA cannot require a renewables portfolio standard throughout the utility industry. TVA has, however, included more than 2,500 megawatts of renewable energy in the

Energy Vision 2020 portfolio. This includes a wind turbine and biorefinery projects as well as research and development programs for supply and customer service renewables in the short-term action plan.

59

Comment: *Alternative and renewable energy sources have the potential for assisting the rural families in Appalachia by providing employment and benefiting the environment.*

Comment by: Calvin Moore

Response: TVA believes in the importance of the Valley's economic development. TVA has set up an Economic Development Office and through its appropriated-funded programs helps disadvantaged rural communities. In addition, economic development is one of the criteria being used in the Energy Vision 2020 process. As part of the Energy Vision 2020 study, each strategy was analyzed as to its environmental and economic development impacts. Strategies in Energy Vision 2020 included alternative energy sources such as wind power and conservation. The key strategies from which the long-term plan is derived (all of which performed well in terms of economic development and the environment) contain such energy sources. Energy Vision 2020 is not a site-specific analysis. Siting issues, impacts, and benefits will be examined when TVA proposes to implement specific resource options.

60

Comment: *Although its fundamentals are excellent, the report is not strong enough as it relates to protecting the environment and TVA's economic survival.*

Comment by: John Noel

Response: Environmental quality and competitive electric rates were among the criteria used to evaluate and develop the strategies considered in Energy Vision 2020. The evaluation of the strategies using these and other criteria are reported in Volume 1, Chapter 9, Figures 9-4 to 9-10.

Early in the evaluation process, it was recognized that strategies that improved the quality of the environment also increased electric rates and, conversely, strategies that provided competitive electric rates also provided less improvement to the environment. This trade-off between environmental quality and competitive electric rates was improved by including in strategies low-cost renewable energy options with few environmental emissions. These renewable energy options include wind power, biomass, landfill methane recovery, and small modular distributed generation such as fuel cells. These options are identified in TVA's long-term plan. (See Volume 1, Chapter 9, Figure 9-23.)

61

Comment: *TVA's draft plan is not capable of achieving its stated goal. Its goal is to provide electricity at the lowest cost by integrating and balancing new technology, consumer needs, existing resources, and environmental concerns. This means providing clean, safe, and affordable energy. However, the plan continues to lean heavily on conventional technologies with negative environmental and health impacts.*

Comment by: Bruce Wood, Sharon Force

Response: The goal of the long-term plan and the short-term action plan in Energy Vision 2020 was to develop strategies and resource options that balanced several criteria besides the lowest cost. These included minimizing short- and long-term electric rates and TVA debt, reducing environmental impacts, increasing economic development and customer value, and providing robustness and flexibility to meet an uncertain future. The long-term plan and short-term action plan provide a balance of existing resources, supply-side resources, demand-side management, and new technologies in order to meet future customer needs. (See Volume 1, Chapter 9 and Chapter 10.)

62

Comment: *I recommend that TVA adopt the six principles that the National Association of Regulatory Utility Commissioners adopted at its 1995 summer meeting and to advocate these principles with its distributors. The National Association of Regulatory Utility Commissioners adopted these warnings about the risk to the low income customers by the restructuring of the electric utility industry.*

The principles are: One, prevent unfair cost shifting between customer classes; two, make available the benefits of the competitive market to each customer class without undue discrimination; three, maintain fair and reasonable billing and collection practices; four, sustain Commission approved low income energy efficiency and rate programs; five, limit disproportionate environmental impact in low income neighborhoods; and six, ensure the effective participation of all citizens in the restructuring debate.

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Michael Karp (Northwest Conservation Act Coalition)

Response: Although the exact nature of the changes due to the restructuring of the electric utility industry is not yet fully known, TVA developed evaluation criteria which reflected many of the values underlying the National Association of Regulatory Utility Commissioners' six principles related to the restructuring of the electric utility industry. These criteria were used to evaluate all strategies considered when developing TVA's plan for the future. These include equity among rate classes, customer value, and environmental impacts. The process for developing the plan included extensive public participation efforts. TVA and distributors of TVA power have a long history of providing outreach and assistance to low income customers, and a number of initiatives are included in the proposed short-term action plan that would benefit low income customers. (See Volume 1, Chapter 10, Figure 10-1.)

63

Comment: *The growth paradigm is destroying the biosphere, and to just assume that as a culture we are going to continue with unlimited growth, unlimited economic growth, and so-called progress, is really short-sighted. Unlimited growth on a planet with limited resources is a really ridiculous and short-sighted view—it is a very destructive way to run a society.*

Comment by: John Johnson (Earth First)

Response: There are limits to uncontrolled growth. Economic development was only one of the criteria that TVA considered in evaluating various strategies for the future. Each strategy was also carefully evaluated considering a number of other criteria, including the environmental impacts on air, water, and other aspects of the environment.

64

Comment: *We do not need a mean and lean TVA. We need a TVA that thinks not only of low-cost energy but of socioeconomics, the environment, and jobs for the people.*

Comment by: Anne Redwine

Response: Like other utilities, TVA is expecting important changes in the relationships between customers and utilities. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a competitive marketplace. Energy Vision 2020 will guide TVA in entering this competitive marketplace and beyond by identifying the best energy resource choices for the current and future generation of consumers.

However, Energy Vision 2020 goes beyond simply providing competitively priced power. The plan also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are the means by which TVA can achieve all of these goals: competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

65

Comment: *For a competitive strategy, TVA should focus on customer service, value, and bills, not just rates, unless TVA plans to compete solely on price.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Robert Schreiber (Common Sense), Arthur Smith, Eric Hirst (Oak Ridge National Laboratory)

Response: TVA has considered both electric rates and customer bills by using several measures. These include total resource costs, customer value, and electric rates, including short- to long-term. These evaluation criteria are explained in Volume 1, Chapter 5. TVA's strategies are evaluated using these criteria, and the results are presented in Volume 1, Chapter 9.

Although additional conservation can lower electric bills, it can also increase electric rates. This trade-off is considered in Volume 1, Chapter 9, pages 9.15 to 9.21.

TVA primarily sells wholesale power. Wholesale power is delivered to 160 power distributors that in turn distribute electricity to homes and businesses within their service areas. In the future marketplace, rates and reliability will be critically important.

66

Comment: *Energy Vision 2020 lacks proper quantification of many important externalities. Many states force utilities to charge more for electricity generated from non-renewable technologies and charge less for electricity from renewable energy sources. Fossil and nuclear hidden costs (externalities) should be considered. This promotes the use of alternative resources because the real costs from electricity generated by dirty methods become part of our bills. TVA should factor in externalities (extended costs). A low rate is not necessarily an efficient rate. Rates should cover total costs, including externalities.*

Comment by: Danielle Droitsch, Luther Gulick, A. B. Evans, Mary Anne Terry, Chris Gulick, Faith Young, Myles Jakubowski (Sunbeam Household Products), Ann & Mike Sanders, William Emmott, Powell & Sharon Foster, Brian Bury, Mary Carton, Benjamin Stewart (Faith Lutheran Church), Ruth Peeples, Katherine Osborn, Sharron Eckert, Isahl Hemm, Mary Schwarz, John Schwarz, Jr., Robert Peeples, Jo Anne Clark, Marion Zachiel, Arthur Smith, R. & G. Ludwig, Walter & Dorothy Stark, Ben & Winn Welch, F. W. Munson, N. E. Whitfield, Stephanie Calvert, M. Nathan Perry, Deborah Cuva,

Tohert, Leith Patton, Salo, Ray Williams, Karl Grotke, Susana Harwood, Shirley Schaaf, Dolores Howard, Hermann, Kim Grube, K. Varnum, Garry Shores, Kathy Priore, Karah Bates, M. Case, Dottie Hodges, Sharon Force, C. T. Brewster, Robert Schreiber (Common Sense), Wilson Prichett (Tennessee Valley Energy Management Association), Alan Jones (Tennessee Environmental Council), Maggie Kalen (Tennessee Valley Energy Reform Coalition), John Harwood, John van der Harst, Nancy Bell, Jim Snell, Olivia Lim (Southeast Center for Ecological Awareness), John Johnson (Earth First), Dennis Haldeman, Michelle Neal (Tennessee Valley Energy Reform Coalition), Alan Ball, Linda Ewald, David Bordenkircher, L. M. Johnson, Sr., Stephen Smith (Tennessee Valley Energy Reform Coalition), Sahara, C. Strain, Karen Lovell, Lynn Leach (Alabama Environmental Council)

Response: An "externality" is a cost or benefit that results from the production or consumption of goods and services that is not reflected in the prices of those goods or services. For example, driving a car or generating electricity may produce various forms of pollution that can damage vegetation. If such pollution is not controlled at the source such that the cost of control is included in production costs, it is an environmental externality, or a cost borne by society. TVA and other federal agencies have long assessed potential environmental externalities in the context of the National Environmental Policy Act reviews they perform.

Several commenters asked TVA to monetize the environmental externalities that may result from the strategies or options in Energy Vision 2020. Monetization of externalities involves directly adding the cost of externalities to other costs, such as construction and fuel costs. Given the many difficulties in monetizing externalities, and the lack of a consistent position in the utility industry on the values to be used, TVA chose not to monetize externalities in Energy Vision 2020. (See TVA's Approach to Evaluating Externalities Resulting from the Production and Consumption of Electricity in Volume 2, Technical Document 4.)

Instead, each strategy considered in Energy Vision 2020 was evaluated by multiple evaluation criteria, including environmental evaluation criteria, using a multi-attribute trade-off analysis methodology. The methodology is discussed in Volume 1, Chapters 2 and 9. The consideration of environmental impacts using environmental evaluation criteria was an important factor in the selection of the strategies and energy resources to be included in TVA's Energy Vision 2020 portfolio and plan. The environmental evaluation criteria and the evaluation of each strategy's environmental performance are discussed in Volume 1, Chapters 3, 5, and 9. In addition, environmental issues have been addressed qualitatively in Energy Vision 2020. A more detailed discussion of these issues is located in Volume 2, Technical Document 1, Comprehensive Affected Environment, and Volume 2, Technical Document 2, Environmental Consequences.

67

Comment: *Energy issues and policies can quickly become technically complex and emotionally charged when one begins to consider all the technological, environmental, economic, and socio-political aspects. In such policy debates, the most difficult task is to establish the fundamental principles to guide future decision-making. The National Hydro Association suggests there are three fundamental tenets that should be considered:*

- *The health of modern economics depends on a solid and stable energy foundation.*
- *Energy sources should be sustained over the long term.*
- *All energy sources have drawbacks.*

Comment by: Linda Church Ciocci (National Hydropower Association)

Response: Through Energy Vision 2020, TVA developed a comprehensive evaluation system that reflects TVA's goals and objectives, as well as the concerns and values of the

public. TVA's evaluation criteria include: long-run cost/value, TVA short- to long-term rates, reliability, environment, economic development, financial requirements, risk management, and equity among rate classes. (See Volume 1, Chapter 5 for further information on TVA's evaluation criteria.)

COST/VALUE

68

Comment: *The primary measure of cost that TVA used was total resource cost. This measure incorporates all measurable costs associated with a resource including construction costs, operating and maintenance costs, fuel costs, marketing/administrative costs, rebates, equipment costs, etc. It is the standard used throughout the industry and is similar to a "required revenues" approach commonly used in supply planning and rate making.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

69

Comment: *An extension of the total resource cost is "customer value." This criterion adds to the total resource cost the value of increased comfort or security as well as the value to society of decreased market barriers. Customer value is particularly useful when evaluating beneficial electrification, because the total resource costs ignore the value of increased security, for example, when outdoor lighting is added. The title, "customer value" is an unfortunate one, however, because it implies that this is what customers prefer. This is not necessarily the case. Customer value is simply an extension of the total resource cost that includes an estimate of the value of increased electrification.*

Comment by: Tennessee Valley Public Power Association

Response: The customer value criterion is an extension of the total resource cost test. The value test is rigorously derived from the economic theory of supply and demand and represents a complete test of economic efficiency. It is also unique in that it is the only cost-benefit test that provides a consistent measure of both energy efficiency, as well as beneficial electrification options. Customer value reflects customer preferences to the extent these preferences are revealed in customer demands for energy services.

70

Comment: *Explain how TVA estimates some of the factors in the value test, such as amenity level and market barrier costs.*

Comment by: Eric Hirst (Oak Ridge National Laboratory)

Response: TVA used several methods to estimate the factors considered in the value test. Market barrier costs are estimated by the net benefits identified in the participant test before a utility program is implemented. The participant test compares the benefits in terms of energy bill savings resulting from adoption of high-efficiency technology to the incremental cost of the technology. If the energy savings benefits exceed the cost and the customer does not adopt the technology, one can assume the customer must face market barrier costs. The market barrier costs must be at least as great as the net benefits provided by the technology. The market barriers faced by the customer may be lack of infor-

mation, risk associated with a new technology, or lack of available capital. Programs designed to address these market barriers reduce the costs borne by participants and increase the value of a customer service option. TVA evaluated the effectiveness of each proposed program in reducing or eliminating market barrier costs. Generally, more aggressive programs were more effective at reducing market barrier costs but had higher program costs.

The change in amenity level can also be measured using the results of the participant test. For the beneficial electrification options, for example, customers will incur the cost of a new electrotechnology and increased energy use. For a customer to participate in the program, the customer must receive benefits greater than the increased costs. Those benefits can be improved quality, increased productivity, or reduced environmental compliance cost. In most cases for electrotechnologies, TVA estimated these benefits directly. If the benefits cannot be estimated directly, the participant test provides a conservative estimate of the change in amenity level for a participating customer.

71

Comment: *TVA is proposing to use consumer value as a criteria. This is a highly arbitrary and subjective criterion. TVA should go back and rethink the use of this.*

Comment by: Geoffrey Crandall (MSB Energy Associates)

Response: Customer value as a criterion is based on sound economic principles. In particular, the value test is a rigorously derived test of economic efficiency and is a much more complete criterion than any of the other standard practice tests. Some of the issues associated with evaluation criteria are discussed in Volume 2, Technical Document 4. TVA used the value test, along with many of the other tests commonly used in integrated resource planning as evaluation criteria in the planning process.

72

Comment: *I challenge TVA's viewpoint regarding stable rates. It is not the rate, it is the bill. Others have found that their customers are happy to pay higher rates as long as demand-side features lower their usage, resulting in a net stable monthly bill. For example, TVA should offer programs in which they help customers reduce their demand through efficient lighting, refrigerators, etc., in exchange for higher rates, with the result of a net stable bill.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Will Kidd (Sunsource Unlimited, Inc.), Michelle Neal (Tennessee Valley Energy Reform Coalition), Steven Walsh

Response: All Energy Vision 2020 strategies were evaluated using multiple evaluation criteria. Both the total resource cost criteria and the value test criteria take the customers' electricity bills into account. The advantages of demand-side efforts are apparent when using these evaluation criteria, and were considered when determining which strategies/resource options were included in TVA's Energy Vision 2020 long- and short-term plans. (See Volume 2, Technical Documents 2 and 4.)

ECONOMIC DEVELOPMENT

73

Comment: *Development of the region and employment of its residents are in TVA's best interest long term. TVA should encourage industry that provides a favorable balance between energy use and jobs provided.*

Comment by: Ann Lamb

Response: Because of the importance of the Tennessee Valley's economic development, not only has TVA set up an Economic Development Office, but economic development is one of the evaluation criteria being used in Energy Vision 2020. All the strategies were evaluated as to their economic development effects in terms of Valley employment and income as well as other criteria. All of the final strategies performed well on the basis of economic development.

74

Comment: *Investments in renewable energy would provide 2 to 10 times more jobs than Watts Bar Nuclear Plant at a fraction of the cost.*

Comment by: Peggy Snow, Jenny Willoghby

Response: Economic development is one of the criteria being used in Energy Vision 2020. All the strategies were evaluated as to their economic development effects in terms of Valley employment and income. This included other energy sources such as wind power and conservation. The key strategies from which the long-term plan is derived (all of which performed well in terms of economic development) all contain such energy sources. Watts Bar Nuclear Plant Unit 1 was considered part of the existing system in Energy Vision 2020.

To respond to this comment, however, estimates were made for average direct annual employment for Watts Bar Nuclear Plant Unit 1, a wind power option, and an average compilation of demand-side management options on a per 100-megawatt basis for purposes of comparison. These estimates are: 67 employees per 100 megawatts for Watts Bar Nuclear Plant Unit 1, 54 employees per 100 megawatts for a wind option, and 57 employees per 100 megawatts for demand-side management.

75

Comment: *Other than in one chart, employment of TVA residents is not discussed. Employment from renewables and energy conservation is not addressed.*

Comment by: Nancy Bell

Response: As part of the Energy Vision study, each strategy was analyzed as to its economic development effects as measured by both employment and income. Strategy options such as renewables and energy conservation were found to create jobs directly through the construction and operation of these energy sources or through program setup and operation. Additionally, employment was found to be indirectly generated as related payrolls and expenditures were spent in the Valley. The economic development effects due to electricity costs resulting from the strategies were also estimated. The key strategies from which the long-term plan is derived all performed well in terms of economic development and all contain renewables and energy conservation resources. Further descrip-

tion of the methodology and results of the economic development effect analysis is in Volume 2, Technical Document 2, Environmental Consequences, pages T2.14 to T2.16.

ENVIRONMENT

76

Comment: *The text states that the first objective is to "balance costs, rates, environment, debt, and economic development." We suggest that the term "environment" may be too general in this list of options to be balanced. Clearly, the primary objective is to balance costs, rates, debt, and the cost of economic development; the expression "environment," however, may include either or both financial expense and savings. In addition, it is desirable that the options preserve and protect the environment. To indicate these distinctions, TVA may wish to include the following: the expense of environmental compliance (this may include cost and possible savings which may be incurred through waste reduction and prevention technical assistance programs); prohibitive environmental regulations which may eliminate options; a quantification of ambient conditions and estimated environmental impact; and identification and risk evaluation of the population impacted.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Energy Vision 2020 takes into account all of the cited environmental elements. However, for simplicity, the term "environment" has been used. This has been clarified in the text.

77

Comment: *One of the goals of the plan should be clean air and clean water.*

Comment by: Patricia Chapman, Peggy Snow, Anne Redwine, Sheilla Cheyenne, Dara Chernicky, William Arney

Response: During the Energy Vision 2020 process, extensive effort has been devoted to analyzing numerous environmental impacts and other consequences of each strategy for meeting electricity needs for the future. Clean air, clean water, and other aspects of the environment were important considerations in determining TVA's proposed plan for the future. (See Volume 1, Chapter 9, Figure 9-23.)

78

Comment: *TVA's Energy Vision 2020 is a testament to the status quo. Rather, what is needed is a vision for healthy land, pure water, clean air, rich diversity, renewable energy, and energy conservation. This dream can be realized only by TVA making bold changes.*

Comment by: Myles Jakubowski (Sunbeam Household Products)

Response: During the Energy Vision 2020 process, extensive effort has been devoted to analyzing numerous environmental impacts and other consequences of each strategy for meeting electricity needs for the future. (See Volume 1, Chapter 9, pages 9.22 to 9.27.) TVA's proposed short- and long-term plans include both renewable resources and demand-side management. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

79

Comment: *What criteria and principles should we adopt about the nature and scope of problems we are willing to leave to our children? The National Hydro Association believes that we should leave only those problems to our future generations that are largely solvable and predictable, that do not threaten human health and safety, and that are not largely incompatible with a healthy and diverse environment over the long term.*

Comment by: Linda Church Ciocci (National Hydropower Association)

Response: TVA is committed to planning for the best ways to meet the future electricity needs of the Tennessee Valley. This means that the quality of life for future generations is an important consideration. Therefore, extensive effort has been devoted to analyzing numerous environmental impacts, economic impacts, and other consequences of possible strategies for meeting electricity needs for the future. Health and environment were important considerations in formulating the Energy Vision 2020 plan.

80

Comment: *I feel that TVA has pursued an unsustainable energy policy. The needs of our children should be taken account of in the plan. The planning horizon should be 500 to 1,000 years.*

Comment by: M. Nathan Perry, Jo Anne Clark, John Noel, John Schwarz, Jr., Rodney Webb, L. M. Johnson, Sr., Ruth Peeples, Barbara Soliday, Walter & Dorothy Stark, Howard Switzer (Sun/Earth Tempered Organic Architecture), Robert Peeples, Deborah Cuva, Peter Brinson, William Emmott, Mary Schwarz, Isahl Hemm, Stephen Stedman, C. T. Brewster, Sahara, C. Strain, Karen Lovell, Marion Zachiel, Katherine Osborn, N. E. Whitfield, Lynn Leach (Alabama Environmental Council), Alan Jones (Tennessee Environmental Council), Luther Gulick, A. B. Evans, Mary Anne Terry, Chris Gulick, Faith Young, Ann & Mike Sanders, Ben & Winn Welch, Jamie Pizzirusso, F. W. Munson, R. & G. Ludwig, Salo, M. Case, Karah Bates, Kathy Priore, Garry Shores, K. Varnum, Kim Grube, Hermann, Tohert, Dottie Hodges, Amy Perry, Ray Williams, Shirley Schaaf, John Harwood, Susana Harwood, Jean Cheney, Jennifer Lapidus & Hannah Bennett, Kirk Johnson, Myles Jakubowski (Sunbeam Household Products), Sheilla Cheyenne, Sanford McGee (Cumberland Center for Justice and Peace), Dennis Haldeman, John Johnson (Earth First), Jennifer Hurgeton, Karl Grotke

Response: Energy Vision 2020 identified a viable mix of conservation programs and options for power plant operations that will be used to responsibly and economically provide energy for sustainable economic growth. For all resource options, the environmental consequences and economic impacts were considered as part of TVA's effort to encourage sustainable economic growth in the region.

Energy Vision 2020 explicitly considered a number of criteria or measures related to sustainability. These included long- and short-term economic costs, environmental quality, economic development, and risk management (including fuel diversity). The changes or trends in these criteria over the planning period were all either favorable or were mitigated through the analytical method used for Energy Vision 2020 (multi-attribute trade-off analyses) in the formulation of strategies. The long-term plan (see Volume 1, Chapter 9, Figure 9-23) identifies several resource options that would help provide a more sustainable energy future. These resource options include an increased emphasis on energy efficiency on both the demand and supply side, increased use of natural gas, and more use of renewables such as wind, landfill methane, and biomass.

The uncertainty of a 500- to 1,000-year planning horizon is too large to address in Energy Vision 2020. However, Energy Vision 2020 provides the flexibility to adapt to an uncertain future in the next 25 years.

EQUITY

81

Comment: *Fairness in rates should be a major goal. TVA should establish a rate structure based on cost-of-service for each customer class.*

Comment by: John Sharp, Jr.

Response: TVA uses a cost-of-service-based method for developing its rate structure.

82

Comment: *The rate impacts of the various resource strategies were evaluated in relation to the total TVA system revenue requirements. The nature of the Energy Vision 2020 process and results did not facilitate consideration of impacts on TVA's wholesale rates or the distributors' retail rates on an individual customer classification basis.*

Comment by: Tennessee Valley Public Power Association

Response: Rate changes by class of service due to demand-side management options were considered in Energy Vision 2020. (See Volume 1, Chapter 9, page 9.18.)

FINANCIAL/DEBT

83

Comment: *TVA's problems such as those identified by the United States General Accounting Office—including the level of TVA's debt, the amount of debt that supports non-revenue producing assets, and the possible effects of increasing competition on TVA—should be addressed and not assumed away. The tone of Energy Vision 2020 is too positive.*

Comment by: Eric Hirst (Oak Ridge National Laboratory), Mary English (University of Tennessee), Bryan Deel, Sheilla Cheyenne, Alan Ball

Response: While we agree that continuing attention to TVA's debt will be required, we strongly disagree with the "crisis" tone of the United States General Accounting Office report as a whole and Chapter 5 in particular. TVA is a large corporation with more than $5.4 billion in annual revenues. Debt is a recognized necessity for large corporations, and TVA has consistently met very stringent bond tests and the debt service is recovered in revenues. However, recognizing that managing debt is important, TVA has, as a result of Energy Vision 2020 analyses, placed a limit on its debt that is expected to be $2 billion to $3 billion less than its statutory limit of $30 billion.

TVA's debt and resultant financing costs do not jeopardize its ability to meet competitive challenges from neighboring utilities. When TVA's debt is compared to the overall capitalization of neighboring investor-owned utilities, it is not out of line with its competitors in the utility industry. (See "The Ties that Bind: TVA in a Competitive Electric Market," Palmer Bellevue, April 1995.)

84

Comment: *With the level of debt being one of the major criteria for evaluating the various resource option strategies considered in Energy Vision 2020, both the legal debt ceiling of $30 billion and the internal debt limitation of $27 to $28 billion have significant implica-*

tions for the outcome of Energy Vision 2020. All the resource strategies project that the total debt will exceed both the legal limit and the internal limit placed on TVA during the study period.

Comment by: Tennessee Valley Public Power Association

Response: The seven key strategies which make up the long-term resource plan (see Volume 1, Chapter 9, Figure 9-23) have debt in 2001 well below the voluntary internal debt ceiling of $27 billion to $28 billion as shown in Volume 1, Chapter 9, Figure 9-4. Past the year 2001, the long-term resource plan includes recommendations for unique energy supply arrangements such as partnerships with investors supplying capital, as well as options to purchase power that have no effect on debt while providing the needed generating capacity.

85

Comment: *The United States General Accounting Office report notes that "because of TVA's high fixed costs and impending competition, we believe the federal government may be at risk for some portion of TVA's $26 billion debt." This is in addition to the $4.2 billion that TVA owes directly to the federal government. Clearly, TVA is an agency that needs to seriously consider its finances.*

Comment by: Beth Zilbert (Greenpeace)

Response: Given the significant differences in capital structure between investor-owned and publicly-owned utilities, it is surprising that the United States General Accounting Office neglects to make any financial comparisons between TVA and publicly-owned utilities. Such comparisons would show that TVA has more financial flexibility than most generation and transmission cooperatives and is reasonably on par with other publicly-owned utilities around the country.

While we agree that continuing attention to TVA's debt burden will be required, we strongly disagree with the "crisis" tone of the United States General Accounting Office report as a whole. TVA's debt is large in absolute terms. But it is also true that TVA is a large corporation, with more than $5.4 billion in annual revenues. Debt is a recognized necessity for large corporations, and TVA has consistently met its very stringent bond tests. However, recognizing that managing debt is important, TVA has, as a result of Energy Vision 2020 analyses, placed a limit on its debt that is expected to be $2 billion to $3 billion less than its statutory limit of $30 billion.

TVA's debt and resultant financing costs do not jeopardize its ability to meet competitive challenges from neighboring investor-owned utilities; it is not out of line with its competitors in the utility industry. TVA can finance capital projects only by issuing debt. Investor-owned utilities, in addition to issuing debt, raise approximately one-half of their capital through issuing stock.

RATES

86

Comment: *Industries within the TVA region must have competitive electric rates and reliable service to compete regionally and globally. The competitiveness of electric rates is a major factor when deciding to build new facilities, increase production at existing facilities, or*

close facilities. For large industries directly served by TVA, electric prices are the most important element of the plan.

Comment by: Ron Kapavik, Tennessee Valley Industrial Committee

Response: TVA agrees that electric rates are important and has evaluated all options/strategies for short-term to long-term effects on electric rates and for economic development effects.

87

Comment: *As one of TVA's largest consumers, we are very much interested in anything that will help hold down current and future power costs. I believe this is a key to future development in your service area.*

Comment by: R. D. Newman (Bowater Newsprint)

Response: TVA is also interested in holding down current and future power costs and offering rates for electricity that will enhance the development and quality of life in the Tennessee Valley. Therefore, each strategy for the future was evaluated for its impacts in several areas. Evaluation criteria included total costs, and short-term to long-term rates.

88

Comment: *With deregulation approaching, competitive electric prices may be the Valley's most important resource in preserving and attracting job-producing businesses.*

Comment by: Tennessee Valley Industrial Committee

Response: TVA agrees that electric rates are important for encouraging economic development; it has evaluated the effects of rates on economic development.

89

Comment: *Status quo on boundaries, barriers, and protective territory may be challenged soon. Customers may soon be able to make choices on power-buying decisions. TVA should keep in mind that low-cost provider and cost may take on new meanings. Take this into account in the plan.*

Comment by: Ron Kapavik

Response: TVA recognizes the important changes in the relationships between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a competitive marketplace. TVA is in the forefront of this change and welcomes the opportunity for growth and improved service and responsiveness to the needs of its current and new customers. TVA has taken steps to position itself for success in this new competitive environment. TVA's electric power production and operating costs are competitive with utilities in the regional market. The same is true for electric prices paid by consumers in the TVA service area.

Energy Vision 2020 will guide TVA in entering the emerging competitive marketplace and beyond by identifying the best energy resource choices for the current and future generation of consumers.

However, Energy Vision 2020 goes beyond simply providing competitively priced power. The plan also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches in meeting the demand for energy through new technologies and business arrangements

are the means by which TVA can achieve all of these goals: competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

Recommendations concerning barriers or boundaries inhibiting TVA in a competitive market are found in the Palmer Bellevue report. This study, "The Ties That Bind: TVA in a Competitive Electric Market," has concluded that the fence provisions should be changed in two phases. Phase 1 would allow TVA to conduct all conventional types of wholesale business with utilities bordering TVA and beyond. During Phase 1, TVA would not be allowed unbalanced access to traditional non-profit wholesale customers of neighboring utilities with which TVA's relationship has been severely restricted since 1959 and which cannot serve in the TVA territory under the TVA Act. Phase 2 would remove the fence entirely, giving TVA's current wholesale customers in the Valley free market access and, at the same time, permitting TVA to seek markets outside the Valley on the same basis that competitors could enter the Valley to provide service.

90

Comment: *Although retaining and expanding TVA's customer base through quality service at reasonable rates should remain a corporate goal, encouraging greater consumption per capita of electricity should not.*

Comment by: Sharon Fidler (League of Women Voters)

Response: TVA agrees that retaining and expanding TVA's customer base through quality service at reasonable rates should remain a corporate goal. One of TVA's goals is to be customer driven—to be recognized by our customers as the best and easiest corporation with which to do business, to anticipate the needs of our customers, and to continue to offer competitive prices.

In Energy Vision 2020, TVA has developed over 50 different customer service options (see Volume 1, Chapter 8). TVA has evaluated all customer service options for several criteria including: cost, electric rates, customer value, economic development, environmental quality, and financial factors such as debt (see Volume 1, Chapter 9). All customer service options, whether they increase or decrease consumption, that are recommended for implementation will either reduce cost or improve customer value (see Volume 1, Chapter 10, Figures 10-4 to 10-7).

91

Comment: *Keeping rates stable should not be the vision or goal of Energy Vision 2020.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: As stated in the Summary in Volume 1, the "purpose of Energy Vision 2020 is to identify, with extensive public involvement, long- and short-term actions TVA can take to provide flexible, competitive energy choices." As explained in this same section, TVA hopes to use its energy resource plan "to achieve its goals" of "competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources." Stability of rates is an important indicator that TVA is maintaining itself as the energy supplier of choice, and this certainly advances opportunities for economic growth by contributing to a more stable economic environment.

The recommendations in the long-tern plan and short-term action plan in Energy Vision 2020 are based on consideration of a number of evaluation criteria. These criteria include long-term costs, customer value, short- to long-term electric rates, environmental

quality, economic development, reliability, debt, and risk management. Many of these criteria were suggested to TVA by the public.

92

Comment: *After reviewing the TVA 25-year energy plan, it seems the cost of electricity for the 8 million people in a 7-state region will be enormous.*

Comment by: Olivia Lim (Southeast Center for Ecological Awareness)

Response: In developing Energy Vision 2020, all proposed strategies and resource options were evaluated using several criteria. This includes long-term cost, short- to long-term electric rates, debt, environmental quality, customer value, economic development, reliability, and resource flexibility. The long- and short-term plans in Energy Vision 2020 balance the various criteria listed above.

The projection of electric rates shown in Volume 1, Chapter 10, Figure 10-8 indicates that from 1996 to 2005, electric rates/cost will increase less than the rate of inflation (approximately 3.3 percent per year). In addition, rates over the long term from 2005 to 2020 show only moderate increases. Thus, the plan does not project an enormous increase in the cost of electricity.

RELIABILITY

93

Comment: *TVA generally plans generation reliability to a one-day-outage-in-ten-years criteria. This is common in the utility industry.*

Comment by: Tennessee Valley Public Power Association

Response: Yes, this is a standard criterion in generation planning. TVA establishes its reliability criteria based on balancing the cost of adding capacity that would reduce customer outages and the cost to customers of outages. The resulting reliability criteria is approximately the same as the one-day-outage-in-ten-years criteria.

94

Comment: *The most important criterion for the Tennessee Valley Public Power Association was reliability. Unserved energy was used as a measure of reliability for the strategies.*

Comment by: Tennessee Valley Public Power Association

Response: TVA agrees that reliability is a critical factor when planning to meet future energy needs. For this reason, capacity reserve margins of 13 percent were included in all strategies. The strategies were then evaluated to determine their economic, environmental, and other impacts. All strategies met this reliability criteria.

RISK

95

Comment: *Another TVA objective for Energy Vision 2020 is maintaining flexibility—an appropriate objective in today's utility environment. In resource planning, maintaining flexibility typically means deferring capital commitment as long as possible. In the prelim-*

inary results, TVA has shown that making the strategies more flexible improves their attractiveness under the evaluation criteria. As we enter the twenty-first century, this will be the key to success for both private and public entities.

Comment by: Tennessee Valley Public Power Association, R. D. Newman (Bowater Newsprint)

Response: An important aspect of selecting any strategy for the future is dealing with the uncertainty of a rapidly changing world. Therefore, TVA carefully evaluated each strategy for Energy Vision 2020 for its flexibility (the ability to modify actions quickly in response to future changes).

96

Comment: *Memphis Light, Gas and Water, through its experience in the gas industry, has learned that flexibility is achieved by making short-term commitments to supply alternatives. Robustness is achieved by identifying the lowest cost alternatives that satisfy a range of uncertainties. Success is determined by one's ability to correctly perceive the market and respond with the proper financial and operational tools at hand. TVA's challenge in the electric industry will be no different.*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: TVA agrees with this comment concerning the need for flexibility and robustness. The long-term plan in Energy Vision 2020 emphasizes both robustness and flexibility, using a portfolio approach. TVA's short-term action plan emphasizes the implementation of flexible internal and external options that will allow TVA to adapt to changing industry circumstances. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

THE PROCESS

This section includes comments and responses about:

- the overall Energy Vision 2020 process
- the public participation process used in Energy Vision 2020

General

97

Comment: *TVA should be commended for seeking to develop and implement a process that would be beneficial to TVA, to its stakeholders, and to the nation.*

Comment by: Tennessee Valley Industrial Committee, Michael Browder (Bristol Tennessee Electric System), Mary English (University of Tennessee)

Response: This is one of TVA's goals for the integrated resource planning process.

98

Comment: *TVA is commended for doing an integrated resource plan. It is long overdue.*

Comment by: Patrick Byington (Alabama Environmental Council), Arthur Smith

Response: Although TVA has for many years done resource energy planning, this is the first time that TVA has sought widespread public involvement at the planning stage itself.

99

Comment: *TVA is congratulated for a planning process, including extensive public participation, that shows TVA's genuine regard for any effects that its actions may have on the environment, the economy, and the TVA region.*

Comment by: William Bowker (Kentucky Coal Marketing and Export Council), Marjorie Raines

Response: Your comment has been reviewed and noted.

100

Comment: *The Tennessee Valley Energy Reform Coalition believes that least-cost—including the environmental cost—strategic planning, coupled with vision will provide the formula and methodology for the long-term economic and environmental health of our region and TVA. Energy Vision 2020 has great potential to rekindle a sense of pride and mission in the employees of and citizens served by TVA as it charts a 25-year course.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Energy Vision 2020 considers competitively priced power, economic development, and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches to meeting the demand for energy through new technologies and business arrangements are the means by which TVA can achieve all of

these goals: competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

101

Comment: *Energy Vision 2020 is being developed with many state-of-the-art processes.*

Comment by: Tennessee Valley Public Power Association

Response: Many constructive comments and references to the best practices in doing integrated resource planning were very helpful in the early stages of TVA's process. These suggestions came from a variety of sources identified in the discussion on Public Participation in Volume 1, Chapter 1.

102

Comment: *The TVA Retirees Association is a voluntary group representing the interests of TVA retirees. Our active membership includes over 7,000 TVA retirees, organized in 21 chapters throughout the Tennessee Valley and Florida. Members represent a wide range of talents and perspectives gained from their years of work at TVA. Although no longer in the active work force, we continue our close interest in the success of TVA's programs and planning.*

Based on their views, the Association has concluded that the 18-month study which resulted in the draft Energy Vision 2020 represents a thorough and comprehensive approach to integrated resource planning and environmental analysis. It is clearly based upon a solid foundation of top-quality professional work. It reflects a sincere effort to fairly consider difficult issues, such as the nuclear construction program and TVA debt, in the context of providing a reliable and low-cost power supply.

Comment by: TVA Retirees Association

Response: Your comment has been reviewed and noted.

103

Comment: *If there are large numbers of the draft documents on hand, they should not go to waste. TVA could look for opportunities to place them in the hands of college students studying industry and technology, ecology, environmental policy, technical writing, and the like.*

Comment by: Tom Forsythe

Response: Thank you for the suggestion. We will take it into consideration.

104

Comment: *The public should be informed about the significance of the plan and how it will affect them and their children.*

Comment by: TVA Retirees Association, John Johnson (Earth First)

Response: The purpose of TVA's integrated resource plan is to develop a portfolio of resource options to meet customer needs. Increasing competition, changing technologies, and environmental concerns were among the many issues considered when TVA developed its plan. The long-term and short-term plans have set forth a range of actions TVA can use to meet the future needs of its customers.

Energy Vision 2020 has provided significant opportunities for public participation. TVA sought to incorporate a broad base of public input into the scope of the planning process. During the scoping stage, before the draft was published, and again after the draft was published, a series of public meetings was held in cities around the Valley to collect public input. At these meetings, interactive computer-video displays were available that addressed key issues related to the development of Energy Vision 2020. TVA technical experts also attended every meeting to discuss issues, respond to questions, and help record people's comments. The draft resource plan was offered for public review and comment through October 15, 1995. (See the Public Participation section of Volume 1, Chapter 1.) Over 2,500 copies of the document were sent out to the public.

Public Participation

105

Comment: *TVA is commended for its public involvement efforts.*

Comment by: Tom Fitzgerald (Kentucky Resources Council, Inc.), Jason Gurley, Barbara Altizer (Virginia Coal Council), Jamie Pizzirusso, Catherine Murray (Sierra Club, State of Franklin Group), Alan Jones (Tennessee Environmental Council), David Bordenkircher, Carolyn Novkov, Barbara Soliday, Retha Ferrell, Philip & Winfred Thomforde, Bruce Wood, Martha McGill, Mary Byrd Davis (Ygdrasil Institute), Michelle Neal (Tennessee Valley Energy Reform Coalition)

Response: Your comment has been reviewed and noted.

106

Comment: *TVA has conducted a thorough and effective planning process, seeking information from a diverse pool of interests. This includes the Energy Vision 2020 Review Group.*

Comment by: Don Dills (Tennessee Department of Environment and Conservation), Tennessee Valley Industrial Committee, Tennessee Valley Public Power Association, William Pippin (Huntsville Utilities), TVA Retirees Association

Response: This is one of TVA's goals for the integrated resource planning process.

107

Comment: *The hard work and cooperative spirit during the year-long Energy Vision 2020 Review Group was appreciated.*

Comment by: Eric Hirst (Oak Ridge National Laboratory), Sharon Fidler (League of Women Voters)

Response: Your comment has been reviewed and noted.

108

Comment: *TVA is commended for allowing individuals with diverse viewpoints to participate in a detailed way on the Energy Vision 2020 Review Group.*

Comment by: Michael Browder (Bristol Tennessee Electric System), Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: The plan is strengthened by diverse input.

109

Comment: *TVA provided an open forum and placed all information, assumptions, and data before the Energy Vision 2020 Review Group. It allowed the Energy Vision 2020 Review Group to hire independent consultants to provide opinions on load forecasting, the nuclear program, and resource integration. As a result of this, TVA changed its medium peak load forecast from 2.5 to 2.2 percent. The long-range forecast went from 2.0 to 1.9 percent.*

Comment by: William Pippin (Huntsville Utilities)

Response: The Energy Vision 2020 Review Group provided valuable input for the Energy Vision 2020 process.

110

Comment: *The TVA staff involved in Energy Vision 2020 are commended for their hard work and spirit of cooperation. TVA shared its data and rationale for the actions under consideration.*

Comment by: Sheila Holbrook-White (Sierra Club, Alabama Chapter), Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

111

Comment: *TVA listened to the Energy Vision 2020 Review Group's diverse plans of interests and suggestions and incorporated viewpoints into the overall plan.*

Comment by: William Pippin (Huntsville Utilities)

Response: In an effort to produce the best possible plan, TVA purposefully sought diverse viewpoints.

112

Comment: *Many on the Energy Vision 2020 Review Group have concerns about TVA's nuclear program and based on cost data, it became clearly evident that continuation of Bellefonte Nuclear Plant, Watts Bar Nuclear Plant Unit 2 and Browns Ferry Nuclear Plant Unit 1 would be very costly. The review panel could only conclude that it would not be wise to finish these units. It is very important to witness TVA in action. When the Board saw these figures themselves they announced that these units would not be completed.*

Comment by: William Pippin (Huntsville Utilities)

Response: TVA and its Board of Directors are concerned about and focused on TVA's financial viability, the size of its debt, and the ability of its generating resources to compete in the future. The TVA Board decided that TVA should not by itself complete Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2 or return Browns Ferry Nuclear Plant Unit 1 to service in light of the economic analyses that were produced during the Energy Vision 2020 process. (See Volume 2, Technical Document 8.)

113

Comment: *TVA should have challenged the Energy Vision 2020 Review Group to build consensus. TVA was more interested in hearing diverse opinions so that the Energy Vision 2020 Review Group would not give recommendations.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: It is true that the regularly held meetings between TVA staff and Energy Vision 2020 Review Group were used to learn from each other, as well as from outside experts, in all areas of the Energy Vision 2020 process. In an effort to produce the best possible plan, TVA purposefully sought diverse viewpoints. The input of Energy Vision 2020 Review Group members was seriously considered in every phase of the process in order to develop a long-range energy plan for a diverse constituency.

114

Comment: *You should listen to your elders, rather than arrest grandmothers.*

Comment by: Jennifer Hurgeton

Response: TVA encourages those interested in TVA's activities to make their views known. This has been especially true for Energy Vision 2020 where TVA's public participation effort has been wide-ranging and comprehensive.

115

Comment: *TVA should listen to its customers.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition), Hollis Fenn

Response: TVA makes a concerted effort to obtain the input of stakeholders and customers. The process used for Energy Vision 2020 exemplifies this. (See the Public Participation section of Volume 1, Chapter 1.)

116

Comment: *Citizens' comments should be taken seriously and interjected in the final plan.*

Comment by: Sheilla Cheyenne, Stephen Smith (Tennessee Valley Energy Reform Coalition), Jamie Pizzirusso, Michelle Neal (Tennessee Valley Energy Reform Coalition), Catherine Murray (Sierra Club, State of Franklin Group), Jonathan Scherch, Scott Banbury

Response: TVA has taken seriously all substantive public comments. Summaries of all oral and written comments TVA received on the draft Energy Vision 2020 have been included in the final document. When appropriate, changes to TVA's energy resource plan have been made in response to comments. We have not necessarily changed TVA's preferred strategy or its components in ways that every commenter has requested, but this does not mean that a particular commenter's position was not seriously considered.

117

Comment: *TVA should not treat the public as an antagonist, but as possible sources of resolution for its difficulties.*

Comment by: John Johnson (Earth First), Elizabeth Garber

Response: TVA greatly values public input. In developing Energy Vision 2020, TVA gathered comments from a series of public meetings, opinion leader interviews, and the Energy Vision 2020 Review Group. These comments provided the basis for the issues and criteria considered in the plan. After releasing the draft plan, TVA obtained additional comments from the public and the Energy Vision 2020 Review Group. These comments have been used as appropriate to further modify the plan. All comments are addressed in this volume.

118

Comment: *The only reason TVA is having a public process is because it is required to do so by law and it does not really care what its ratepayers think.*

Comment by: Leith Patton

Response: It is true that the National Environmental Policy Act requires that there be opportunities for public review and comment of proposed major federal actions for which environmental impact statements are required. However, TVA went well beyond the minimum requirements of the National Environmental Policy Act. For example, TVA decided to hold 12 scoping meetings and 9 hearings at various locations throughout the TVA region to ensure that the public had ample opportunities to learn about Energy Vision 2020 and to provide input. TVA also met with various stakeholder representatives for monthly meetings throughout the process (the Energy Vision 2020 Review Group). Finally, TVA provided 81 days for public comment on the draft document; applicable National Environmental Policy Act procedures require only a 45-day comment period.

119

Comment: *We understand that this public review process is just for show to make us feel as if we are being listened to.*

Comment by: Sheilla Cheyenne, Ann Harris, Beth Zilbert (Greenpeace)

Response: In general, the comments that TVA has received about the public participation process used in Energy Vision 2020 have commended TVA for the efforts it made to obtain public input. Public input was very critical to the formulation of evaluation criteria that were used to assess energy resource options and strategies. Public input also played an important role in the development of actual resource strategies.

120

Comment: *My earlier comments from the last round have not been addressed in the draft. I am nervous that they are not going to be addressed this time.*

Comment by: John van der Harst

Response: All comments received during the scoping phase of Energy Vision 2020 were carefully considered in determining the scope and formulating the process to develop TVA's plan for the future. This process resulted in a draft plan. You will find responses in this volume to each of the concerns you expressed in your comments on the draft Energy Vision 2020.

121

Comment: *Describe how the comments from the public meetings will be reviewed and handled in the agency; how will we know what the public supports?*

Comment by: Ann Harris, Monique Mollet, Rowland Huddleston

Response: The comment evaluation process is explained in the introduction to this volume.

122

Comment: *The TVA Least-Cost Planning Program, as outlined in the Energy Policy Act of 1992, calls for participation by TVA distributors. Memphis Light, Gas and Water believes that TVA did not adequately include distributors in the analysis of contract reform, rate structure incentives, distributor cost of capital, and demand-side management programs.*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: TVA provided distributors of TVA power a number of opportunities to participate in Energy Vision 2020, in full compliance with the requirements of the 1992 Energy Policy Act. TVA Energy Vision 2020 staff met with representatives of all distributors of TVA power, including Memphis Light, Gas and Water, to encourage and facilitate their input into the Energy Vision 2020 process. TVA provided the Tennessee Valley Public Power Association, which is an association representing TVA distributors, substantial financial assistance in order that they could retain independent expertise to review and comment on TVA's energy resource planning activities. Four distributors were designated by the Tennessee Valley Public Power Association to represent distributors on the Energy Vision 2020 Review Group. In addition, TVA Energy Vision 2020 staff met on a number of occasions with the Tennessee Valley Public Power Association Power Supply Committee whose responsibility it was to review the Energy Vision 2020 process. The Tennessee Valley Public Power Association and other distributors, who commented on Energy Vision 2020, generally expressed satisfaction with the opportunities TVA provided them for participation and the efforts TVA made to obtain their input.

123

Comment: *The opportunity for the Tennessee Valley Public Power Association to be directly involved in TVA's long-range planning process has been an enlightening experience. Four Tennessee Valley Public Power Association representatives had the opportunity to participate and comment for the Tennessee Valley Public Power Association through membership on the Energy Vision 2020 Review Group. Additionally, the 28 Tennessee Valley Public Power Association system managers who comprise the Tennessee Valley Public Power Association Power Supply Planning Committee, with consulting assistance, reviewed in-depth all the topics covered in the Energy Vision 2020 study.*

The opportunity to directly participate in this planning review process has been extremely helpful to the Tennessee Valley Public Power Association in assessing the long-term power supply options and range of potential effects on rates, reliability, debt, and various other measures of interest to power distribution systems and their customers.

Comment by: Tennessee Valley Public Power Association

Response: The input of customers in the Energy Vision 2020 process was an important part of the process.

124

Comment: *Staff willingness to work with the Tennessee Valley Public Power Association consultants in testing additional scenarios helped us reach separate but similar conclusions on the preferred plans for TVA to retain in its portfolio. Incidentally, several scenarios that Tennessee Valley Public Power Association members thought would score well did not turn out that way.*

Comment by: Tennessee Valley Public Power Association

Response: Thank you for your comments on the cooperation between TVA and the Tennessee Valley Public Power Association's consultants. It is an important form of validation when two groups can come to similar results when using different scenarios.

125

Comment: *I would like to see two public opinion surveys: one on the start-up of Watts Bar Nuclear Plant and one on photovoltaic pioneering programs.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition)

Response: TVA has no plans to conduct public opinion surveys at this time.

126

Comment: *The State of Tennessee will monitor implementation of the plan. We would like to be involved in future phases of decision-making as you determine which options would be most beneficial for the Tennessee economy, and its cultural and environmental prosperity.*

Comment by: Don Dills (Tennessee Department of Environment and Conservation)

Response: We look forward to cooperating with the State of Tennessee in TVA's future activities.

127

Comment: *TVA should establish a mechanism for regular public participation in its energy resource decision-making. For example, TVA needs to meet regularly with a knowledgeable group of people.*

Comment by: John Johnson (Earth First), Olivia Lim (Southeast Center for Ecological Awareness), Susan Bailey, Debra Jackson, Clark Buchner (Sierra Club, Tennessee Chapter), Hester Cope (Alabama Environmental Council)

Response: There are a number of existing processes for involvement in TVA decision-making, including its energy resource decision-making. For example, the meetings of TVA's Board of Directors are open to the public, and members of the public can address the Board on matters that interest them. Prior to making decisions to select new major energy resource options, TVA provides the public opportunities to be involved in the context of its environmental reviews under the National Environmental Policy Act. As appropriate, TVA seeks out the views of knowledgeable people as it did for Energy Vision 2020.

128

Comment: *My library has no copy of your Energy Vision 2020 report and I do not know if it pertains to organizational structure and advice on how to run your business, or precludes everything.*

Specifically, I wish to know if ordinary citizens like myself may send inventive ideas and solutions for your consideration and development. If so, to whom would they be addressed?

Comment by: William Shadden

Response: You can provide your comments by calling any one of the TVA Customer Service Centers listed below:

Chattanooga, TN	423-697-4220	Mayfield, KY Office	502-247-2442
Cleveland, TN	423-472-3355	Bowling Green, KY	502-781-7653
Columbia, TN	615-380-8000	Memphis, TN	901-756-3500
Huntsville, AL	205-534-8434	Murfreesboro, TN	615-893-8161
Jackson, TN	901-423-5100	Muscle Shoals, AL	205-386-2025
Johnson City, TN	423-434-8700	Nashville, TN	615-231-7245
Kentucky	502-782-6559	Tupelo, MS	601-891-4450
Knoxville, TN	423-673-2200	Starkville, MS	601-338-3160

We will make every effort to ensure that the final version of Energy Vision 2020 will be at your local library, and we will send you a copy.

129

Comment: *Please include my resume and miscellaneous information attached to my resume as appendices in the final Energy Vision 2020.*

Comment by: Daniel Axelrod

Response: The submittal is not appropriate as appendices to the final document.

130

Comment: *TVA's 25-year energy plan affects us all.*

Comment by: Patricia Chapman, Linda Church Ciocci (National Hydropower Association), Olivia Lim (Southeast Center for Ecological Awareness)

Response: It is because of the importance of Energy Vision 2020 that TVA sought widespread public input and provided many more opportunities for this than the minimum specified by law.

131

Comment: *I appreciate TVA allowing people to either speak in a lecture hall or a small room on tape since I do not have much time.*

Comment by: Susan Jata

Response: You are welcome.

132

Comment: *The decision-makers of TVA should be at the public meetings.*

Comment by: Tom Phillips, Beth Zilbert (Greenpeace), Retha Ferrell

Response: Senior TVA management attended every public meeting to serve as hearing officers and listen to commenters. Management representatives included:

- Dwight Nunn, Vice President Nuclear
- Bill Museler, Senior Vice President Transmission/Power Supply
- Glenn Parrish, Vice President Customer Group
- Jimmy Cross, Vice President System Planning
- Henry Martinez, Vice President Hydro Operations
- Terry Kemp, Customer Service Center Manager
- Don Dickerson, Customer Service Center Manager
- Myron Callahan, Customer Service Center Manager
- Ron Williams, Acting Vice President, Environmental Research Center.

The TVA Board of Directors will be provided the final Energy Vision 2020 document, which will include this public comment and response volume. The Board will consider the final document, its recommendations, and the public comments for at least a 30-day period before making a final decision.

133

Comment: *TVA employees should be at the public meetings to hear the public's views rather than what they are being fed at TVA.*

Comment by: Retha Ferrell

Response: A number of TVA employees with technical expertise relevant to the Energy Vision 2020 process were present at every public meeting to respond to public questions and hear their concerns. All TVA employees received notice of scheduled public meetings and could have attended those meetings if they desired. A number of employees in fact did so and also provided their own comments on Energy Vision 2020.

134

Comment: *TVA did not adequately advertise the public meetings.*

Comment by: Carolyn Novkov, Retha Ferrell, Dianna Young

Response: The Energy Vision 2020 public meetings on the draft document were widely advertised. Press notices containing the meeting schedules were released in August prior to the first meeting, notices of the meetings were placed in 50 local newspapers, and approximately 150 public service announcements about the meetings were made. A substantial number of newspapers carried stories about the meetings, and various TVA employees were interviewed by the press about the meetings and Energy Vision 2020 prior to each meeting. In addition, over 2,000 copies of the meeting schedules were directly mailed to interested members of the public along with copies of the draft document. Notice of the meetings was also provided in "TVA Today," and TVA employees received notice of the meetings.

135

Comment: *There were too many people at the Nashville hearing for the time allotted for comment.*

Comment by: John van der Harst

Response: The Nashville hearing was extended by an hour and a half to allow time for all commenters. Also, there was a separate room for tape-recorded comments for individuals whose time was constrained. In addition, almost a month was available after the hearing in which to submit written comments.

136

Comment: *I attended the Chattanooga public hearing and there were no accommodations for the handicapped.*

Comment by: Ann Harris

Response: There was a ramp next to the front stairs at the Chattanooga public meeting. Needs of the handicapped were a consideration at all the meetings. The advertisements gave a TDD number for the hearing impaired to request an interpreter, and all meeting rooms were wheelchair accessible.

EXISTING SYSTEM

This section includes comments and responses about:
- TVA's debt
- TVA's existing electric rate structure and its effect on energy use
- the operation of TVA's existing generating units, including its coal-fired, hydroelectric, and nuclear units
- the merits and economics of Watts Bar Nuclear Plant Unit 1, and other issues (assumptions, safety and health) related to start-up and operation of Watts Bar Nuclear Plant Unit 1 and restart of Browns Ferry Nuclear Plant Unit 3

This section includes a comprehensive response for a number of comments about the economics of operating Watts Bar Nuclear Plant Unit 1.

General

137

Comment: *TVA has several improvements planned for the transmission system. The projects are needed primarily due to load flow issues. No voltage stability problems were identified on the bulk system.*

Comment by: Tennessee Valley Public Power Association

Response: Generator unit stability is a concern in TVA, but voltage stability is not known to be a problem in this area.

138

Comment: *TVA has financial and environmental problems.*

Comment by: Debra Jackson

Response: TVA recognizes the importance of financial health and environmental stewardship. For this reason, both the financial situation and environmental impacts are used as criteria to evaluate all strategies considered in Energy Vision 2020.

Financial/Debt

139

Comment: *As businesses looking at TVA's worth and value to the Valley and to the nation, we do not view TVA's debt as unmanageable.*

Comment by: Tennessee Valley Industrial Committee

Response: We agree. TVA has an aggressive debt management program. Since 1989, it has refinanced high-interest debt to accomplish annual interest savings of $317 million. By

1998, TVA expects to generate all of its capital funds internally, thus, eliminating the need to borrow new debt.

140

Comment: *TVA has taken a big step by voluntarily capping its debt at $28 billion. It would be more believable if this was a legal requirement.*

Comment by: Powell & Sharon Foster, Jamie Pizzirusso, Hamp Dobbins, Jr., Alan Jones (Tennessee Environmental Council), Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA is committed to not exceeding its voluntary cap of $2 to $3 billion below its statutorily mandated $30 billion cap.

141

Comment: *In light of its bad financial straits, TVA's selling bonds seems like fraud.*

Comment by: James Riccio (Public Citizens Critical Mass Energy Project)

Response: Since 1988, TVA has taken significant actions to improve its financial position—notably by reducing the work force by half and cutting expenses throughout the corporation by $800 million. TVA generates more than sufficient cash to fund its ongoing operations and to service its debt.

TVA, like many industrial companies, borrows to finance growth. Once it completes its major capital program to expand capacity in the first quarter of 1996, TVA's need for capital will decrease significantly, which will continue to improve its competitive position within the region.

TVA has consistently met its very stringent bond tests and continues to carry the highest possible debt rating from rating agencies.

142

Comment: *Who would invest in TVA in light of its deplorable debt?*

Comment by: Bruce Wood

Response: The amount of debt a company has is not as important as its ability to repay its debt. TVA has over $33 billion in assets along with sufficient revenue to meet all of its debt obligations. TVA expects to be able to continue to manage its debt.

143

Comment: *In noting the financial strength of TVA, the following statement is made: "TVA's power program is self-supporting with revenues from power sales." Does TVA also have "non-power programs" which are factored into projections? (See Executive Summary, page 3.)*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Energy Vision 2020 considers TVA's power program since integrated resource plans generally address the types of resources necessary to meet electricity or energy needs. Therefore, TVA's non-power program, which receives funds through congressional appropriations, is not factored into projections.

144

Comment: *TVA has misled the ratepayers in the past by not including $14 billion in the rate base. How many other costs has TVA left off?*

Comment by: Ann Harris

Response: All of TVA's financial information is properly disclosed in its financial statements as certified by Coopers and Lybrand L.L.P. This is an independent accounting firm.

145

Comment: *According to the United States General Accounting Office, 69 percent of TVA's $27 billion debt is due to its nuclear program, which produces only 14 percent of TVA's power.*

Comment by: Bryan Deel, Andy Fazio, Susan Switzer, Jenny Willoghby, Richard Simmers, Beth Zilbert (Greenpeace)

Response: The nuclear program has contributed to TVA's debt. However, the completion of the remaining large nuclear capital construction projects and the addition of other non-nuclear resources to the TVA system should reduce the nuclear program's contribution to any future debt. By 1997, nuclear generation is expected to be 20 percent of TVA's total generation. TVA is committed to keeping its debt below the statutorily-mandated $30 billion cap.

146

Comment: *According to my calculations, TVA has accrued $3,000 of debt for every person in the TVA region.*

Comment by: Kirk Johnson

Response: TVA can only issue debt to provide capital for its power program and to refund existing indebtedness. TVA provides electric power for the residents in the 7-state TVA region. TVA's customers have among the lowest residential rates in the United States.

147

Comment: *Approximately 30 percent of my bill goes to pay interest on TVA's $26 billion debt.*

Comment by: Jean Cheney

Response: While it is true that approximately 30 percent of TVA's expenses is for debt service, TVA has undergone an aggressive debt refinancing program since 1989 which has resulted in annual interest savings over $317 million. TVA's customers have among the lowest residential rates in the United States, and TVA has not had a rate increase in nine years.

148

Comment: *Since TVA's focus has become profits, the debt has increased.*

Comment by: Paul Elliott

Response: TVA's debt has increased as its business has grown. TVA's focus is on providing electric power to the residents and businesses in the seven state Tennessee Valley region. TVA's rates are among the lowest in the nation and have remained stable for nine years. This low-cost electric power has contributed to attracting new businesses to the region.

149

Comment: *Allowance for funds used during construction (AFUDC), or interest expense capitalized as part of the cost of construction, has been recognized by TVA in its financial statements. AFUDC transfers a portion of the interest costs from current period expenses on the income statement to the assets on the balance sheet. This decreases the amount of interest cost recovered in current revenues and spreads that recovery through depreciation over the life of the assets.*

The exception to this is that TVA has not recognized AFUDC on new nuclear construction for several years. AFUDC is still recorded on all plant additions and improvements, including those related to nuclear facilities. Since no current interest cost has been capitalized on the investment in the new nuclear facilities which were included in construction work-in-progress or on the investment in those nuclear units which were deferred, the carrying cost (interest on investment) of these plant investments has been recovered from the current ratepayers. If AFUDC had continued to be recorded on the nuclear facilities, it would have caused the costs of the nuclear facilities to be much higher but the current revenue requirement would have been substantially lower. This approach has provided TVA with more timely recovery of these financing costs than it would have received if the AFUDC was recognized. Since this has had the effect of raising the current revenue requirement and lowering the amount of rate increase required when the nuclear units are placed in service, the non-recognition of AFUDC on these facilities has had somewhat of a rate stabilization effect.

Comment by: Tennessee Valley Public Power Association

Response: The discontinuance of AFUDC on substantially complete and deferred nuclear units has the effect of lowering revenue needed to produce desired operating margins.

150

Comment: *To be credible TVA should be honest as in accounting for expenditures.*

Comment by: Elizabeth Garber, John Sharp, Jr.

Response: We agree. TVA uses standard accounting practices.

Rates

151

Comment: *In 1994, TVA's average revenue rate per kilowatt-hour was 4.22 cents. Compared to other major utilities in the southeastern quadrant of the country, TVA's average rates are at the lower end of the spectrum, which ranges from approximately 4.0 cents per kilowatt-hour to about 8.5 cents per kilowatt-hour.*

Comment by: Tennessee Valley Public Power Association

Response: We agree that TVA rates are very competitive.

152

Comment: *We commend TVA for holding rates constant.*

Comment by: Bill O'Brien (B. F. Goodrich)

Response: Your comment has been reviewed and noted.

153

Comment: *One of the more significant issues that could cause TVA's rates to rise in the future is its level of debt service requirements. TVA has stated that it plans to limit further growth in the amount of its outstanding debt. TVA's ability to hold level or reduce its outstanding debt is contingent on the extent of its capital expenditures programs. If the level of these expenditures drops substantially after the nuclear program is completed, TVA would then be able to use internally generated funds to reduce the debt and, potentially, have the flexibility to decrease its rates. However, if extensive future investments in new or replacement facilities are planned or come up unexpectedly, this may prevent TVA from having that flexibility to adjust its rates downward.*

Comment by: Tennessee Valley Public Power Association

Response: TVA, like many industrial companies, borrows to finance growth. Once it completes its major capital program to expand capacity in the first quarter of 1996, TVA's need for capital will decrease significantly. The level of capital spending is scheduled to be reduced by $1 billion through fiscal year 1997. This enables TVA to, in the near term, cap its debt at the self-imposed limit of $2 to $3 billion below the $30 billion allowed by Congress and, ultimately, to reduce its debt, thereby continuing to improve its competitive position within the region.

154

Comment: *TVA's existing rate structure includes a demand charge that is high for peak usage that encourages demand-side management.*

Comment by: Michael Browder (Bristol Tennessee Electric System)

Response: It is true that as demand charges increase, consumers are encouraged to reduce demand.

155

Comment: *Residential ratepayers are subsidizing big business and industries. I do not understand that.*

Comment by: Michelle Carratu, Bruce Wood

Response: Residential ratepayers do not subsidize big business or industry. TVA employs a cost-of-service concept and its rates are based on the cost of providing service to each customer class.

156

Comment: *TVA's rates are artificially low because the federal government pays some of their bills.*

Comment by: Lynn Leach (Alabama Environmental Council)

Response: The TVA power program is totally self-financing and receives no appropriated (taxpayer) monies. The power program operates on funds collected from electricity users. The appropriations TVA receives fund other programs such as the management of TVA's reservoir system and the watershed water quality protection activities.

157

Comment: *TVA's Economy Surplus Power rate is interruptible and this reduces the capacity TVA would need during peak periods such as in July. People buying this power were interrupted.*

Comment by: Michael Browder (Bristol Tennessee Electric System)

Response: Your comment has been reviewed and noted.

158

Comment: *TVA should eliminate the rate breaks for industries that have agreed to allow service to be interrupted. TVA has not exercised its right to interrupt for years. These special rates mean increased rates for others who must make up the revenue difference.*

Comment by: John Sharp, Jr.

Response: TVA has several different types of interruptible power available to industrial customers. Many of these industrial customers agreed to use interruptible power for a portion of their requirements in lieu of installing their own generation facilities or moving the production to another location outside the TVA service area. By allowing these customers to use interruptible power, TVA has retained a portion of the firm load that would have been lost and has also gained an important demand-side management tool. Over the years TVA has in fact exercised its right to interrupt power to these customers. The interruptions have been on both a voluntary and mandatory basis. This type of demand-side management tool benefits all TVA power consumers.

Generating Resources

FOSSIL AND HYDROELECTRIC

159

Comment: *Energy Vision 2020 properly places great emphasis on TVA's existing coal-fired generating plants in both the short-term and long-term plans. Along with the nuclear units (including Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3), they will continue to be the backbone of TVA's power system. By the year 2020, the coal-fired units, which make up over 50 percent of today's capacity, will be approaching 70 years old. This is about twice the service life expected when the units were planned and built.*

Formal life extension or modernization programs have been in place for many of the units for a number of years. Routine rehabilitation of major unit components has been a part of the operation and maintenance program for the last 30 years. The technology to secure the expected improvement in plant efficiency and reliability that the plan projects is readily available and achievable for the short-term 10-year period. Additionally, there

is no reason to believe that given good maintenance practices, the great majority of the coal-fired plants cannot continue to operate through the Energy Vision 2020 period.

Comment by: TVA Retirees Association

Response: Your comment has been reviewed and noted.

160

Comment: *Modern high-tech coal-fired plants are meeting clean air standards, operating with zero discharge levels for water, and recycling combustion byproducts—all of this by producing electricity for low cost to the consumer.*

Comment by: Barbara Altizer (Virginia Coal Council)

Response: TVA agrees that modern coal-fired plants, with their associated pollution control equipment and designs, produce much less pollution than older plants. The coal-fired plants included as supply-side options for the Energy Vision 2020 analyses assume the use of Best Available Control Technology (BACT) for emissions from the facilities.

161

Comment: *TVA should be congratulated for its clean coal technology improvements.*

Comment by: James Gillum (Tennessee River Valley Association)

Response: Your comment has been reviewed and noted.

162

Comment: *I do not expect the fossil units now in service to provide another 25 years of efficient service.*

Comment by: Whiting Delk

Response: TVA has a program to replace or refurbish major unit components at its fossil units as well as the auxiliary equipment where assessments show a need and benefit. With this dedication to the maintenance of the units, the units are expected to continue to be a viable source of electricity for at least another 25 years. Energy Vision 2020 takes this into account. (For information on TVA's existing power system, see Volume 1, Chapter 4.)

163

Comment: *The out-of-state corporations from whom TVA buys coal are failing to declare this for purposes of state franchise revenue purposes. TVA should guarantee proper state tax enforcement.*

Comment by: Charles Sanford (Sanford & Associates)

Response: State tax enforcement is not a TVA responsibility. TVA requires and expects its contractors to comply with all applicable laws.

164

Comment: *Hydroelectric power is reliable, efficient, and low cost. TVA's 29 existing conventional hydro projects and the Raccoon Mountain pumped-storage project have helped provide a solid economic foundation throughout the Tennessee Valley for decades.*

TVA's hydro projects contribute to the quality of life in the Tennessee Valley beyond the traditional electricity benefits. Hydro project reservoirs and associated lands provide many opportunities for families and recreationists with a wide variety of interests, including fishing, boating, camping, hiking, picnic areas, and sports playing fields. Reservoirs also may supply community drinking water and irrigation needs. Hydro development creates opportunities to enhance fish and wildlife habitat, promote scientific understanding of aquatic life, and reduce water pollution. By controlling water levels, many hydropower facilities also control seasonal flooding or facilitate the navigation of ships and barges that transport products and agricultural goods.

Comment by: Linda Church Ciocci (National Hydropower Association)

Response: TVA considers the resources provided by the Tennessee River system to be one of the cornerstones for the prosperity of the Tennessee Valley.

165

Comment: *Reconsider deep drawdowns to TVA lakes, since this results in sedimentation, decreased recreation values, and damage to the flora and fauna. Any losses in revenue involved in this procedural change could be offset by modernizing the hydro plants to increase their efficiency.*

Comment by: Powell & Sharon Foster

Response: In the late 1980s, TVA evaluated the potential financial and environmental impacts of altering TVA's reservoir management policies. This evaluation culminated in a Final Environmental Impact Statement, "Tennessee River and Reservoir System Operation and Planning Review," that was released to the public in December 1990. Based on this evaluation, TVA decided to maintain higher lake levels on its tributary (headwater) reservoirs for a longer period in the summer months, but to continue with normal winter drawdowns. Maintaining higher lake levels for even longer periods of time was determined to be financially or environmentally unacceptable. TVA has not proposed to re-evaluate reservoir levels as part of its Energy Vision 2020 integrated resource planning process. It has, however, evaluated the merits of continuing the modernization of hydroelectric plants, and this is one of the energy resource options identified in the short-term action plan.

166

Comment: *The hydro plants are undermaintained and are disasters waiting to happen.*

Comment by: Stan Gloeckner (Sierra Club)

Response: TVA's Dam Safety Program, which includes regularly scheduled rigorous inspections, was audited by the United States Office of Management and Budget in 1987. The program was recognized as one of the best among federal programs and one which should be a model for other agencies. All of TVA's dams have been assessed against today's seismic, hydrologic, and structural standards. Several require upgrades to handle

the probable maximum flood. These upgrades will be completed in the next four years. The hydro power plants have continuously been the most reliable units in the TVA system. The current hydro modernization program is designed to increase capacity and efficiency, and to ensure continual exceptional reliability for the next 50 years.

167

Comment: *A study revealed that TVA has the highest operating costs compared to other utilities for hydro operations. TVA believes that by remotely controlling all of its plants, the operating and maintenance costs should be reduced to be more in line with other utility hydro operations.*

Comment by: Tennessee Valley Public Power Association

Response: The comment is correct in its observations about TVA's previous operating costs for its hydro facilities. These costs are being reduced.

NUCLEAR

168

Comment: *TVA is assuming that steam generator replacements at Sequoyah Nuclear Plant Units 1 and 2 and at Watts Bar Nuclear Plant Units 1 and 2 will cost $150 million per unit. It does not give a basis for this number, which is generally consistent with recent industry experience.*

Comment by: Tennessee Valley Public Power Association

Response: The basis for the cost of $150 million per unit is recent industry replacement costs at domestic plants. North Anna Nuclear Plant Unit 1 completed steam generator replacement in 1993 for a cost of $125 million. This replacement was for three steam generators; Sequoyah and Watts Bar Nuclear Plants have four steam generators each.

169

Comment: *It is not clear that TVA has done all that might be done to minimize the potential for future impacts of generic equipment problems at its nuclear plants. The failure to install hydrogen water chemistry (to reduce the potential for stress corrosion cracking of reactor vessel internals) at Browns Ferry Nuclear Plant is one example. Also, it appears that TVA has not done all that could be done to prevent problems with low-pressure turbine rotors or generator rotors and stators. This is of particular concern given how much money has been spent on additions and improvements at Browns Ferry Nuclear Plant and Sequoyah Nuclear Plant.*

Comment by: Tennessee Valley Public Power Association

Response: TVA is currently evaluating the feasibility of installing hydrogen water chemistry at Browns Ferry Nuclear Plant.

TVA performs all required inspections and necessary repairs on low-pressure turbine rotors or generator rotors and stators, and does not have a history of major problems with this equipment. Three spare turbine rotors are maintained at each site to support the Browns Ferry and Sequoyah nuclear operating units. With regard to the generators,

TVA has been proactive in upgrading its Sequoyah Nuclear Plant generators, including replacement of the Sequoyah Nuclear Plant Unit 1 stator winding, replacement of all generator rotor retaining rings, and installation of upgraded winding modules for Sequoyah Nuclear Plant Unit 2. In addition, the Browns Ferry Nuclear Plant Unit 2 generator was tested and defective stator bars were replaced.

170

Comment: *There is a crack in the reactor pressure vessel head at Weld W-09-10 at Sequoyah Nuclear Plant Unit 1.*

Comment by: Jeannine Honicker

Response: The preservice ultrasonic examination of the Sequoyah Nuclear Plant Unit 1 reactor closure head revealed a flaw in weld W-09-10. The flaw exceeded the acceptance tables and required acceptance by analytical evaluation as allowed by the American Society of Mechanical Engineers Boiler and Pressure Vessel code. The flaw was classified as a subsurface (mid-wall) planar flaw. The code classifies flaws of this nature as a crack for conservatism even though this flaw was actually entrapped slag from the fabrication welding process. TVA demonstrated that if the crack growth rate was one thousand times greater than that used in the analysis, the resultant flaw would still meet the acceptance criteria of the American Society of Mechanical Engineers code.

Based upon an independent calculation and a review of TVA's analysis, the Nuclear Regulatory Commission agreed that the closure head was acceptable for service. In order to verify the predictions of the analysis, the Nuclear Regulatory Commission required TVA to monitor the flaw for growth rates.

The flaw in weld W-09-10 was identified in 1979. Sequoyah Nuclear Plant Unit 1 began producing commercial power in 1981. The flaw was ultrasonically examined in 1984, 1990, and 1993 with no flaw growth found. The weld will continue to be monitored throughout the service life of the plant in accordance with the American Society of Mechanical Engineers Inservice Inspection Code.

171

Comment: *Without license extensions by the United States Nuclear Regulatory Commission for Browns Ferry Nuclear Plant Units 1, 2, and 3 and Sequoyah Nuclear Plant Units 1 and 2, Watts Bar Nuclear Plant Unit 1 will be the only TVA nuclear unit producing power in 2020.*

Comment by: Whiting Delk

Response: TVA nuclear units have a 40-year operating license. Both Sequoyah Nuclear Plant units and Watts Bar Nuclear Plant Unit 1 will be licensed to produce power in 2020. TVA anticipates that Browns Ferry Nuclear Plant Units 2 and 3 are excellent candidates for license extension and are expected to be available over the Energy Vision 2020 study period. This is discussed in the section on TVA's Nuclear Plants in Volume 2, Technical Document 3.

In 1995, the Nuclear Regulatory Commission revised and issued 10-CFR-54, a rule on license extension. TVA's assessment of the revised rule is that it is a workable approach to license renewal and TVA expects that any process questions will be resolved in time to support preparation of license extension applications for TVA nuclear units.

172

Comment: *If you add together capital, decommissioning, and maintenance costs, Watts Bar Nuclear Plant Units 1 and 2 cost $15 billion and have not generated anything yet.*

Comment by: Ann Harris

Response: TVA has invested a total of $8.5 billion into Watts Bar Nuclear Plant. This includes an investment of $6.8 billion in the construction of Watts Bar Nuclear Plant Unit 1 and $1.7 billion in Watts Bar Nuclear Plant Unit 2. These costs have been incurred and will have to be repaid whether or not Watts Bar Nuclear Plant Unit 1 operates. Operating the unit will allow TVA the opportunity of earning a return on the agency's investment. In December 1994, the TVA Board decided it would not, by itself, complete Watts Bar Nuclear Plant Unit 2 as a nuclear unit.

No expenses have been incurred for maintenance or decommissioning. Expenses for maintenance will be spent over the life of the unit to ensure safe and efficient operation. Payments to the decommissioning fund will also be made over the 40-year life of the unit.

173

Comment: *TVA is violating the TVA Act requirement to produce electricity at the lowest possible cost because of the cost of its nuclear program.*

Comment by: Jeannine Honicker

Response: The current cost of power is dependent on many factors, and TVA produces electricity at the lowest possible cost in light of these factors. TVA has not violated the TVA Act.

174

Comment: *TVA is locked into huge nuclear plants that are extremely expensive, high risk, and have permanent pollution.*

Comment by: Bruce Wood

Response: Nuclear power is a vital part of TVA's power mix. Nuclear plants supply energy reliably, safely, and with little environmental impact. The Nuclear Regulatory Commission monitors plant operations every day and conducts comprehensive reviews that cover all aspects of the plants. TVA's Nuclear Plants are economical to operate. The nuclear industry and TVA are dedicated to safe and efficient nuclear plant operation.

In December 1994, as one of the actions to limit debt, TVA decided it would not, by itself, complete Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2, as nuclear units. Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.

The short- and long-term plans proposed in Energy Vision 2020 provide TVA enhanced flexibility so that it is not locked into any specific kind of resource in the future. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

175

Comment: *For the amount of money TVA spent on its nuclear program, it could have put photovoltaics on every residence and business in Tennessee. I know this cannot be done now because TVA's debt has eliminated choices. That is money that could have been used for cleaning up emissions, insulating homes, and advanced power systems.*

Comment by: Dolores Howard, Myles Jakubowski (Sunbeam Household Products)

Response: Energy Vision 2020 evaluated the completion of Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2, as well as central station and end-use solar photovoltaics. (See Volume 2, Technical Document 8, Figures T8-9 and T8-18, and pages T8.65 to T8.83.) The short-term action plan recommends research and development of distributed generation alternatives, which includes end-use solar photovoltaics. (See Volume 1, Chapter 10, Figure 10-1.)

WATTS BAR NUCLEAR PLANT UNIT 1/BROWNS FERRY NUCLEAR PLANT UNIT 3

Economics/Alternatives of Watts Bar Nuclear Plant Unit 1

The following comments are addressed in a comprehensive response that appears after comment number 205.

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176 **Comment:** *To have an adequate Energy Vision 2020, TVA needs to fully assess and include in Energy Vision 2020 the completion of Watts Bar Nuclear Plant Unit 1 including uncertainties of start-up date, completion costs, operating costs and performance, decommissioning costs, capital cost, total cost, cost effectiveness, alternative resources, and corrections of safety violations. According to the United States General Accounting Office, TVA spent in 1994 an average of $1.1 million daily on Watts Bar Nuclear Plant Unit 1.*

Comment by: Eric Hirst (Oak Ridge National Laboratory), Mary English (University of Tennessee), Mary Byrd Davis (Ygdrasil Institute), Powell & Sharon Foster, Danielle Droitsch, Mandy Tiesler, Jamie Pizzirusso, Michelle Neal (Tennessee Valley Energy Reform Coalition), Stephen Smith (Tennessee Valley Energy Reform Coalition), Nancy Bell, Leith Patton, Sheila Holbrook-White (Sierra Club, Alabama Chapter), Bryan Deel, Stephanie Calvert, Beth Zilbert (Greenpeace), Andy Fazio, Maggie Kalen (Tennessee Valley Energy Reform Coalition), James Riccio (Public Citizens Critical Mass Energy Project), Jim Snell, David Bordenkircher, Henry Nickell (Memphis Light, Gas and Water Division), John Johnson (Earth First), Tom Fitzgerald (Kentucky Resources Council, Inc.)

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177 **Comment:** *You can slow the Watts Bar Nuclear Plant fuel loading and get the information from independent sources which will prove beyond a doubt that the power generated by Watts Bar Nuclear Plant will not be competitive and that fuel loading should be deferred.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

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178 **Comment:** *I am opposed to the start-up of Watts Bar Nuclear Plant Unit 1. Watts Bar Nuclear Plant Unit 1 costs over $8 billion to construct, costs over $1 million per day until it can be licensed, decommissioning costs will be at least $500,000 million, and it has thousands of outstanding safety violations.*

Comment by: Walter & Dorothy Stark, Jamie Pizzirusso, Mandy Tiesler, Mark Johnson, Jason Gurley, Jenny Willoghby, Beth Zilbert (Greenpeace), Stephen Smith (Tennessee Valley Energy Reform Coalition), Beth Wallace, Leith Patton, Dennis Henke, James Riccio (Public Citizens Critical Mass Energy Project), Peggy Snow, James Barr, Jim Snell, Howard Switzer (Sun/Earth Tempered Organic Architecture), Sharon Force, Tom Phillips, Olivia Lim (Southeast Center for Ecological Awareness), John Johnson (Earth First), Jean Cheney, Jan Jones (Tennessee River Valley Association), Dennis Haldeman

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179 **Comment:** *Given TVA's history of underestimating construction costs and the nuclear power industry's limited experience, nuclear plant decommissioning costs should have been a key uncertainty. TVA admits (see Volume 2, Technical Document 3, page T3.8) the difficulty in estimating actual nuclear plant decommissioning costs and equitably recovering*

these costs from ratepayers throughout the life of the plant. While the majority of Watts Bar Nuclear Plant Unit 1 construction costs are sunk, until fuel is loaded, no decommissioning costs are incurred. If TVA amortized its medium case decommissioning costs over the 30-year life of the plant, at its costs of capital of 7.75 percent, assuming all other costs and capacity factor at the medium case, TVA's production costs would be $22.55 per megawatt-hour (plant production costs at the recent 4-year average capacity factor and operating and maintenance cost is $26.91 per megawatt-hour). Given the uncertainty in capacity factor and operation and maintenance costs, this price is comparable to current bulk power available through interchange. TVA's estimated annual cost of deferring a nuclear plant is $10 to $20 million per year (see Volume 2, Technical Document 8, page T8.72). It would seem prudent to defer the start-up of Watts Bar Nuclear Plant Unit 1 until a clear economic advantage appeared.

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

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180 **Comment:** *Because nuclear costs are as high as 8 cents per kilowatt-hour including operating and maintenance and additions and improvements costs of 3 to 4 cents per kilowatt-hour, TVA probably would be better off trying to divest itself of Watts Bar Nuclear Plant Unit 1 and associated risk.*

Comment by: Edward Smeloff (Sacramento Municipal Utility District)

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181 **Comment:** *If Watts Bar Nuclear Plant Unit 1 costs $6.7 billion to build and it is depreciated over its planned life cycle of 25 years, that amounts to $268 million per year in depreciation alone. If it operates at full capacity 100 percent of the time, 1,100 megawatts at 1.7 cents per kilowatt-hour amounts to income of only $163 million per year. That does not include any costs for operation, fuel, maintenance, decommissioning, and no outages. The true costs of electricity from that plant, I believe, will be 5 or 6 cents per kilowatt-hour. That is not good economics.*

Comment by: Arthur Smith, Bryan Deel, Stephanie Calvert, Debra Jackson, Faith Young, Stephen Smith (Tennessee Valley Energy Reform Coalition)

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182 **Comment:** *In their economic projections, TVA apparently chose to ignore the $6.8 billion they have spent to date trying to build Watts Bar Nuclear Plant.*

Comment by: Beth Zilbert (Greenpeace)

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183 **Comment:** *TVA should recognize that the $7 to $8 billion sunk into Watts Bar Nuclear Plant are already lost and the best thing to do now is to quit throwing money at it. Watts Bar Nuclear Plant is ultimately the camel that breaks the back.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Richard Simmers, Dolores Howard, Dennis Haldeman

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184 **Comment:** *If Watts Bar Nuclear Plant Unit 1 starts producing electricity, it would cap an embarrassing 22-year construction period marred by cost overruns and endless delays. TVA states that Watts Bar Nuclear Plant Unit 1 will be operated at "…a very economical and competitive cost." While it is true that nuclear power is typified by low operation and maintenance costs, its capital costs (the expense to finance and construct a nuclear power plant) are higher than any other energy resource.*

Nuclear construction has become so expensive that no other federal, public, or private utility will build another nuclear power plant. In fact, several utilities have abandoned

their plans to build new nuclear facilities or have shut down operating nuclear units because they are too expensive and in response to public pressure. In TVA's case, the construction delays and Nuclear Regulatory Commission licensing problems will result in a finished construction cost of approximately $7 billion or $6,000 per kilowatt of installed capacity—more expensive than any other commercial energy source. Quite simply, there is no way for TVA to bring Watts Bar Nuclear Plant Unit 1 into operation without a significant increase in electric rates, adversely affecting its customers, or without a massive federal bailout.

Watts Bar Nuclear Plant Unit 1 is an expensive plant and cannot pay for itself. Including construction debt, costs attributable to Watts Bar Nuclear Plant Unit 1 will be 20 to 44 cents per kilowatt-hour. Without construction debt, Watts Bar Nuclear Plant Unit 1 costs to TVA will be 4.1 to 9.2 cents per kilowatt-hour. Consider that with Watts Bar Nuclear Plant on-line, TVA's average system-wide production cost will be only 3.9 cents per kilowatt-hour. The result is, at best, TVA will lose 0.2 cents per kilowatt-hour for every kilowatt-hour of Watts Bar Nuclear Plant energy it sells. With all costs included, TVA will lose 16 to 40 cents on each kilowatt-hour of energy produced at Watts Bar Nuclear Plant Unit 1.

On average, on an annual basis, operating Watts Bar Nuclear Plant Unit 1 and paying on its debt will cost TVA between $1 billion and $1.5 billion per year. However, Watts Bar Nuclear Plant Unit 1 will only generate $240 million to $213 million in revenue from the sale of its electricity. The result is that Watts Bar Nuclear Plant Unit 1 will lose between $804 million and $1.3 billion per year for TVA and its bondholders.

Despite TVA's pledge to not raise rates for another year, it is reasonable to expect that some or all of these costs will be passed on to citizens in Tennessee.

Comment by: Beth Zilbert (Greenpeace)

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185 **Comment:** *Why is the TVA Board completing Watts Bar Nuclear Plant Unit 1, which is not technologically or economically feasible or environmentally sensitive? Perhaps they are getting golden parachutes in the retirement funds of $20 to 30 million.*

Comment by: Tom Phillips

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186 **Comment:** *TVA continues to maintain that bringing Watts Bar Nuclear Plant Unit 1 on line is the only economical option open to them at this late stage of construction. The MSB report shows this assertion to be simply not true. TVA's case for bringing Watts Bar Nuclear Plant Unit 1 on line is based on a series of flawed assumptions.*

The study "Deadly Dollars - The Economic Fallout of TVA's Watts Bar Nuclear Plant Unit 1" by MSB Energy Associates indicates that TVA's decision to load fuel into Watts Bar Nuclear Plant Unit 1 will only deepen TVA's financial woes.

TVA has spent $6.8 billion to date building Watts Bar Nuclear Plant, and they expect to spend at least another $200 million to finish the plant. TVA asserts that since $6.8 billion has already been spent, it would be foolish to not finish the plant and operate it to recoup their investment. But if TVA brings Watts Bar Nuclear Plant into service, two events occur. One is that they immediately buy into paying for decommissioning of the plant, which may cost as much as $5.9 billion if they run the plant for 30 years or at least $475 million if Watts Bar Nuclear Plant Unit 1 is shut down in 1996. These annual decommissioning payments are not factored into TVA's presentation of Watts Bar Nuclear Plant economics, and will make the operation of Watts Bar Nuclear Plant more expensive than natural gas-fired power plants and wind energy. The second consequence of Watts Bar Nuclear Plant's operation is that TVA will immediately have to begin making payments on

the total construction cost, which has been deferred in special accounts the whole time Watts Bar Nuclear Plant Unit 1 has been under construction.

Watts Bar Nuclear Plant Unit 1 construction costs will have to be paid by somebody at sometime and there are no easy answers as to whom and when. TVA's analysis of Watts Bar Nuclear Plant economics only considers future operating costs, not their accumulated construction debts. But since these costs do have to be repaid, it is disingenuous at best to hide them from the public.

The MSB report asks two questions of TVA's decision to operate Watts Bar Nuclear Plant:

- *First, what economic effect will Watts Bar Nuclear Plant Unit 1 have on TVA's finances when all construction costs are included along with expected operating costs?*
- *Second, even if construction costs are ignored, do the economics of finishing and operating the power plant make sense? TVA apparently believes they should throw more good public money after bad just to prove that they can get the plant operating in a misguided attempt to rectify a $6.8 billion mistake.*

The study shows that even when excluding construction debts, the decision to finish Watts Bar Nuclear Plant makes poor economic sense. If all costs are included, then the decision to complete Watts Bar Nuclear Plant is nothing short of incompetent.

Our study (the table below summarizes the cost analysis) conclusively shows that the decision to operate Watts Bar Nuclear Plant is fiscally irresponsible to both ratepayers in Tennessee and the United States taxpayer. If TVA insists on loading fuel into Watts Bar Nuclear Plant Unit 1, it will not only endanger the lives of people in the Tennessee Valley, it will be guilty of creating one of the largest wastes of public money ever.

TVA Watts Bar Nuclear Plant Unit 1 (WBN1) – Economic Analysis Summary (including WBN1 construction costs)

Carrying Charge 20%	Existing System	TVA with Watts Bar Unit 1, under assumption: TVA	Case 1	Case 2	Case 3	Case 4	WBN1 Average
ENERGY PROD. COSTS							
System Cost (cents/kWh)	2.64	3.84	3.88	3.84	3.85	3.85	3.85
Increase		45%	47%	45%	46%	46%	46%
WBN1 Cost (cents/kWh)		20.16	20.73	23.41	30.21	43.94	27.69
Increase Over System Average		1,532%	1,585%	1,857%	2,536%	3,909%	2,284%
WBN1 Annual Cost (millions)		1,570	1,614	1,559	1,579	1,576	1,580
WBN1 Annual Revenue (millions)		299	302	255	201	138	239
WBN1 Net Cost (millions)		1,271	1,312	1,304	1,378	1,438	1,341
STRANDED COSTS							
Nuclear Only (millions)	$ (467)	(1,780)	(1,815)	(1,814)	(1,885)	(1,946)	(1,848)
All TVA Generation (millions)	$ 1,732	112	116	68	14	(49)	52
				most likely			

Carrying Charge 12.01%	Existing System	TVA	Case 1	Case 2	Case 3	Case 4	WBN1 Average
ENERGY PROD. COSTS							
System Cost (cents/kWh)	2.64	3.41	3.45	3.41	3.42	3.42	3.42
Increase		29%	30%	29%	29%	29%	29%
WBN1 Cost (cents/kWh)		12.94	13.47	14.97	19.46	28.27	17.82
Increase Over System Average		853%	902%	1,056%	1,504%	2,385%	1,340%
WBN1 Annual Cost (millions)		1,008	1,049	997	1,017	1,014	1,017
WBN1 Annual Revenue (millions)		266	269	227	179	123	213
WBN1 Net Cost (millions)		742	784	770	838	891	805
STRANDED COSTS							
Nuclear Only (millions)	$ (168)	(1,034)	(1,067)	(1,064)	(1,129)	(1,182)	(1,095)
All TVA Generation (millions)	$ 2,392	725	729	686	638	582	672

For TVA's nuclear generation as a whole, their average production costs (capital costs plus operating and maintenance) increase from a current level of 6.6 cents per kilowatt-hour to 11.5 cents per kilowatt-hour, a 75 percent increase. Under these conditions there is no way TVA can claim Watts Bar Nuclear Plant is an economical source of energy.

Scenario (including construction debts)	Watts Bar Unit 1 Cost of Energy: 20% capital cost	12% capital cost	Nuclear Stranded Costs: 20% capital cost	12% capital cost
TVA w/o Watts Bar Unit 1	Average generation cost w/o WBN1 = 2.60		467	168
TVA Assumption	20.16	12.95	1,780	1,034
Case 1	20.73	13.51	1,815	1,067
Case 2	23.40	14.97	1,814	1,064
Case 3	30.21	19.46	1,885	1,129
Case 4	43.93	28.27	1,946	1,182

Comment by: Beth Zilbert (Greenpeace)

187 **Comment:** *TVA's justification for bringing Watts Bar Nuclear Plant Unit 1 on-line is wholly unrealistic and fatally flawed. Given this problem, the MSB study constructs four additional scenarios, all of which are based on average costs and performance in the nuclear*

industry as a whole and in TVA. In each one of these scenarios, Watts Bar Nuclear Plant is not a cost-effective option.

Comment by: Beth Zilbert (Greenpeace)

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188 **Comment:** *By excluding consideration of alternatives for the start-up of Watts Bar Nuclear Plant Unit 1, management has committed TVA to a course of action that could substantially increase the utility's cost, and limit its opportunities to take advantage of the competitive wholesale power market.*

Comment by: Edward Smeloff (Sacramento Municipal Utility District)

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189 **Comment:** *Watts Bar Nuclear Plant Unit 1 should not be started up because the spot market purchase of power costs is less than the incremental cost of power from Watts Bar Nuclear Plant Unit 1.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

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190 **Comment:** *TVA is projecting a cost of 2.1 cents per kilowatt-hour to produce power from Watts Bar Nuclear Plant. This is significantly lower than the historic estimates at other plants, including Watts Bar Nuclear Plant's sister plant, Sequoyah Nuclear Plant. Sequoyah Nuclear Plant's operating and maintenance costs are more than that. Even taking this at face value, TVA can now buy power for less than that. The market price for energy exchanged between the states of Washington and Oregon at times falls below 2 cents per kilowatt-hour.*

Comment by: Edward Smeloff (Sacramento Municipal Utility District), Stephen Smith (Tennessee Valley Energy Reform Coalition)

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191 **Comment:** *With a TVA system average production cost (assumed to set the market selling price) of 3.9 cents per kilowatt-hour, Watts Bar Nuclear Plant Unit 1 is still not economical in all but one scenario in TVA's own projection, even when construction costs are excluded.*

Scenario	*WBN 1 Cost of Energy (cents per kilowatt-hour) at 20 Percent*	*WBN 1 Cost of Energy (cents per kilowatt-hour) at 12 Percent*
TVA WBN 1 Projection	*4.15*	*3.71*
Case 1	*4.72*	*4.27*
Case 2	*4.69*	*4.17*
Case 3	*6.36*	*5.69*
Case 4	*9.17*	*8.21*

Comment by: Beth Zilbert (Greenpeace)

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192 **Comment:** *A TVA Board decision to fuel and operate the Watts Bar Nuclear Plant Unit 1 would cause severe economic damage to TVA. The cost of bringing Watts Bar Nuclear Plant Unit 1 on-line would effectively prevent TVA from participating in a competitive market with other utilities. As a result, TVA would most likely require federal protection or assistance to keep its existing customers locked into getting their energy from TVA. This would more than likely result in excessive electric rates, hindering the economic development of the TVA region as business and industry relocate to secure more favorable energy rates.*

Comment by: Beth Zilbert (Greenpeace)

193 **Comment:** *If Watts Bar Nuclear Plant goes into operation, TVA costs will increase to where they will not be competitive with other electric utilities. Outside electric companies could come in and cherry-pick TVA's largest customers. With the resulting loss in revenue, the possibility of TVA defaulting on its debts becomes real. If TVA defaults, its bondholders (including the federal government) will be stuck with the debt, or TVA may call on the federal government to bail them out for the entire debt amount.*

On the other hand, if TVA abandons Watts Bar Nuclear Plant, then TVA, Congress, and all interested parties will have the luxury of time to decide on the best approach to reconcile TVA's massive debt. This may mean forming strategic alliances with other businesses and utilities, more aggressive refinancing strategies, or innovative market-based solutions. Delaying Watts Bar Nuclear Plant offers TVA and its stakeholders the maximum flexibility to resolve these critical issues.

Comment by: Beth Zilbert (Greenpeace)

194 **Comment:** *By starting up Watts Bar Nuclear Plant Unit 1, you will raise rates and drive away customers. If TVA continues with Watts Bar Nuclear Plant Unit 1, TVA will either be privatized or it will lead to a bailout by the federal government.*

Comment by: James Riccio (Public Citizens Critical Mass Energy Project)

195 **Comment:** *TVA's stranded investment (stranded investment indicates the amount of existing generation resources owned by a utility that will be unlikely to be able to produce energy at a competitive cost in the open market), as determined for its current existing nuclear system, is estimated to be approximately $467 million. If Watts Bar Nuclear Plant Unit 1 is completed, the stranded investment potential increases over 300 percent to $1,848 million. At this level, instead of making a reasonable profit each year, TVA revenues will barely cover their production and capital costs, leaving almost no money left over for other expenses such as plant improvements and pollution control.*

Note that this calculation does not include decommissioning costs for Watts Bar Nuclear Plant Unit 1, which have been estimated at $500 million to $1 billion if the plant shuts down in 1996, and up to $5.8 billion if Watts Bar Nuclear Plant operates for 30 years. Therefore, the total stranded investment for TVA including Watts Bar Nuclear Plant Unit 1 is estimated to be $2.4 billion to $7.6 billion.

Utility	*Stranded Nuclear Investment (excluding decommissioning) (millions)*
TVA (Without Watts Bar Nuclear Plant Unit 1)	*$467*
TVA (With Watts Bar Nuclear Plant Unit 1)	*$1,858*
Boston Edison Company	*$475*
Western Massachusetts Electric Company	*$150*
New England Electric System	*$600*

As can be seen from the table above, TVA's current stranded costs are similar to the nuclear-owning utilities of New England, but the addition of Watts Bar Nuclear Plant Unit 1 to the TVA system adds almost $1.5 billion in unrecoverable costs (excluding decommissioning costs).

Comment by: Beth Zilbert (Greenpeace)

196 **Comment:** *A concern for TVA (and every other vertically integrated regulated power producer) is the specter of competition in the electric industry. For over 60 years, electric companies have been tightly regulated and controlled by regulatory agencies. Regulators have set rates, authorized construction, and ensured compliance with federal and state laws. In return, the regulated utility is given exclusive rights to service areas and is allowed to earn a predetermined rate of return for its stockholders. Today, many utilities and large industrial customers are pushing for the deregulation of the electric industry. The goal is to give large electric companies the same freedoms as have already been given to the telecommunications and airline industries. Under deregulation, an electric company would be separated into independent units, each responsible for the generation, transmission, and distribution of electricity. With over 25,000 megawatts of generation, TVA would likely stay a generating company. In a competitive marketplace, generation costs will be the driver of success. Advocates of competition cite excessive electric rates as the need for deregulation and assert that rates will go down if the "market" is allowed to set rates. Therefore, as the TVA Board considers its future in the "brave new world" of competition, cost minimization should be a high priority. Loading fuel into the Watts Bar Nuclear Plant reactor and starting commercial operation does not support a philosophy of cost minimization or maximization of TVA's future competitiveness.*

Comment by: Beth Zilbert (Greenpeace)

197 **Comment:** *Financial analysis of decisions involving large capital investments over a long time period must include the cost of capital or carrying charge. The carrying charge, unique to every organization, reflects a business's cost of financing its operations, capital investments, taxes, and depreciation of capital assets.*

For this analysis, Watts Bar Nuclear Plant Unit 1 energy production, annual costs and production costs were evaluated at TVA's 12 percent carrying charge and at an anticipated competitive market carrying charge of 20 percent. The 12 percent value was calculated for TVA based on data contained in their 1994 Annual Report and in TVA's federally filed annual report (Form EIA-412). The 20 percent carrying charge is a reasonable approximation of the capital costs TVA would incur if it were truly competing on a level playing field in the power generation market. Today, most investor-owned utilities' carrying costs are approximately 20 percent.

As a federal agency, TVA pays no taxes. If TVA were privatized, a competitive market would mandate that TVA operate under the same laws as other electricity sellers which in turn would require that TVA lose its tax-exempt status. TVA has openly embraced the ideals of a competitive market. In doing so, they must be willing to enter the market fairly. This means paying taxes like every other for-profit business. If TVA balks at the idea of losing their tax-exempt status, then they are implying that they want competition, but want to maintain an unfair market advantage over their competitors.

Comment by: Beth Zilbert (Greenpeace)

198 **Comment:** *The start-up of Watts Bar Nuclear Plant Unit 1 limits flexibility because it commits TVA to raising $300 to $700 million over the length of time to pay for its decommissioning. Once the plant has started up, decommissioning becomes an unfunded plant cost.*

Comment by: Edward Smeloff (Sacramento Municipal Utility District)

199 **Comment:** *The start-up of Watts Bar Nuclear Plant Unit 1 limits flexibility because it adds a substantial amount of new power; and the regional marketplace already has surplus capacity. The United States General Accounting Office directly questions the assumption made by TVA that it will be able to market all the power when these plants are in operation.*

Most likely the power generated by Watts Bar Nuclear Plant Unit 1 will displace current capacities, or be sold on the spot market at a substantial discount.

Comment by: Edward Smeloff (Sacramento Municipal Utility District), Sheilla Cheyenne

200 **Comment:** *The large array of smaller, more dependable power options available to TVA through the request for proposals for future power needs should provide TVA more flexibility at less cost than starting the remaining troubled nuclear units. A more thorough analysis of smaller generation replacing the non-operational nuclear units would be preferable.*

Comment by: Sharon Fidler (League of Women Voters)

201 **Comment:** *TVA predicts it will need 2,396 megawatts of new capacity by 2005 of which 2,235 megawatts are expected to come from nuclear sources. As part of this study, alternative energy resources were considered and compared to costs of Watts Bar Nuclear Plant. The technologies evaluated included 500-megawatt integrated gasification combined cycle coal-fired plants, 50-megawatt gas-fired combustion turbines, 225-megawatt combustion turbine-combined cycle gas units, 40-megawatt municipal solid waste plant, 50-megawatt biomass combustion stokers, 100-megawatt whole-tree energy plants, and energy conservation programs. Using conservative utility data, cost and performance characteristics for each of these technologies were evaluated to meet the capacity and energy needs that Watts Bar Nuclear Plant would provide.*

When construction costs are included, each of the above energy resource options, with the exception of municipal solid waste, would meet TVA's needs at a lower cost than Watts Bar Nuclear Plant Unit 1. Without construction costs, combustion turbines, combined cycle combustion turbines, and wind plants are cost-effective options to Watts Bar Nuclear Plant. Demand-side management capital costs were not fully developed since they vary widely with the type of conservation program employed. Utility experience with demand-side management shows that the majority of programs have achieved energy savings in the 0.5 cents per kilowatt-hour to 6.0 cents per kilowatt-hour ($5 per megawatt-hour to $60 per megawatt-hour) range. For this analysis, a conservative estimate of 3 to 6 cents per kilowatt-hour was used. At 3 cents per kilowatt-hour, TVA should be able to achieve additional energy savings based on their current average production cost of 2.64 cents per kilowatt-hour. At 6 cents per kilowatt-hour, an upper boundary is set for the most expensive demand-side management programs where the "last" or marginal level of energy savings occurs.

Combustion turbines and combined cycle power plants use natural gas as a fuel source. The combustion of natural gas produces almost no sulfur dioxide or oxides of nitrogen. Both of these pollutants are regulated by the Clean Air Act Amendments of 1990. TVA argues that nuclear power avoids the problem of the expensive pollution control equipment required by the Clean Air Act Amendments for their coal-fired power plants. Using natural gas as a fuel, these concerns are completely avoided. Also, wind power is a renewable energy resource which produces no air emissions at all. And because wind is a free "fuel," TVA is insulated form potential price jumps in fossil and nuclear fuel prices.

In addition to being cheaper, each alternative energy option is available in smaller capacity increments and can therefore be installed as (and if) TVA's forecast energy needs develop. In this way, system resource additions can be added when and only when they are needed, spreading out the costs over time, and providing flexibility for TVA to respond to technological, economic, demographic, and industry changes.

The MSB report examines TVA's alternatives prior to loading fuel and contaminating Watts Bar Nuclear Plant. Wind energy and natural gas power turn out to be more cost-effective than Watts Bar Nuclear Plant even when you disregard the $6.8 billion that TVA has already spent and look only at current and future costs. Opting for either of these more environmentally friendly technologies will leave TVA with the greatest range of flexibility possible for dealing with its huge debt in the future.

Comment by: Beth Zilbert (Greenpeace)

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202 **Comment:** *Watts Bar Nuclear Plant should be converted to another form of energy, such as gas.*

Comment by: Michelle Carratu

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203 **Comment:** *The most prudent decision TVA can make, one that protects its long-term interests and respects its customers' desire for reliable and economic service, would be to abandon all plans to fuel and operate the Watts Bar Nuclear Plant Unit 1. By scrapping the Watts Bar Nuclear Plant now, TVA can prevent massive rate hikes, avoid the problems of funding an ever-increasing decommissioning cost schedule, and also lessen their exposure to radioactive waste storage and disposal problems.*

Comment by: Beth Zilbert (Greenpeace)

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204 **Comment:** *TVA has not demonstrated the ability to safely and reliably operate their existing nuclear plants, and there is no compelling reason to believe that Watts Bar Nuclear Plant Unit 1 would be an exception. As a result, TVA's cost and performance projections for Watts Bar Nuclear Plant should be regarded as highly optimistic. If Watts Bar Nuclear Plant Unit 1 experiences unexpected or delayed outages, or if maintenance requirements are higher than expected, TVA will find itself in a deeper and deeper financial hole.*

Comment by: Beth Zilbert (Greenpeace)

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205 **Comment:** *In light of TVA's poor nuclear management record, I am distressed that TVA is still proceeding with some nuclear power plants. TVA has ignored that both TVA's and private nuclear programs are economic disasters. As an example, TVA has continued with Watts Bar Nuclear Plant which, is a shining example of an overpriced, poorly built plant.*

Comment by: Steven Walsh, Sharon Force, Paul Elliott

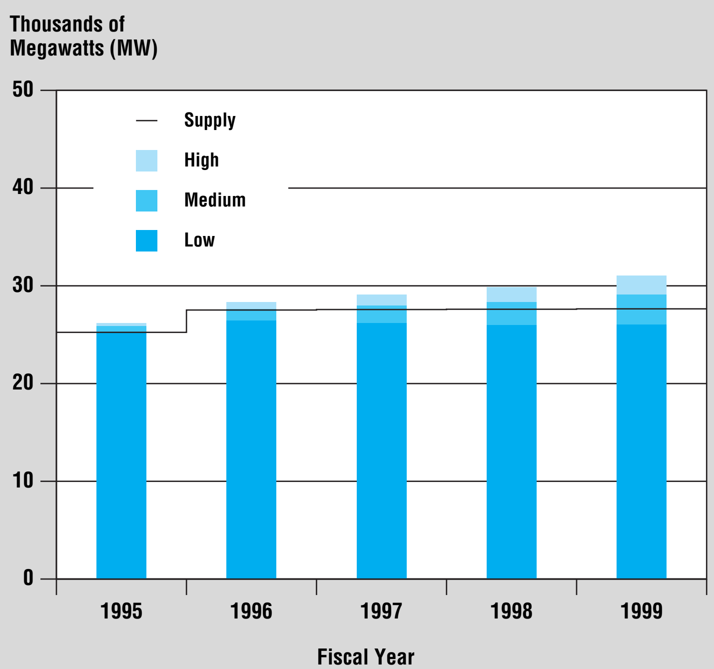
COMPREHENSIVE RESPONSE ON WATTS BAR NUCLEAR PLANT UNIT 1

Because Watts Bar Nuclear Plant Unit 1 was essentially complete when Energy Vision 2020 was initiated, TVA appropriately decided to include it in the Energy Vision 2020 evaluations as an existing resource. Generation from Watts Bar Nuclear Plant Unit 1 is needed to meet customer needs in 1996 and it is a cost-effective alternative for meeting this need.

Customer Power Needs

Figure 1 shows the capacity situation through 1999, with Watts Bar Nuclear Plant Unit 1 commencing operation in fiscal year 1996 and Browns Ferry Nuclear Plant Unit 3 also returning to service the same year. As shown, with the addition of these two units, the supply is about equal to the medium load requirements in 1996. The need for additional capacity increases to 1,500 megawatts by 1999. Based on the high load forecast, additional capacity of 800 megawatts would be needed in 1996, increasing to 3,400 megawatts by 1999. For the low load forecast, TVA would not need additional capacity during the forecast period (2020) with Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 operating. The most likely load growth scenario is the medium forecast, which shows that a supply deficit would be expected without Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 available to generate in fiscal year 1996. Figure 2 shows the surplus (or deficit) capacity values based on the low, medium, and high load forecasts with both Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 operating.

FIGURE 1. **Long-Term Capacity Requirements and Supply – High Medium & Low Load Forecast**



Note: Requirements equal peak load plus desired reserves.

FIGURE 2. **TVA Capacity Situation Based on Low, Medium, and High Load Forecasts – Projected Surplus Capacity (Megawatts)**

	Low Load Growth	Medium Load Growth	High Load Growth
1996	1,075	-125	-825
1997	1,375	-400	-1,525
1998	1,625	-775	-2,275
1999	1,575	-1,475	-3,375

Watts Bar Nuclear Plant Unit 1 Current Status

Commercial operation of Watts Bar Nuclear Plant Unit 1 is expected to be achieved in spring of 1996. The unit was granted a license to load fuel and perform low power operations in November of 1995. Fuel loading was completed in November. As explained above, generation from Watts Bar Nuclear Plant Unit 1 continues to be needed.

TVA has invested approximately $6.8 billion in constructing Unit 1 and common facilities at the plant. Since these costs have already been incurred, changing TVA's course of action and deciding not to operate the plant would not avoid these costs. TVA would still have to recover the incurred costs in its power rates. Operating the plant would allow TVA to begin earning a return on agency investment in the form of generation from Unit 1.

Alternatives to Watts Bar Nuclear Plant Unit 1

TVA considered a number of alternatives to constructing and operating Watts Bar Nuclear Plant in its 1972 final environmental impact statement. Among those alternatives were construction of coal-fired units, hydroelectric units, gas-fired units, and oil-fired units. These alternatives were either deemed not feasible, more costly, and/or more environmentally detrimental than operation of Watts Bar Nuclear Plant. TVA also considered purchasing firm power from neighboring utilities. However, TVA projected that neighboring utilities would not be able to supply sufficient firm power to meet its needs and concluded that the environmental impacts of a neighboring utility generating that power would likely be similar to or greater than those impacts associated with operation of Watts Bar Nuclear Plant.

Construction at Watts Bar Nuclear Plant Unit 1 is now complete, and the alternatives available to TVA in light of the status of Watts Bar Nuclear Plant Unit 1 and the need for the power in 1996 are limited. Those alternatives are described below. TVA has determined that operating Watts Bar Nuclear Plant Unit 1 is both the most cost-effective and environmentally preferable alternative available.

Description of Watts Bar Nuclear Plant Unit 1 Alternatives

TVA identified and evaluated three alternatives in connection with TVA's supplemental environmental review of the plant issued in June 1995. These included: operate Watts Bar Nuclear Plant Unit 1, delay operation of Watts Bar Nuclear Plant Unit 1 and purchase power, and cancel Watts Bar Nuclear Plant Unit 1 and purchase power. TVA identified a number of other alternatives, but these were dismissed from further consideration as not feasible.

Operate Watts Bar Nuclear Plant

Commercial operation of the unit is now expected in spring 1996. Watts Bar Nuclear Plant Unit 1 would add 1,170 megawatts of base-load capacity to the TVA system. Because this alternative does not change TVA's current course of action, it would be tantamount to the "No Action Alternative" in an environmental impact statement.

Delay Operation of Watts Bar Nuclear Plant Unit 1 and Purchase Power

TVA also considered the consequences of not operating Watts Bar Nuclear Plant Unit 1 and purchasing power from neighboring utilities, independent power producers, or other sources to meet any shortfall in available generation. To ensure that the power is available when needed, TVA would have to purchase it on a firm-power basis. This would involve paying a demand (reservation) charge and a price for the energy itself. Assuming firm power is available from neighboring utilities, TVA could purchase it for a number of years and delay operation of Watts Bar Nuclear Plant Unit 1 for this period. For purposes of this analysis, TVA assumed that Watts Bar Nuclear Plant Unit 1 would be delayed only one year; longer delays would have consequences similar to cancellation. While Watts Bar Nuclear Plant Unit 1 could be delayed, there would be the added cost of power purchases along with the completion costs of the unit. At the same time, some risk is inherent in depending on other utilities for peak load supply.

Cancel Watts Bar Nuclear Plant Unit 1 and Purchase Power

Canceling Watts Bar Nuclear Plant Unit 1 would require that power be purchased for an extended period of time. As with the delay and purchase alternative discussed above, the purchase of firm power would require the payment of both a demand charge and an energy price. Assuming power is available, it would have to be purchased until another means of meeting system needs could be deployed.

Non-Viable Alternatives

Constructing another generating source instead of Watts Bar Nuclear Plant Unit 1 would take a number of years to complete and would result in additional environmental impacts. Figure 3 identifies a representative set of alternative generating methods and the time required to implement these alternatives (including development of a technology if necessary). Those methods considered demonstrated and available now include: supercritical pulverized coal, recirculating atmospheric fluidized bed combustion, simple cycle combustion turbines, gas-fired combined cycle turbines, small combined cycle turbines, and compressed air storage. There are other generating methods, but those have not been demonstrated commercially and are not considered available without further development.

FIGURE 3. **Alternative Generating Methods**

Generating Method	Lead Time	Earliest Operation Date
Supercritical Pulverized Coal	8 years	2004
Circulating AFBC*	8 years	2004
Simple Cycle Turbine	5 years	2001
Gas-Fired Combined Cycle	5 years	2001
Small Combined Cycle	4.5 years	2000
Compressed Air Storage	10 years	2006
Fuel Cell	4 years	2005
Advanced Battery	3 years	2015
Light Water Reactor	10 years	2008
Cogen/Combined Cycle	4 years	2000
Wind	6 years	2002

* Atmospheric Fluidized Bed Combustion

These generation alternatives could be constructed and operated either by TVA or by an independent power producer. However, the lead time required to bring on another generating source would not be appreciably faster if an independent power producer undertook the project. Because of the need for power in 1996, none of these alternative methods of generating power are considered viable.

There are also a large number of energy conservation (demand-side management) options which could reduce the need for power on the TVA system. These include such things as replacing less efficient electric heating with electric heat pumps, envelope tightening measures (for example, home insulation programs, energy-efficient appliances, and the use of more energy-efficient materials in manufactured homes), the use of more energy-efficient lighting, the use of more energy-efficient appliances, and the use of more energy-efficient motors by industries. Most of the demand-side management measures have some associated environmental impacts (for example, the disposal of old appliances and lighting waste) but, compared to the construction and operation of new generating sources, their associated impacts would be less. TVA's analyses indicate that it would take a large number of these demand-side management programs to achieve sufficient energy savings to offset the demand that is intended to be met by operating Watts Bar Nuclear Plant Unit 1. It also takes from three to five years to put in place demand-side management programs and to begin to achieve noticeable energy savings. The combination of sufficient demand-side management programs to offset Watts Bar Nuclear Plant Unit 1 is estimated to cost approximately 7.0 cents per kilowatt-hour which substantially exceeds the cost of operating Watts Bar Nuclear Plant Unit 1 (about 1.7 cents per kilowatt-hour). In addition, Watts Bar Nuclear Plant Unit 1 generates cash compared to the demand-side management alternatives.

Comparison of Viable Alternatives

TVA compared the potential environmental and economic consequences associated with the viable alternatives identified. Because of the uncertainties associated with purchasing replacement power for Watts Bar Nuclear Plant Unit 1, a range of costs for purchased power is used. The cost of power purchases is compared to the incremental cost of operating Watts Bar Nuclear Plant Unit 1.

Cost of Watts Bar Nuclear Plant Unit 1

Key Assumptions	
Capital Additions and Improvements ($/kilowatt/year)	$26.5/kW
Fuel Cost (cost per kilowatt-hour)	0.425/kWh
Operation and Maintenance Cost ($/kilowatt/year)	$69/kW
Decommissioning (millions of 1994$)	$300

Incremental Cost of Power from Watts Bar Nuclear Plant Unit 1	*Cents/Kilowatt-Hour*
Capital Additions and Improvements	0.10
Fuel	0.43
Operation and Maintenance	1.01
Decommissioning	0.11
Total Cost to Operate	1.65

With fuel and operating costs added to decommissioning costs, the first-year cash cost of generating power at Watts Bar Nuclear Plant Unit 1 is estimated to be 1.7 cents per kilowatt-hour (Figure 4). This compares very favorably to the estimated cost of purchasing firm base-load power— 2.5 to 3.6 cents per kilowatt-hour. TVA has already spent approximately $6.8 billion on the construction of the unit and common facilities. These costs have to be recovered whether or not the unit operates. Watts Bar Nuclear Plant Unit 1 should be among TVA's lowest-cost generating sources.

FIGURE 4. **Power Cost Comparison**

Watts Bar Nuclear Plant Unit 1 (Fuel, Operation and Maintenance, Decommissioning)	1.7 cents per kilowatt-hour
Purchase with Reservation Charge (Firm)	2.5 -3.6 cents per kilowatt-hour

The Preferred Alternative

Based on the need for power, the lack of sufficiently viable alternatives, and the economics and other limitations of purchasing versus operating Watts Bar Nuclear Plant Unit 1, operating Watts Bar Nuclear Plant Unit 1 is clearly in TVA's and its customers' best interest. In the short term, the variable cost of Watts Bar Nuclear Plant Unit 1 is the fuel cost of 0.4 cents per kilowatt-hour. Because of the low fuel cost, this unit will be dispatched before other non-nuclear units. This provides TVA the flexibility to lower the generation from higher cost units on the power system, therefore, minimizing overall variable costs. Because completion and operation of Watts Bar Nuclear Plant Unit 1 would have environmental impacts similar to or less than purchasing power, it was also considered the environmentally preferred course of action.

Sunk Cost and Economic Analysis

It appears that many of the comments (particularly comment numbers 184 and 201) estimated the cost of Watts Bar Nuclear Plant Unit 1 to include the construction costs which have already been spent (sunk costs). TVA's analysis of the cost of Watts Bar Nuclear Plant Unit 1 is based on the incremental operating and other costs necessary to operate the unit compared to delaying this unit one year. The construction costs—or sunk

costs—have been paid whether or not Watts Bar Nuclear Plant Unit 1 is operated and regardless of future competitive conditions. Therefore, sunk costs should be excluded from the analysis.

There is also some confusion related to the accounting cost changes that would result when Watts Bar Nuclear Plant Unit 1 begins operation. When Watts Bar Nuclear Plant Unit 1 begins commercial operation, accounting costs will increase for depreciation, operation and maintenance, and fuel. The costs associated with Watts Bar Nuclear Plant Unit 1 will be offset by additional revenue from the generation from Watts Bar Nuclear Plant Unit 1 or reductions in operating costs due to lower generation from TVA fossil units or combustion turbines. Still, many commenters believe that electricity rates will increase substantially. This notion is probably based on the idea that when Watts Bar Nuclear Plant Unit 1 begins operation, all interest costs associated with capital invested to construct Watts Bar Nuclear Plant Unit 1 will be included in rates at that time. But, in fact, TVA pays such interest from current revenues. Thus, when Watts Bar Nuclear Plant Unit 1 begins operation, electric rates will not increase due to interest costs.

When Watts Bar Nuclear Plant Unit 1 begins operation, the costs have been appropriately accounted for in the electric rate projections shown for the short-term action plan in Volume 1, Chapter 10, Figure 10-8. These electric rate projections indicate that TVA will hold rates constant through 1997, and from 1998 to 2005, electric rates will increase less than the projected rate of inflation (3.3 percent per year). Furthermore, readers should be aware that the TVA budget for 1996, in which Watts Bar Nuclear Plant Unit 1 was operating for six months, was presented to the TVA Board in September of 1995, and no rate increase was announced.

TVA's Economic Analysis Versus Other Analyses of the Cost of Watts Bar Nuclear Plant Unit 1

TVA's estimated cash cost to operate Watts Bar Nuclear Plant Unit 1 is 1.7 cents per kilowatt-hour. Other commenter estimates for Watts Bar Nuclear Plant Unit 1 range from 4.2 to 9.2 cents per kilowatt-hour. These cost estimates are based on the cost to complete Watts Bar Nuclear Plant Unit 1 plus a variety of other assumptions concerning operation and maintenance costs, fuel costs, and decommissioning costs.

In our opinion, TVA's assumptions of these costs components are better than the assumptions made by a number of the commenters who came up with higher cost estimates. TVA's assumptions have been reviewed by National Economic Research Associates, Inc., and R. J. Rudden Associates, Inc., in the report "An Evaluation of the Nuclear Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan." Their conclusions were that TVA's estimates were reasonable. These companies were retained for and provided advice to the Energy Vision 2020 Review Group, the stakeholder group involved in Energy Vision 2020.

Rate impacts, comparative operating cost, performance/capacity factor, decommissioning costs, safety, and uncertainty of costs portions of the comments listed above are further addressed in the responses to comments found below.

Assumptions for Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3

206

Comment: *TVA is bringing on Watts Bar Nuclear Plant Unit 1 only to allow it to begin to charge ratepayers more in order to pay off TVA's debt.*

Comment by: Leith Patton, Ann Harris, Bryan Deel

Response: Watts Bar Nuclear Plant Unit 1 will be brought on-line to help meet customer demand. The completion of this unit will end TVA's requirement to borrow capital funds for major power system construction. All of TVA's capital requirements will be generated internally by 1998 and rates are expected to remain stable until at least 1998.

207

Comment: *If it starts up Watts Bar Nuclear Plant, TVA will have to raise rates. According to my calculations, it would have to pay $960 million per year which is 20 percent of TVA's current revenue.*

Comment by: Jeannine Honicker

Response: TVA does not expect to raise rates when Watts Bar Nuclear Plant Unit 1 is started.

208

Comment: *We feel very strongly that Watts Bar Nuclear Plant Unit 1 will probably never achieve the capacity factors that TVA has projected.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Bryan Deel

Response: National Economic Research Associates, Inc. and R. J. Rudden Associates, Inc. were retained for the Energy Vision 2020 Review Group to evaluate the key assumptions related to the cost and performance of TVA's nuclear units. Their conclusions regarding capacity factor were that the TVA estimates for Watts Bar Nuclear Plant are reasonable and somewhat lower than their estimates. The details of the analysis and conclusions regarding TVA's estimates of capacity factor are found on pages 9 and 10 of the report titled "An Evaluation of the Nuclear-Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan."

209

Comment: *TVA has now received an exemption to lower the temperature of the core at Watts Bar Nuclear Plant, which will lower capacity.*

Comment by: Ann Harris

Response: TVA intends to operate Watts Bar Nuclear Plant at the licensed core power level and at the highest capacity factors possible.

210

Comment: *Right now, Watts Bar Nuclear Plant is a clean, uncontaminated site and should stay that way. The moment fuel is loaded, TVA will incur at least a $500 million and possibly up to a $1 billion commitment to decommission and decontaminate the site.*

Comment by: Sheilla Cheyenne, Stephen Smith (Tennessee Valley Energy Reform Coalition), Susan Switzer, Michelle Carratu, Scott Banbury, Leith Patton

Response: Decommissioning costs were fully considered in the Energy Vision 2020 analysis. National Economic Research Associates, Inc. and R. J. Rudden Associates, Inc. were retained for the Energy Vision 2020 Review Group to evaluate the key assumptions related to the cost and performance of TVA's nuclear units. The overall conclusions regarding TVA's estimates of decommissioning costs (for pressurized water reactors $200 to $600 million per unit) are that the range of costs estimated by TVA are reasonable, and decommissioning costs represent a relatively small part of nuclear generating costs; therefore, large increases in the estimated costs would have a very small impact on the overall operating costs of a nuclear plant.

The details of the analysis and conclusions regarding TVA's estimates of decommissioning costs and waste disposal are found on pages 13 to 15 of the report titled "An Evaluation of the Nuclear-Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan."

211

Comment: *TVA has excluded decommissioning costs from their calculations—a potential $5.9 billion omission.*

A review of current literature and cases leads to the following estimate of Watts Bar Nuclear Plant Unit 1 decommissioning costs (expressed in 1994 dollars for a 1996 shutdown):

Minimum Cost: $475 million
Maximum Cost: $655 million

These estimates do not include contingency factors for unknown and unquantifiable events. Contingency factors are designed to include such events as labor problems, weather stoppages, equipment/tool problems, regulatory changes and procedural changes. In New York, the Shoreham decommissioning study added a 40.7 percent contingency factor and in 1987, the California Energy Commission ordered a 50 percent contingency factor for the Diablo Canyon decommissioning. If a 50 percent contingency factor is added to the Watts Bar Nuclear Plant decommissioning cost estimate, the costs increase to :

Minimum Cost: $713 million
Maximum Cost: $996 million

The cost to decommission a nuclear plant increases with the amount of time the plant has been fueled and operating. If Watts Bar Nuclear Plant Unit 1 is fueled when planned, it will incur some decommissioning costs even if TVA decides to shut it down before commercial operation. But the longer it remains fueled and is subject to low- and high-power testing, the more expensive it will be to decommission the unit. This is a result of several factors: 1) hot plant operation consumes fuel which in turn generates high and low level radioactive wastes, 2) neutron bombardment (a byproduct of fission) of the containment structure causes the structure's metals and concrete to become radioactive, and 3) low levels of tritium are produced from neutron bombardment of hydrogen in the primary cooling system resulting in a contamination of the primary cooling loop components.

Studies have indicated that the escalation rate of decommissioning cost estimates has run as high as 3 to 9 percent over the rate of general inflation. This means that each year TVA waits to decommission Watts Bar Nuclear Plant Unit 1, the expected costs to decommission the plant will rise exponentially. To demonstrate the effect of an escalation rate in this range, consider that the value of an investment made today will double in only 10 years if it is earning seven percent annually.

Two factors should be clear:

1. *It will be less expensive to shut down Watts Bar Nuclear Plant Unit 1 if it has not been fueled*
2. *Even if it is fueled and tested, it will still be significantly less expensive to shut it down sooner rather than later.*

A preliminary review of TVA's financial statements indicate it is highly unlikely that TVA is accurately funding decommissioning accounts. The TVA 1994 Annual Report lists a fund balance of $264 million. Additionally, TVA's Annual Report of Public Electric Utilities states that the decommissioning provision for Browns Ferry Nuclear Plant is $190 million per unit and $150 million for each Sequoyah Nuclear Plant unit (1990 dollars). If TVA's Watts Bar Nuclear Plant Unit 1 decommissioning estimates are similar, they will clearly encounter severe financial problems at the plant's end-of-life.

Accurately accounting for nuclear decommissioning costs is important for several reasons. First and foremost is so that TVA can establish and properly fund decommissioning accounts now to ensure the required funds are available when they are needed. Failure to do so may result in huge rate increases for TVA customers or federal bailouts at the time of decommissioning. The second reason is so that electricity costs and rates accurately reflect the full cost of generating electricity from nuclear power.

Comment by: Beth Zilbert (Greenpeace)

Response: Decommissioning costs were fully considered in the Energy Vision 2020 analysis for nuclear options as illustrated in Volume 2, Technical Document 6, Figure T6-1. All costs of operating Watts Bar Nuclear Plant Unit 1 for a 40-year operating life, including decommissioning costs, are included in the Energy Vision 2020 analysis as part of existing assets.

National Economic Research Associates, Inc. and R. J. Rudden Associates, Inc. were retained for the Energy Vision 2020 Review Group to evaluate the key assumptions related to the cost and performance of TVA's nuclear units. Their overall conclusions regarding TVA estimates for performance and costs were that the ranges estimated by TVA are reasonable, including decommissioning costs of $200 to $600 million per unit for pressurized water reactors, and that decommissioning costs represent a relatively small part of nuclear generating costs; therefore, large increases in the estimated costs would have a very small impact on the overall operating costs of a nuclear plant. The details of the analysis and conclusions regarding TVA's estimates of costs and performance are found in the report titled "An Evaluation of the Nuclear-Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan."

TVA's policy on the collection of funds for decommissioning is explained and activities associated with the decommissioning fund since it was established are described in the section on TVA's Nuclear Plants in Volume 2, Technical Document 3.

Investments of power funds have been made since 1982 to provide for the accumulation of funds for decommissioning nuclear plants. TVA's policy is to collect funds for decommissioning through rates based on a constant dollar amount adjusted for inflation

over the life of the operating license of a nuclear plant. Decommissioning expense has been recovered from ratepayers annually based on the present value of amounts not provided through earnings on the fund.

212

Comment: *TVA has not factored in the risks of spent fuel storage and the increasing possibility that a high level nuclear waste repository may never be available.*

Comment by: Beth Zilbert (Greenpeace)

Response: All costs of operating nuclear units, including the costs for life-of-plant on-site storage, are included in the Energy Vision 2020 analysis. (See Volume 2, Technical Document 1, pages T1.122 to T1.125.)

213

Comment: *TVA has not considered the total cost of Watts Bar Nuclear Plant Units 1 and 2 combined ($11 billion).*

Comment by: Bryan Deel

Response: TVA has invested $6.8 billion in the construction of Watts Bar Nuclear Plant Unit 1 and $1.7 billion in Watts Bar Nuclear Plant Unit 2. These costs have been incurred and will have to be repaid whether Watts Bar Nuclear Plant Unit 1 operates or not. Operating the unit will allow TVA the opportunity of earning a return on the agency's investment. In December 1994, TVA decided it would not, by itself, complete Watts Bar Nuclear Plant Unit 2 as a nuclear unit.

214

Comment: *TVA has assumed that Watts Bar Nuclear Plant Unit 1 will operate at a lower cost than any other TVA reactor has ever operated.*

Comment by: Bryan Deel

Response: If Watts Bar Nuclear Plant is a one-unit plant, TVA cost projections for Watts Bar Nuclear Plant Unit 1 operation are about one-third higher than operation of either Browns Ferry Nuclear Plant or Sequoyah Nuclear Plant on a single unit basis.

National Economic Research Associates, Inc. and R. J. Rudden Associates, Inc. were retained for the Energy Vision 2020 Review Group to evaluate the key assumptions related to the cost and performance of TVA's nuclear units. Their conclusion regarding the TVA estimates for operating and maintenance, additions and improvements, and capacity factor was that the TVA estimates are reasonable. The details of the analysis and conclusions regarding TVA's estimates are found in the report titled "An Evaluation of the Nuclear-Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan."

215

Comment: *TVA claims that they can operate and maintain Watts Bar Nuclear Plant Unit 1 at a lower cost than the current national averages for all nuclear plants and for less money than it now costs TVA to run either their Sequoyah or Browns Ferry nuclear units. This is unrealistic, particularly considering the fact that Watts Bar Nuclear Plant Unit 1*

has set a national record of over 6,000 whistleblower allegations of safety violations during its 23-year construction period.

TVA claims that Watts Bar Nuclear Plant Unit 1 will operate 76 percent of the time, while they have only been able to operate Browns Ferry and Sequoyah Nuclear Plants (Watts Bar's sister plant) at a combined capacity factor of 51 percent.

Comment by: Beth Zilbert (Greenpeace)

Response: Because Watts Bar Nuclear Plant is a one-unit plant, TVA cost projections for Watts Bar Nuclear Plant Unit 1 operation are about one-third higher than operation of either Browns Ferry Nuclear Plant or Sequoyah Nuclear Plant on a single plant basis.

There have been numerous modifications made over the past several years to improve plant safety and performance. Modifications have included alterations in design, processes, and hardware to improve safety, performance, and costs of nuclear unit operation. Each of the plant modifications has been thoroughly reviewed for safety implications and the plant design documents have been updated to reflect design changes. The Nuclear Regulatory Commission has conducted comprehensive inspections on the construction activities, including the review of design changes. Extensive operational readiness inspections by the Nuclear Regulatory Commission and TVA continued to be conducted prior to TVA certifying to the Nuclear Regulatory Commission that TVA was ready to load fuel and begin safe operation. All safety issues were resolved to the satisfaction of TVA and the Nuclear Regulatory Commission prior to fuel load. TVA is dedicated to safe and efficient nuclear plant operation.

National Economic Research Associates, Inc. and R. J. Rudden Associates, Inc. were retained for the Energy Vision 2020 Review Group to evaluate the key assumptions related to the cost and performance of TVA's nuclear units. Their conclusion regarding the TVA estimates for operating and maintenance, additions and improvements, and capacity factor was that the TVA estimates are reasonable. The range for capacity factor used in Energy Vision 2020 was 55 to 86 percent with a medium estimate of 67 percent. The details of the analysis and conclusions regarding TVA's estimates are found in the report titled "An Evaluation of the Nuclear-Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan."

Overall capacity factor through fiscal year 1995 for Browns Ferry Nuclear Plant and Sequoyah Nuclear Plant units since restart after the 1985 outages is 69 percent. Combined capacity factor for fiscal year 1995 is 80 percent.

Safety/Health

216

Comment: *The Nuclear Regulatory Commission does not agree with TVA's fuel load date for Watts Bar Nuclear Plant Unit 1. They are going slow because the plant was built wrong and there continue to be employee and other safety concerns and violations.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Jeannine Honicker, Bryan Deel, Dennis Henke

Response: The Nuclear Regulatory Commission approved fuel load at Watts Bar Nuclear Plant in early November 1995. Prior to fuel load all safety issues were resolved and TVA demonstrated that the plant could be operated safely.

217

Comment: *I am concerned about how employees who report safety violations at Watts Bar Nuclear Plant Unit 1 have been treated.*

Comment by: Dennis Henke

Response: TVA employees are our most important asset and provide valuable information concerning all aspects of our nuclear program. Therefore, it is TVA policy that intimidation, harassment, discrimination, or retaliation will not be tolerated. TVA is committed to ensuring an environment where employees feel free to express their concerns and ensuring their concerns are properly addressed.

TVA has established two programs to assure that employee concerns have been, and will continue to be, properly addressed and resolved. The ongoing Concerns Resolution Program, put in place on February 1, 1986, was established to encourage the prompt and effective resolution of employee concerns through the normal line management process, as well as provide an alternate avenue for concerns that cannot be effectively resolved that are similar to and under the oversight of the Concerns Resolution Staff. Employees and line management are the key building blocks of this program; however, the Concerns Resolution Staff and contractor programs are available on-site as alternate avenues for employee to raise and resolve concerns. Concern programs are made known to employees in General Employee Training, site bulletins, and postings on bulletin boards. In addition, employees leaving the site participate in an exit interview with the Concerns Resolution Staff or their contractor concern program to specifically identify any unresolved safety issues they are aware of. These programs have been successful. The number of issues expressed to concern programs TVA-wide has consistently trended downward from 1,298 in 1986 to 77 in 1995 (through October). Nuclear Regulatory Commission reviews in 1993 and 1995 of the programs revealed the site-wide employee concerns programs are being effectively implemented. Employee interviews conducted by the Nuclear Regulatory Commission during their 1993 and 1995 inspections of the programs, and by the TVA Office of the Inspector General in 1994 and 1995 were very positive and indicated that the vast majority of employees will report nuclear safety or quality problems by some available avenue, have confidence in line management to resolve issues, and will, if needed, use the concern programs as an alternative avenue to raise issues.

The second program, known as the Employee Concerns Special Program was established to resolve concerns expressed prior to February 1, 1986. The Employee Concerns Special Program made use of an independent contractor in 1985 and early 1986 to interview all employees associated with Watts Bar Nuclear Plant to make sure all employee concerns were identified. Over 5,800 employees associated with Watts Bar Nuclear Plant (not necessarily on-site) were interviewed which resulted in over 5,000 employee concerns being identified by approximately 1,850 employees. Hot lines for all employees and the public were also established. Due to the large number of concerns expressed, TVA established Employee Concern Task Groups to categorize and investigate the concerns. The Employee Concern Task Groups issued 1,591 Corrective Action Tracking Documents for issues that were validated and required further corrective actions. All 704 Corrective Action Tracking Documents that are applicable to Watts Bar Nuclear Plant Unit 1 have been closed.

218

Comment: *Because of the risk of accidents and its proximity to people, I recommend that TVA cease work on Watts Bar Nuclear Plant Unit 1.*

Comment by: Clark Buchner (Sierra Club, Tennessee Chapter), Scott Banbury, Debra Jackson, Calvin Moore, Jean Cheney, Stephanie Calvert, Bryan Deel, Sanford McGee (Cumberland Center for Justice and Peace), Ann Harris, Hamp Dobbins, Jr., Arthur Webb

Response: TVA's Watts Bar Nuclear Plant has been one of the most closely monitored and evaluated nuclear plants in the United States. TVA is committed to ensuring that it can be operated safely. Through careful, conservative planning for safety, the potential risk of nuclear reactors has been reduced to a very low level. Nuclear plants supply energy reliably, safely, and with little environmental impact. The Nuclear Regulatory Commission monitors operations every day and conducts comprehensive reviews that cover all aspects of Watts Bar Nuclear Plant.

Two serious accidents have occurred in 30 years of commercial energy production, the Three Mile Island and Chernobyl accidents. At Three Mile Island, no one was injured or killed because nuclear energy plants in the United States use a series of physical barriers to prevent the release of radioactivity. About half of the uranium fuel melted at Three Mile Island, but only minute amounts of radioactive material escaped into the environment. The radiation exposure from Three Mile Island was actually much less than most of us receive each year from naturally occurring radioactive materials in soil, rocks, air, food, and water.

The Chernobyl plant in the Soviet Union had design flaws and no containment structure. As a result of the Chernobyl accident, radioactive material escaped and significant environmental damage occurred. More than 200 people were hospitalized for radiation exposure and burns, and approximately 30 people died. Reports suggest that more people may have died later. A plant like Chernobyl could not be licensed in the United States, and its design is completely different than Watts Bar Nuclear Plant.

219

Comment: *I am concerned about Watts Bar Nuclear Plant Unit 1 because it is located on a fault line.*

Comment by: Dennis Henke

Response: Watts Bar Nuclear Plant is not located on a seismic fault line. TVA and the Nuclear Regulatory Commission are aware of the data and studies of the seismic activity in east Tennessee. In fact, the data was gathered from TVA's Seismic Monitoring Network. Watts Bar Nuclear Plant has been designed for earthquakes significantly larger than any in the historical record for the eastern Tennessee seismic zone. The plant also has design margins well in excess of the earthquake design basis. The Nuclear Regulatory Commission addressed this specific issue in section 9.4.6 of Supplement 1 to NUREG-0498, "Final Environmental Impact Statement Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2", April, 1995.

220

Comment: *I am concerned about Watts Bar Nuclear Plant Unit 1 because the escape routes rely on an unconstructed bridge and a ferry boat.*

Comment by: Dennis Henke

Response: The evacuation routes and plan for evacuation for Watts Bar Nuclear Plant are developed by the Tennessee Emergency Management Agency. TVA works closely with the Tennessee Emergency Management Agency in this effort. No evacuation route in the plan crosses the Tennessee River; therefore, an unconstructed bridge or ferry boats on the river are not factors in the evacuation plan.

Each year TVA provides information, including maps and evacuation routes, to residents within a 10-mile radius of each nuclear plant. For Watts Bar Nuclear Plant, the information is mailed each November.

221

Comment: *If there is a catastrophic accident at the Watts Bar Nuclear Plant, people will know that Craven Crowell, Johnny Hayes, and Bill Kennoy are responsible. Your grandchildren will revile your names.*

Comment by: Tom Phillips

Response: The TVA Board is fully aware of its responsibilities in this area. Through careful, conservative planning for safety, the potential risk of nuclear reactors has been reduced to a very low level. Nuclear plants supply energy reliably, safely, and with little environmental impact. It is physically impossible for a nuclear plant to explode because the low-enriched fuel is not concentrated enough. The Nuclear Regulatory Commission monitors plant operations daily and conducts comprehensive reviews that cover all aspects of the plant. TVA is dedicated to safe and efficient nuclear plant operation.

222

Comment: *I am concerned about the prediction in the Nuclear Regulatory Commission's report that there is a 45 percent chance of a meltdown of Watts Bar Nuclear Plant Unit 1 within the next 25 years.*

Comment by: Bryan Deel

Response: TVA is not aware of a Nuclear Regulatory Commission report in which the Nuclear Regulatory Commission predicts a 45 percent chance of meltdown at Watts Bar Nuclear Plant within the next 25 years. TVA has performed a Probabilistic Risk Assessment which analyzes failure probabilities. One estimate in these analyses is core damage frequency (this is not equivalent to meltdown). The Probabilistic Risk Assessment was updated in 1994 to incorporate plant changes, procedural changes, and to more realistically model Watts Bar Nuclear Plant Unit 1. The latest submitted analysis has a core damage frequency of 0.00008 event per reactor year. The plant configuration and procedures that were in place at the time of fuel load lead to an estimated reduction in this value to 0.000044 event per reactor year. Over the 40-year life of the plant, this corresponds to less then a 0.2 percent chance of core damage. Core damage does not necessarily result in a release from the reactor coolant system, from the containment, or a

radiation release to the environment. When the core was damaged in the Three Mile Island accident, about half of the uranium fuel melted, but only minute amounts of radioactive material escaped into the environment because the multiple barriers contained the release of radioactivity. The radiation exposure from Three Mile Island was much less than most of us receive each year from naturally occurring radioactive materials in soil, rocks, air, food, and water.

223

Comment: *Watts Bar Nuclear Plant is a complicated issue. The parts that have been there for 22 years probably have metal fatigue, and there are probably going to be misfits between old and new parts. Because of this, it will be very difficult to operate the plant safely.*

Comment by: Michelle Carratu

Response: There have been numerous modifications made over the past several years to improve plant safety and performance. Modifications have included alterations in design, processes, and hardware to improve safety, performance, and costs of nuclear unit operations. Each of the plant modifications has been thoroughly reviewed for safety implications, and the plant design documents have been updated to reflect design changes. The Nuclear Regulatory Commission has conducted comprehensive inspections on the construction activities, including the review of design changes. Extensive operational readiness inspections by the Nuclear Regulatory Commission and TVA were conducted prior to TVA certifying to the Nuclear Regulatory Commission that TVA was ready to load fuel and begin safe operation. TVA is dedicated to safe and efficient nuclear plant operation.

224

Comment: *The reason it is taking so long to get Watts Bar Nuclear Plant started is nuclear power is dangerous. The nuclear accident at Chernobyl killed 125,000 people, so society is being cautious at Watts Bar Nuclear Plant. That is why it has cost billions of dollars to get it together.*

Comment by: Susan Switzer

Response: The Chernobyl plant in the Soviet Union had design flaws and no containment structure. As a result of the Chernobyl accident, radioactive material did escape. More than 200 people were hospitalized for radiation exposure and burns, and approximately 30 people died. There have been reports that additional people have died. A plant like Chernobyl could not be licensed in the United States.

Two serious accidents, at Chernobyl and Three Mile Island, have occurred in 30 years of commercial energy production. No one was injured or died as a result of the accident at Three Mile Island. In the United States, nuclear energy plants use a series of physical barriers to prevent the release of radioactivity. At Three Mile Island, about half of the uranium fuel melted, but only minute amounts of radioactive material escaped into the environment because the multiple barriers contained the release of radioactivity. The radiation exposure from Three Mile Island was much less than most of us receive each year from naturally occurring radioactive materials in soil, rocks, air, food, and water.

Through careful, conservative planning for safety, the potential risk of nuclear reactors has been reduced to a very low level. Nuclear plants supply energy reliably, safely, and with little environmental impact. It is physically impossible for a nuclear plant to explode

because the low-enriched fuel is not concentrated enough. The Nuclear Regulatory Commission monitors operations daily and conducts comprehensive reviews that cover all aspects of the plant. TVA is dedicated to safe and efficient nuclear plant operation.

225

Comment: *There are 71 counties within 100 miles of the Oak Ridge National Laboratory, Tennessee's current radioactive site. Cancer rates went up 29 percent in that region, while the rest of the country went up only 1 percent and that is just breast cancer death rates, not all cancers. We are going to see cancer rates go up when Watts Bar Nuclear Plant goes on-line. It is crazy.*

Comment by: Jean Cheney, Howard Switzer (Sun/Earth Tempered Organic Architecture), Anne Redwine

Response: The report alleging that fatalities from breast cancer are increasing in areas affected by nuclear facilities was released by Greenpeace at press conferences in several locations. It was not published in any technical journal and was released without peer review. Other reports issued by Greenpeace have been criticized by respected health physicists for selectively using statistics to support a desired outcome.

The Greenpeace report, "Nuclear Power, Human Health and the Environment: The Breast Cancer Warning in the Great Lakes Basin" (1995) is an example where proof of the assertions was not supported by the analysis according to a peer review by two experts in environmental and cancer epidemiology at the University of Massachusetts. A report issued in March 1995 by the Minnesota Department of Health, Chronic Disease and Environmental Epidemiology, found that breast cancer mortality trends over the period 1950 to 1992 in the 10 counties near nuclear power plants in the state of Minnesota showed no discernible difference from the statewide trend.

The largest study of cancer rates, by the National Cancer Institute, found no increased levels of cancer around nuclear plants. Rather, this study found that breast cancer mortality increased more in states without nuclear power plants than in states with such facilities.

Repeated surveys around TVA's operating nuclear plants have shown no detectable increase in radiation levels over normal background levels. The nearest plant neighbor gets about 10 times more radiation from watching a color television than from the nuclear facility. TVA does not expect to see cancer rates go up with operation of Watts Bar Nuclear Plant Unit 1.

226

Comment: *Nuclear can be compared to asbestos, which was once thought to be a wonder material, but is now known to be potentially life-threatening and very costly to remove. Therefore, I think we should be moving away from nuclear power. The money being spent on Watts Bar Nuclear Plant is money going down a black hole.*

Comment by: Susan Jata

Response: Nuclear energy is a mature technology with over three decades of operating history. More than 400 nuclear plants are operating in 27 countries around the world. Nuclear energy is the most researched of all power production technologies. Technical issues and health effects are well understood. The nuclear industry and TVA are dedicated to safe and efficient nuclear plant operation.

227

Comment: *Greenpeace's contractor, MSB Energy Associates, has been credited and praised by TVA as being fair and unbiased in utility regulatory and economic analysis. This firm has over 100 years of combined experience.*

Comment by: Beth Zilbert (Greenpeace)

Response: TVA has never had a contract with MSB Energy Associates.

228

Comment: *I do not trust Watts Bar Nuclear Plant. TVA should set up a trust fund to cover catastrophic accidents, like 1 cent per kilowatt.*

Comment by: Beth Speltz

Response: Through careful, conservative planning for safety, the potential risk of nuclear reactors has been reduced to a very low level. TVA is confident that Watts Bar Nuclear Plant Unit 1 can and will be operated safely. Collecting money for a fund to cover the cost of a catastrophic accident at the plant would unnecessarily burden customers because the chance of this occurring is very small. TVA carries insurance that covers catastrophic accidents.

Other Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 Issues

229

Comment: *We fully agree with the TVA decision to treat Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 as existing in-place TVA power supply assets. The units are expected to be placed in or returned to service in 1996. With the relatively low remaining incremental cost required, they clearly provide an attractive low-cost generating source for the consumer. Since these two units will be among the lowest dispatch cost units on the system, they will be base-loaded as soon as available. This will not only lower system generating costs, but also will displace higher cost coal-fired generation and thereby reduce the environmental impacts associated with coal-fired generation in the short run.*

These two units will also reduce the need to purchase power from other utilities, which is expected to become much more expensive after the turn of the century. Clearly, these two nuclear units are properly included in any TVA plan for power supply.

Comment by: Matt Smith, TVA Retirees Association

Response: TVA agrees that the completion of Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 is important to TVA's economic and competitive health. TVA analyses indicate that these units will generate electricity at a competitive cost.

230

Comment: *To have an adequate Energy Vision 2020, TVA needs to fully assess and include in Energy Vision 2020 the completion of Browns Ferry Nuclear Plant Unit 3 including uncertainties of start-up date, completion costs, operating costs and performance, decommissioning costs, capital cost, total cost, cost effectiveness, alternative resources, and corrections of safety violations. According to the United States General Accounting Office, TVA spent in 1994 an average of $833,000 daily on Browns Ferry Nuclear Plant Unit 3.*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division), Nancy Bell, Jamie Pizzirusso, Danielle Droitsch, Mary Byrd Davis (Ygdrasil Institute), Eric Hirst (Oak Ridge National Laboratory), Sheila Holbrook-White (Sierra Club, Alabama Chapter), John Johnson (Earth First), Mary English (University of Tennessee)

Response: Your comment has been reviewed and noted. However, Browns Ferry Nuclear Plant Unit 3 has been restarted. TVA has a need for this capacity in 1996. The operating costs of this unit are approximately 1.7 cents per kilowatt-hour and it is cost-effective compared to other viable alternatives.

231

Comment: *I am opposed to the start-up of Browns Ferry Nuclear Plant Unit 3.*

Comment by: Dennis Haldeman, Walter & Dorothy Stark, Jamie Pizzirusso, Beth Wallace, Sharon Force

Response: Your comment has been reviewed and noted. However, Browns Ferry Nuclear Plant Unit 3 has been restarted. TVA will need this capacity beginning in 1996.

232

Comment: *I believe the completion of the nuclear units as described is appropriate.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: Your comment has been reviewed and noted.

233

Comment: *It is more difficult to criticize the restart of Browns Ferry Nuclear Plant Unit 3 because they already have an operating license.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA recognizes that one of the benefits of Browns Ferry Nuclear Plant Unit 3 is that it does have an operating license.

234

Comment: *"If we were a private utility we would not still be constructing nuclear power plants. But we are a government agency and we have access to capital that allows us to continue construction."—TVA Chairman Craven Crowell*
In the fall of 1995, TVA intends to load nuclear fuel into its Watts Bar Nuclear Plant Unit 1 reactor. In February of 1996, TVA plans to bring Watts Bar Nuclear Plant Unit 1 into commercial operation.

Comment by: Beth Zilbert (Greenpeace)

Response: The first statement was taken out of context. The Chairman was referring to the fact that as the nuclear program evolved, TVA had access to capital easily and moved aggressively forward building nuclear power plants.

Chairman Crowell stated that the nuclear construction program needed to end to ensure the corporation was looking at all of the available power resources and that TVA was making the right decisions for continued power generation. In December, 1994, the Chairman announced that TVA would not itself complete Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2 as nuclear units. He also said that TVA would cap its debt $2 to $3 billion below the congressionally mandated cap of $30 billion.

Fuel was loaded into Watts Bar Nuclear Plant Unit 1 reactor in early November 1995. TVA expects to bring Watts Bar Nuclear Plant Unit 1 into commercial operation in the spring of 1996.

235

Comment: *While TVA claims they welcome competition in an open energy market, their assessment of Watts Bar Nuclear Plant Unit 1 was conducted under current market economic conditions in which TVA receives huge subsidies and tax breaks.*

Comment by: Beth Zilbert (Greenpeace)

Response: TVA's power sales fully support all power activities. Although TVA is not required to pay taxes, it makes payments in lieu of taxes which amount to about 5 percent of revenues.

236

Comment: *The public is very aware of the gross mismanagement in construction of Watts Bar Nuclear Plant.*

Comment by: Scott Banbury

Response: TVA did not attempt to avoid acknowledgment of problems in the management and work control processes in the construction of Watts Bar Nuclear Plant. Corrective actions have been taken, and TVA was granted a license from the Nuclear Regulatory Commission to load fuel and perform low power operations at Watts Bar Nuclear Plant Unit 1 in early November 1995.

237

Comment: *Congressional hearings should be held before TVA starts up Watts Bar Nuclear Plant Unit 1.*

Comment by: Yvonne Seperich

Response: TVA oversight hearings were held by Congress on March 9, 1994. Watts Bar Nuclear Plant Unit 1 was addressed in those hearings.

238

Comment: *Why was sensitivity analysis not performed on Watts Bar Nuclear Plant Unit 1 to determine if the expected costs, including fuel, operations and maintenance, capital additions, and decommissioning costs were lower than available bulk power purchases?*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: In Energy Vision 2020, Watts Bar Nuclear Plant Unit 1 is considered an existing resource and not as an option for future power supply because the unit was essentially complete and is expected to operate in 1996. Watts Bar Nuclear Plant Unit 1 was granted a license to load fuel and perform low power testing in November 1995. Full loading was completed in November, and Watts Bar Nuclear Plant Unit 1 is expected to begin commercial operation in spring of 1996. There is an immediate need for power that could be provided by Watts Bar Nuclear Plant Unit 1, and the alternative of purchasing firm power on

the bulk power market would be more costly than operating Watts Bar Nuclear Plant Unit 1. A detailed sensitivity analysis of all the cost components of the nuclear units was not deemed necessary since nuclear assumptions used in Energy Vision 2020 were reviewed by R. J. Rudden Associates, Inc. for the Energy Vision 2020 Review Group. They concluded that these assumptions were reasonable. This review is titled "An Evaluation of the Nuclear-Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan."

In addition, the uncertainty in the need for power for Watts Bar Nuclear Plant Unit 1 was analyzed. This result is reported in the "Final Supplemental Environmental Review of Operation of Watts Bar Nuclear Plant Units 1 and 2" (Tennessee Valley Authority, June 1995).

239

Comment: *According to the Nuclear Regulatory Commission, Watts Bar Nuclear Plant is the worst design. They should tear it down and put up solar cells.*

Comment by: Howard Switzer (Sun/Earth Tempered Organic Architecture)

Response: There have been numerous modifications made over the past several years to improve plant safety and performance. Modifications have included alterations in design, processes, and hardware to improve safety, performance, and costs of nuclear unit operation. Each of the plant modifications has been thoroughly reviewed for safety implications and the plant design documents have been updated to reflect design changes. The Nuclear Regulatory Commission has conducted comprehensive inspections on the construction activities, including the review of design changes. TVA was granted a license from the Nuclear Regulatory Commision to load fuel and perform low power operations at Watts Bar Nuclear Plant Unit 1 in early November 1995. TVA is dedicated to safe and efficient nuclear plant operation.

240

Comment: *TVA should sue Westinghouse for its faulty steam generators. TVA is afraid to do it because it will not be able to license Watts Bar Nuclear Plant. Westinghouse designs are plaguing utilities throughout the country and resulting in very costly capital additions and modifications. This means TVA is underestimating the costs.*

Comment by: James Riccio (Public Citizens Critical Mass Energy Project), Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA has already addressed this issue with Westinghouse and entered into a settlement agreement in 1986, which provided financial considerations for TVA. Potential steam generator replacement costs were factored into the Energy Vision 2020 process.

241

Comment: *Watts Bar Nuclear Plant should not be started in the interest of long-term healthy ecosystems.*

Comment by: Dennis Haldeman

Response: The environmental reviews for the Watts Bar Nuclear Plant have not found any potentially significant environmental impacts. These reviews include:

- "Supplemental Environmental Review (Final), Operation of Watts Bar Nuclear Plant Units 1 and 2," Tennessee Valley Authority, June 1995.

- "Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant Units 1 and 2," Dockets Nos. 50-390 and 50-391, Tennessee Valley Authority, (NUREG-0498 Supplement No. 1) U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, April 1995.
- "Final Environmental Impact Statement, Watts Bar Nuclear Plant Units 1 and 2," Tennessee Valley Authority, 1992.

242

Comment: *The Watts Bar Nuclear Plant facility should be turned into a nuclear waste storage facility rather than operated.*

Comment by: Bryan Deel

Response: The Watts Bar Nuclear Plant facility was not designed for operation only as a nuclear waste storage facility. It has been designed for nuclear plant operation with limited areas for spent fuel and low level waste storage. A 10 CFR part 30 license would be required by the Nuclear Regulatory Commission for low level waste storage facility operation. A 10 CFR part 72 license would be required for spent fuel storage.

LONG-TERM PLAN

This section includes comments and responses about:
- the energy resource strategies considered in Energy Vision 2020
- the process TVA used to develop strategies
- the merits of various supply-side resource options contained in Energy Vision 2020 strategies, including the conversion of Bellefonte to a gasification plant with a chemical coproduct, nuclear units, renewable energy resources such as wind, and emerging or new technologies
- TVA's decision to cease constructing Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2
- the role of demand-side management resources in Energy Vision 2020
- TVA's strategy for complying with the 1990 Clean Air Act Amendments, including the role of scrubbers and the use of sulfur dioxide allowances
- the use of biomass and refuse-derived fuel in the plan
- the merits of the use of coal-fired units in the plan
- the treatment of debt and TVA's electric rates in Energy Vision 2020
- the treatment of various uncertainties, including competition in the electric utility market, load growth, natural gas prices, environmental regulations, and nuclear performance and costs
- the evaluation methods used in Energy Vision 2020

Strategies Considered

FINAL STRATEGIES

243

Comment: *TVA has done an excellent job in the preparation of Energy Vision 2020 and has considered every conceivable energy option.*

Comment by: J. E. Butt

Response: Your comment has been reviewed and noted.

244

Comment: *To TVA's credit, the resource expansion strategies identified to date do not place heavy reliance on any one generation technology. TVA is considering diversified portfolios of expansion strategies which should help to mitigate the risks associated with the various options.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

245

Comment: *The Environmental Protection Agency commends TVA on its efforts to increase dissolved oxygen in its reservoir release waters. Low-dissolved oxygen releases are recognized as an important water quality issue. Will improvements in dissolved oxygen levels in reservoir releases be included in all scenarios or only in scenarios involving capacity*

increases to existing plants? Also, what level of improvement (increase in milligram per liter of dissolved oxygen) is expected as a result of TVA's Lake Improvement Plan?

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA's Lake Improvement Plan was approved in 1991 and is proceeding in concert with the hydro modernization process. TVA has committed to improve tailwater conditions by maintaining minimum flows and aerating releases below 16 dams. The aeration target is to increase dissolved oxygen to a 5 or 6 milligrams per liter minimum, depending on the fishery, through a combination of aeration at TVA dams and state action to control sources polluting the reservoirs. These improvements are planned regardless of future energy strategy decisions.

246

Comment: *The strategies diverge past the year 2000 with different mixes of resources. However, no strategy is dominated by a single technology or single generator size greater than approximately 300 megawatts.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

247

Comment: *Of the strategies (A-U) presented in the long-term action plan (see Volume 1, Chapter 9), Strategy T appears to be rated the best for all TVA criteria including environmental aspects. This strategy includes the repowering of coal-fired power plants to natural gas plants, which are environmentally superior. Specifically, Strategy T involves low-cost renewables, low-price demand-side management, repowering, and Bellefonte coproduct partnership, which all have some associated environmental benefits.*

Comment by: Heinz Mueller (United States Environmental Protection Agency), Catherine Murray (Sierra Club, State of Franklin Group)

Response: Strategy T is best for some of the evaluation criteria. For example, of all of the strategies, it performs best on reducing potential contributions to air quality impacts. It performs less well on other criteria such as enhancement of customer value and average annual income (a measure of economic development). The overall good performance of Strategy T was the reason that it is included as one of the seven final strategies. Other strategies such as Strategies Q and R provided flexibility to adapt to changing conditions in an uncertain future. These strategies were developed through an iterative process that refined the elements of each strategy so that it could perform as well as possible over multiple criteria. The resource options from all of these final strategies, including Strategy T, were used to develop the long-term plan or "portfolio" discussed in Volume 1, Chapter 9, Figure 9-23.

248

Comment: *The following comment is based on projected project impacts described in Volume 2, Technical Document 2, Environmental Consequences. It is based on our concerns regarding impacts to fish and wildlife resources from reservoir operations and land use on TVA projects in North Carolina.*

Our primary air quality concern is the effect of atmospheric deposition on high elevation forests. Project alternatives that appear to reduce atmospheric impacts include Strategy O and Strategy T.

Comment by: Chrys Baggett (North Carolina State Clearinghouse)

Response: The options contained in Strategies O and T are contained in TVA's preferred alternative, which is a portfolio of energy resource options. As a result, the environmental advantages of these options are inherent in the portfolio.

249

Comment: *The Environmental Protection Agency would encourage TVA to avoid components of Strategy D ("No Action" alternative dominated by coal-fired plants) and to prefer components of Strategy T (although we note that a new coal-fired unit is proposed at Shawnee Fossil Plant under Strategy T) in your portfolio approach to the implementation of energy resource options through the year 2020.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Strategy D was not selected for the Energy Vision 2020 portfolio. Strategy T is best for some of the evaluation criteria. For example, of all of the strategies, it performs best on reducing potential contributions to air quality impacts. It performs less well on other criteria such as enhancement of customer value and average annual income (a measure of economic development). The overall good performance of Strategy T was the reason that it is included as one of the seven final strategies. Other strategies such as Strategies Q and R provided flexibility to adapt to changing conditions in an uncertain future. These strategies were developed through an iterative process that refined the elements of each strategy so that it could perform as well as possible over multiple criteria. The resource options from all of these final strategies, including Strategy T, were used to develop the long-term plan or "portfolio" discussed in Volume 1, Chapter 9, Figure 9-23.

250

Comment: *In general, the strategies with the use of gas-based capacity, Bellefonte coproduct, and low-cost demand-side management are the better-performing strategies using TVA assumptions.*

Comment by: Tennessee Valley Public Power Association

Response: We agree with this assessment.

251

Comment: *Given the information available, it is the opinion of Burns & McDonnell/XENERGY that a reasonable strategy for TVA should include the following:*

1. *Elimination of new investment in nuclear beyond the current plans for completing Browns Ferry Nuclear Plant Unit 3 and Watts Bar Nuclear Plant Unit 1*
2. *Installation of gas-fired combustion turbine and combined cycle units or use of lower cost purchases if available, over the next several years to approximately 2003*
3. *Implementation of the first two blocks of demand-side management that include cost-effective load management and generally accepted low-cost conservation*
4. *Options that maximize flexibility in the design and construction process—both internally and externally to TVA*

5. *Consideration of renewables such as wind and biomass in the long-term years (after 2005)—doing nothing other than reviewing research by others in the short term*
6. *Addition of base-load facilities after 2003 using conventional, proven technologies such as pulverized or fluidized bed coal units*
7. *Reduction of the percentage of debt to depreciated assets*

Comment by: Tennessee Valley Public Power Association

Response: The short-term and long-term plans identified in Energy Vision 2020 contain the suggested options and provide TVA the flexibility to take the suggested actions. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

252

Comment: *TVA has planned all of the strategies developed for Energy Vision 2020 to be equivalent from a loss-of-load probability standpoint and to maintain the appropriate reserve margin to achieve this level. Since the strategies utilize similarly-sized generating units, there is little difference in the reliability of the strategies.*

Comment by: Tennessee Valley Public Power Association

Response: All strategies considered in Energy Vision 2020 had adequate and comparable levels of reliability.

253

Comment: *A measure of reliability to consider in the strategies is the amount of unserved energy. Unserved energy is a measure of the probability, due to forced and scheduled outages, that a given set of generating units would be unable to serve all of the load on a system. Unserved energy was determined for all of the selected strategies. Strategies with maximum capacity diversity resulted in the lowest amount of unserved energy.*

Comment by: Tennessee Valley Public Power Association

Response: The loss-of-load probability method is the most widely accepted approach in the electric utility industry for calculating generation requirements. This method estimates a certain amount of unserved energy per year. A simple comparison of unserved energy may be appropriate for evaluating reliability.

254

Comment: *TVA developed strategies designed to compare favorably under the environmental decision criteria.*

Comment by: Tennessee Valley Public Power Association

Response: TVA developed strategies to address both specific environmental criteria and key environmental uncertainties.

DEVELOPMENT OF STRATEGIES

255

Comment: *Generally, TVA's approach to developing strategies was well above the industry norm. A wide range of strategies was developed and evaluated, each containing significant detail regarding the timing and mix of resource options to be added. The idea of developing strategies that focus on each evaluation criterion or uncertainty is a good approach.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

256

Comment: *TVA has studied the construction process in sufficient detail to identify what it calls flexible base-load resources and flexible peak load resources. Strategy 40 incorporates these efficiencies into Strategy 20 (Bellefonte coproduct). The concept of flexibility could actually be incorporated into all of the strategies.*

Comment by: Tennessee Valley Public Power Association

Response: These flexible options have been incorporated into the long-term and short-term resource plans. (See Volume 1, Chapters 9 and 10.)

257

Comment: *TVA's sensitivity analyses show that should low load growth occur, strategies containing high levels of demand-side management perform worse, while those that have high levels of sales (e.g., Strategy 12) do better. Nuclear strategies such as Strategy 23 perform poorly under a low growth future. Strategies 34, 34A, and 41 look strong on most criteria.*

For high growth futures, strategies such as Strategy 34 with higher demand-side management do better with respect to total resource cost. In general, Strategies 20, 34, 34A, and 34B continue to perform well regardless of the growth projection.

It is interesting to note that rates tend to increase for most strategies in both the high growth and low growth futures. This would seem to indicate that the strategies have been developed to perform well on the middle growth scenario. One might assume that with low growth, fixed costs would be spread to a smaller population of customers, thus raising rates. And, under the high growth future, that expensive off-system capacity must be purchased, thus increasing rates, as well.

Comment by: Tennessee Valley Public Power Association

Response: Generally this comment is correct, but the flexible strategies, Q and R, perform well under all load growth assumptions. (See Volume 1, Chapter 9, pages 9.27 and 9.28.)

258

Comment: *As part of the early screening of strategies, TVA should have spent more time developing strategies that focus on a single resource such as demand-side management or clean coal. By developing mixed strategies so early in the process, it is very difficult to separate out the impact, for example, of demand-side management from renewables because a mixed strategy tends to include them both. TVA's view is that by conducting a thorough*

ranking of options prior to developing strategies, it is redundant to develop single resource strategies.

Comment by: Tennessee Valley Public Power Association

Response: Early in the integrated resource planning process, TVA developed and evaluated over 2,000 single resource strategies. The single resource strategies formed the basis for the development of the mixed resource strategies. (See Volume 2, Technical Document 8, Figure T8-1 for a partial listing of these strategies.)

259

Comment: *While the strategies were developed systematically, there was a large degree of judgment included. It is not clear if good strategies were missed. Although TVA has the EGEAS optimization model in house, it was never used to develop or evaluate strategies. Burns & McDonnell/XENERGY recommend that EGEAS be run to produce its preferred (i.e., optimal) strategies for several criteria, including total resource cost, environmental emissions, and rates. These strategies can then be compared to those produced using judgment by TVA staff. While optimization models may favor a single dominant resource, they are able to identify the best strategy for a single criterion given the input assumptions. Because of the shortfalls of optimization models, Burns & McDonnell/XENERGY do not recommend automatic selection of the optimal strategy. But, the optimal strategy certainly deserves comparison to the others selected and could be used as a starting point for developing more flexible mixed strategies.*

Comment by: Tennessee Valley Public Power Association

Response: As discussed in the Burns & McDonnell/XENERGY report on page VII-2, "Summary of TVA Methodology," the TVA approach to integration avoids the optimization trap and attempts to evaluate a wide variety of strategies using decision analysis techniques. TVA's philosophy is that plans should contain a portfolio of options that provide a hedge against unforeseen events. Optimization models such as EGEAS tend to produce a rush to an extreme such that the winning supply-side option is relied upon almost exclusively. This approach could be considered as a starting point in future resource planning.

260

Comment: *Innovative ways to combine some distributors' systems should be considered to save money. therefore ensuring a stronger competitive position when protective fences are removed.*

Comment by: Tennessee Valley Industrial Committee

Response: Distributors of TVA power are independent entities. These entities are cooperatives and municipalities and are controlled by local boards and local governments, not TVA.

Content

GENERAL

261

Comment: *We support and approve your Energy Vision 2020 plan.*

Comment by: Bill Kling, Jr. (Top of Alabama Regional Council of Governments), Terry McKinney & Miles Mennele (Association of Tennessee Valley Governments), Linda Church Ciocci (National Hydropower Association)

Response: Your comment has been reviewed and noted.

262

Comment: *I appreciate the magnitude of this project. My reaction is one of total awe. Energy Vision 2020 exhibits a level of excellence second to none. I hope it receives national acclaim and recognition.*

Comment by: Tom Forsythe

Response: Many people contributed to Energy Vision 2020, including the public and the Energy Vision 2020 Review Group.

263

Comment: *The long-term plan and the short-term action plan in general are headed in the right direction.*

Comment by: Mary English (University of Tennessee)

Response: Your comment has been reviewed and noted.

264

Comment: *In summary, TVA has demonstrated that they will be a strong and viable energy provider for the next 25 years.*

Comment by: William Pippin (Huntsville Utilities)

Response: Your comment has been reviewed and noted.

265

Comment: *The draft Energy Vision 2020 reflects a rigorous, in-depth study of all aspects of the power supply options available to TVA for the time period covered. Overall, the long-term and short-term action plans provide a well thought-out and comprehensive approach. If adopted, it will permit TVA to be at the forefront of providing the Tennessee Valley region with the opportunity for economic growth by providing reliable, affordable, improved services of electricity to meet the needs of its present and future customers.*

Comment by: TVA Retirees Association

Response: Your comment has been reviewed and noted.

266

Comment: *I was very impressed by the comprehensive study, as well as the multitude of alternatives that TVA has considered.*

Comment by: R. D. Newman (Bowater Newsprint)

Response: TVA has used the best industry practices in integrated resource planning, which include looking at a broad range of supply-side and customer service options, using multiple evaluation criteria, considering future uncertainties, and seeking public input.

267

Comment: *The following were identified as major policy concerns and issues by the Tennessee Department of Economic and Community Development and the Department of Environment and Conservation:*

- *Compliance with the Clean Air Act*
- *Demand-side management*
- *Supply-side options*
- *Investment in the nuclear program*
- *Realistic load growth forecasting and planning system capacity analysis*
- *Potential cost savings through improved energy efficiency*
- *Siting and financing of future construction sites*
- *Control of electricity rates*

We are generally pleased with TVA's initial assessments and reaction to these and other issues.

Comment by: Don Dills (Tennessee Department of Environment and Conservation)

Response: Your comment has been reviewed and noted.

268

Comment: *Energy Vision 2020 has been found consistent with Georgia State social, economic, and physical goals, policies, plans, and programs.*

Comment by: Tripp Reid and Barbara Melvin (Georgia State Clearinghouse)

Response: Your comment has been reviewed and noted.

269

Comment: *The Alabama Department of Environmental Management has reviewed the information submitted and has no objections to the draft Energy Vision 2020. We do point out, however, and refer you to the map in Volume 1, Chapter 3, page 3.11. There are no non-attainment areas in Alabama for total suspended particulate matter as indicated.*

Comment by: Marilyn Elliott (Alabama Department of Environmental Management)

Response: The map has been revised.

270

Comment: *Bowaters thinks that Energy Vision 2020 will continue to ensure that it enjoys a long and prosperous relationship with TVA.*

Comment by: R. D. Newman (Bowater Newsprint)

Response: Your comment has been reviewed and noted.

271

Comment: *TVA's Energy Vision 2020 plan fairly represents the consideration requested by the Energy Vision 2020 Review Group members.*

Comment by: Mary English (University of Tennessee), Tennessee Valley Industrial Committee

Response: Your comment has been reviewed and noted.

272

Comment: *TVA needs to ask, "How much electricity is enough?" This question never seems to be asked in corporate decision-making. The answer is to raise rates, reduce demand, and work on clean, renewable technology. Pay the true cost as we go, not leaving the debt of money or environmental degradation to future generations.*

Comment by: Dolores Howard

Response: Electricity is often credited with contributing to the high standard of living in the United States. Hospitals, schools, manufacturing plants, and other commercial and industrial customers all rely on inexpensive, reliable power to provide consumers with products and services. Increases in rates by TVA would not only cause higher prices for those goods and services, but would also make industrial customers consider relocating to areas of lower priced power since electricity is a major contributor to their operating cost. One of TVA's responsibilities is to provide a reliable source of power to the region.

Energy Vision 2020 balances costs, rates, environmental impacts, reliability, economic development, financial requirements, and other criteria. The short-term and long-term resource plans recommend both demand-side management programs and renewable energy. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

273

Comment: *TVA must become long-range goal oriented. For an example of its shortsightedness, one only has to look at its compliance with the Clean Air Act by using scrubbers and buying credits. Banked credits do not help our carbon dioxide situation and the greenhouse effect, and scrubbers reduce efficiency of power production. Selling energy to areas outside its "fence" is another example of a short-range attempt to fix a long-range problem of indebtedness. With the additional capacity external sales would require, the region would be subjected to even more drastic pollution from current-technology coal-fired units.*

Comment by: Powell & Sharon Foster

Response: Energy Vision 2020 identifies resources to meet the electricity and energy service needs of TVA's customers through the year 2020. This long-range plan addresses increasing competition, changing technologies, environmental concerns, economic devel-

opment of the region, reliability, electric rates, TVA's financial requirements, and risk management, all with public participation.

Sulfur dioxide emissions are to be reduced in two phases, according to the 1990 Clean Air Act Amendments. The larger and more polluting utility units were required to reduce sulfur dioxide emissions in Phase I; Phase I sources generally were to be in compliance by January 1, 1995. In Phase II, the remainder of utility sources become subject to sulfur dioxide reductions, and the allowances issued by the Environmental Protection Agency to the Phase I affected sources will be reduced. All sulfur dioxide sources must be in compliance with Phase II requirements by January 1, 2000. TVA met all Phase I requirements and milestones, and budgetary commitments are in place for TVA to meet Phase II requirements. (See Volume 1, Chapter 4.) TVA evaluated many options for reducing sulfur dioxide emissions, including scrubbers, and found scrubbers to be a very cost-effective solution for certain units. Other units must rely on switching to a low sulfur coal or other control measures. TVA's approach to date has been not to rely on its ability to buy allowances from other sources to achieve its reduction obligations.

Currently there are no carbon dioxide requirements, but Energy Vision 2020 has recognized and evaluated the possibility of a cap on carbon dioxide emissions and the creation of an allowance market for carbon dioxide similar to the sulfur dioxide allowance market. The uncertainty of carbon dioxide regulations was evaluated against all strategies. The long-term resource plan (see Volume 1, Chapter 9, Figure 9-23) adequately responds to this uncertainty.

The removal of "the fence" and other related legislation would allow TVA to serve new customers throughout the nation. According to the National Energy Policy Act of 1992, competition is intended to allow utilities to make better use of existing generating facilities, bring more cost-effective options to the market, and provide utilities and their customers with lower cost electricity. (See The Changing Electric Utility Industry section of Volume 1, Chapter 1.)

TVA expects to meet future load growth using the resources defined in the short-term and long-term resource plans. These plans performed well against the criteria listed above, including the environmental criteria. The plans performed well when they were evaluated for their robustness against environmental regulations and environmental uncertainties. TVA is mindful of the environmental impacts of all resource options evaluated. TVA will identify this further in environmental reviews that will be conducted before it decides to put specific options in place. (See Volume 1, Chapter 10.)

274

Comment: *TVA must become a living laboratory for new technologies if it expects to re-emerge as a competitive force.*

Comment by: Powell & Sharon Foster, Sheila Holbrook-White (Sierra Club, Alabama Chapter)

Response: Supply-side options with both new and existing technology have been evaluated and quantitatively ranked according to multiple criteria, including rates and reliability. New technology options such as cascaded humidified advanced turbines, fuel cells, wind-driven turbines, a biorefinery, landfill and coalbed methane, distributed technologies, and end-use photovoltaics are all potentially cost-effective resources and are in the short-term action plan. (See Volume 1, Chapter 10, Figure 10-1.)

275

Comment: *The plan lacks a sound, strong policy and goals with regard to demand-side management and renewable technologies. As an example, TVA rejected a Kenetech Windpower proposal as unproven technology needing testing while giving serious consideration to a project that has only been done once in the United States—the conversion of Bellefonte Nuclear Plant to an integrated gasification combined cycle plant.*

Comment by: Danielle Droitsch, Stephen Smith (Tennessee Valley Energy Reform Coalition), Michelle Neal (Tennessee Valley Energy Reform Coalition), Eileen McIlvane (Coalition for Jobs and the Environment), Geoffrey Crandall (MSB Energy Associates), Sheila Holbrook-White (Sierra Club, Alabama Chapter), Michelle Carratu, Mary Carton

Response: The Kenetech proposal, a wind farm, had a projected cost of 4.5 cents per kilowatt-hour, which was higher than other resource options. It was therefore concluded that the proposal was not currently competitive. However, wind turbines may be a more cost-effective source of power in the future. Accordingly, wind turbines have been included in TVA's proposed long-term plan. (See Volume 1, Chapter 9, Figure 9-23.) The conversion of Bellefonte Nuclear Plant to an integrated gasification combined cycle plant with the production of a chemical coproduct has been identified in Energy Vision 2020 as one of the best options available to TVA. Recognizing the risk associated with this type of project, TVA is proposing to further study Bellefonte Nuclear Plant conversion options over the next 18 to 24 months before deciding to pursue this option. Prior to making a decision on Bellefonte Nuclear Plant, TVA intends to complete a site-specific environmental review.

The short-term action plan includes demand-side management options, which would add up to 650 megawatts by 2002 and potentially 2,200 megawatts by 2010. This includes several flexible demand-side management programs. These programs will include a low income program, heat pump water heater program, and several programs in the commercial sector. The short-term action plan includes investigations and research into the possibility of a wind project, landfill methane, coalbed methane, end-use photovoltaics, and biomass energy projects to produce power. Short-term actions by TVA will include a flexible wind project at a selected site in the TVA service area. The first phase will determine the potential for this technology and the second phase will include building a wind turbine depending upon the outcome of the first phase. Biomass energy facilities include a biorefinery that uses refuse-derived fuel, wood waste, and energy crops, and a combined garbage and biomass energy plant. (See Volume 1, Chapter 10 for the short-term action plan.)

276

Comment: *When given a choice of 6 funding priorities, the public supported solar and energy efficiency programs by 62 percent; nuclear, coal, and oil by 19 percent; and natural gas by 14 percent. (Source: Safe Energy Communication Council)*

Comment by: Al Fritsch (Appalachia–Science in the Public Interest)

Response: Your comment has been reviewed and noted.

277

Comment: *TVA is forcing people to choose between jobs and their children's health and future.*

Comment by: Beth Zilbert (Greenpeace)

Response: TVA disagrees that it is posing such a dilemma. The long-term plan and short-term action plan recommended in Energy Vision 2020 seek to balance both short- and long-term needs. Among other criteria, the plans were evaluated for both the short-term and long-term effects on economic development (jobs and income), long- and short-term environmental impacts, and short-term electric rates and long-term costs. These evaluations are shown in Volume 1, Chapters 9 and 10.

278

Comment: *TVA should focus more on environment than on rates.*

Comment by: Debra Jackson, Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: In Energy Vision 2020, TVA has sought to balance several evaluation criteria in deciding on both the long-term plan and short-term action plan. The criteria (see Volume 1, Chapter 5) included both environmental emissions and electric rates. The evaluation of strategies (long-term plan) using both electric rates and environmental measures is included in Volume 1, Chapter 9, Figures 9-4 to 9-10. In Volume 1, Chapter 9, Figure 9-11, all strategies lessened TVA's contribution to various air quality problems compared to the reference strategy.

The final strategies used to formulate TVA's proposed long- and short-term action plans were determined to provide the best balance among criteria, including environmental criteria. (See Volume 1, Chapter 10, Figures 10-4 to 10-7.)

279

Comment: *It certainly makes sense for TVA to make practical purchases of peaking and base-load power resources to improve its hydro plants and to invest in cost-effective demand-side management measures.*

Comment by: Edward Smeloff (Sacramento Municipal Utility District)

Response: Your comment has been reviewed and noted.

280

Comment: *There needs to be an immediate moratorium on TVA's unsafe, uneconomical, and unwanted nuclear program.*

Comment by: Jim Sells, Fred Wright, Myles Jakubowski (Sunbeam Household Products)

Response: Nuclear power is a vital part of TVA's power mix and should not be abandoned. Nuclear plants are economical to operate and supply energy reliably, safely, and with little environmental impact. It is physically impossible for a nuclear plant to explode because the low-enriched fuel is not concentrated enough. United States nuclear energy plants use a series of physical barriers to prevent the release of radioactivity. The Nuclear Regulatory Commission monitors operations every day and conducts comprehensive reviews that cover all aspects of the plant. TVA is dedicated to safe and efficient nuclear plant operation.

In Energy Vision 2020, the possibility of a nuclear moratorium was evaluated. Such an event would increase TVA's costs significantly but was deemed to have a low probability of occurrence. (See Volume 2, Technical Document 8, page T8.27 and Figure T8-32.)

281

Comment: *Energy Vision 2020 presents a portfolio (bundle) of options drawn from seven key strategy alternatives. These options were chosen because they are projected to best meet TVA's objective of economic development, environmental control, debt management, etc., and to be the most robust and flexible options. However, uncertainties of the future can dramatically alter the plans for providing the best balance of options. Thus, building flexibility into the integrated resource plan bundle is a key.*

TVA not only should undertake resource options which can be altered as to size and schedule of commercial operation, but should also take steps in the short run to ensure that future options are not limited. Proven resources should not be ruled out because initial steps such as site selection, environment monitoring, and site purchases were not undertaken on a timely basis.

For these reasons, Energy Vision 2020 should make it very clear that other resource options not specifically included in the final portfolio may still provide the best balance and be most cost-effective, given the many uncertainties which could arise and the possibility of significant improvements in technology.

Thus, while Energy Vision 2020 is an impressive review of TVA's energy options, it should be viewed only as a guide, not a concrete strategy, and as only one management tool available to the TVA Board to plan the future of the TVA power system. TVA should remain flexible enough to adopt other options both in the short-term and long-term plans if they should prove to best meet the objectives of the integrated resource plan.

Comment by: TVA Retirees Association

Response: TVA recognized that the Energy Vision 2020 must be a flexible plan, one that is conducive to change as events unfold and near-term futures become more clearly known. Flexible supply-side options are ones that have smaller unit size, shorter lead times to construct or start, lower capital costs, and low walk-away costs.

With flexibility in mind, TVA's proposed short-term action plan incorporates flexible purchase agreements for peaking and base-load power to meet customer needs through the year 2002. TVA's short-term plan includes preliminary work for siting and engineering for combustion turbines (peaking power) at existing TVA sites to provide TVA with the flexibility to meet an uncertain future. The short-term plan also includes flexible demand-side management options. (See Volume 1, Chapter 10, Figure 10-1.)

282

Comment: *TVA should treat its plan as a flexible instrument, permitting alternative courses and new options to keep pace with evolving needs and future uncertainties.*

Comment by: TVA Retirees Association, Tennessee Valley Industrial Committee

Response: TVA recognized that Energy Vision 2020 must be a flexible plan, one that is conducive to change as events unfold and near-term futures become more clearly known. Flexible supply-side options are ones that have smaller unit size, shorter lead times to construct or start, lower capital costs, and low walk-away costs.

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283

Comment: *Six of the seven final strategies include the Bellefonte Nuclear Plant conversion, but the viability of this option remains uncertain. This option may be helping to tilt the scales in favor of the six strategies. Consequently, the final strategy overrelies on the Bellefonte Nuclear Plant conversion and may not be robust enough.*

Comment by: Mary English (University of Tennessee), Danielle Droitsch

Response: Based on the analyses done for Energy Vision 2020, the Bellefonte Nuclear Plant conversion options appear to be both viable and very beneficial. The Ranking of Options section of Volume 2, Technical Document 8 shows that the best options are the conversion options. The best conversion is the integrated gasification combined cycle plant, with the production of a chemical coproduct.

As shown in Volume 1, Chapter 9, Figure 9-5, Strategy Trade-off for Short-Term Rates vs. Total Resource Cost, all of the strategies that are low cost, with the exceptions of Strategies M and F, contain the Bellefonte Nuclear Plant conversion to a coal gasification plant with the production of both electricity and a chemical coproduct. The Bellefonte Nuclear Plant conversion option reduces both costs and electric rates. The costs and rates are reduced because the sale of the chemical coproduct provides benefits that reduce the cost of electricity. In addition, this option minimizes electric rates because much of the existing plant at Bellefonte can be used in the conversion that reduces the potential write-off of unused plant and equipment. The chemical coproduct sales associated with some of these conversions provide a natural hedge against a rising gas market.

Without the Bellefonte conversion options, there would be more of a trade-off between costs and short-term electric rates. For example, again in Figure 9-5, Strategies B, L, and F could be lower cost if they included the Bellefonte Nuclear Plant conversion option, but would have higher electric rates. Even if the Bellefonte conversion option is removed from TVA's final strategies, they would still be preferred over competing strategies, and the long-term portfolio would still represent TVA's best course of action.

284

Comment: *TVA's efforts to be a world leader in total resource development through innovative approaches to new technology and business arrangements are to be applauded. At the same time, however, it is important that TVA plan to expand capacity only by using proven, mature technology for a significant amount of the new resources, if it is to maintain a dependable power system. Proven technology not only should be more reliable, but also more predictable as to construction schedules, cost, and environmental consequences. In our view, only a small portion of the required new capacity should be committed to innovative technology.*

This is not to say that TVA should not be commended for exploring the new options included in the portfolio. However, we do believe it would be prudent to try only small prototype units for new designs in order to gain practical experience on costs and reliability. In its planning, TVA should allow adequate time to research, test, and prove a new resource type before having to count on it as a significant source of dependable power supply.

The proposed strategies in Energy Vision 2020 appear to include significant reliance on innovative technologies such as cascaded humidified advanced turbines, compressed air energy storage, biomass, fuel cells, wind turbines, and landfill and coal mine methane sources. These power sources are in varying degrees of development, but it is not yet clear

that they can at any time soon be called mature, proven technology. TVA should guard against being overly optimistic in relying on these sources.

Comment by: TVA Retirees Association

Response: TVA agrees with this cautionary advice and has structured Energy Vision 2020 to provide the kind of flexibility that will allow TVA to respond appropriately to changing technologies and future uncertainties. The Energy Vision 2020 short-term action plan identifies both resource options for implementation and research and development activities. Among the options proposed for implementation are the purchase of call options for both base capacity and peaking capacity, investments in hydro modernization projects, and cost-effective biomass cofiring. TVA also proposes to expand its demand-side management efforts.

As part of the short-term action plan, TVA proposes research and development activities for fuel cells, wind turbines, and landfill and coalbed methane. TVA also proposes to further study the feasibility of converting Bellefonte to integrated gasification using natural gas or coal. In addition, TVA proposes to invest in siting and engineering studies for combined cycle, combustion turbines, cascaded humidified advanced turbines, and compressed air energy storage. If during the engineering development, there are significant problems with any of these technologies (many of which are proven technologies) TVA would not pursue these technologies further.

285

Comment: *Many of the power supply options identified by TVA as attractive options involve technologies that are not currently commercially proven. As electric utilities head toward competition, maintaining costs as low as possible will become a top priority. TVA has stated its commitment to maintaining the lowest possible power costs. However, pursuing the addition of generation technologies which are not commercially mature exposes TVA to risks which could ultimately upwardly influence wholesale power costs. (In the past, TVA has pushed new technology and size limits. If continued, this may put TVA at a competitive disadvantage vs. others who use proven technology with low risk.)*

Comment by: Tennessee Valley Public Power Association

Response: TVA agrees with this cautionary advice and has structured Energy Vision 2020 to provide the kind of flexibility that will allow TVA to respond appropriately to changing technologies and future uncertainties. The Energy Vision 2020 short-term action plan identifies both resource options for implementation and research and development activities. Among the options proposed for implementation are the purchase of call options for both base capacity and peaking capacity, investments in hydro modernization projects, and cost-effective biomass cofiring. TVA also proposes to expand its demand-side management efforts.

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286

Comment: *The long-term action plan includes 2,000 megawatts of wind turbines to serve as base-load power. This installation would require an estimated 50,000 acres of land located on a prominent bluff or ridge line for proper operation. This would make the wind turbines visible over great distances. Although variable speed wind turbines have been developed, locations that offer wind speeds sufficient to generate significant amounts of base-load power may be quite limited in the Tennessee Valley. A prototype wind turbine was constructed in the North Carolina mountains a few years ago, and test results should now be available and taken into account by TVA. Even if the public would accept 50,000 acres of wind turbines, TVA should be assured that this would be a dependable source of power before embarking on such a venture.*

Comment by: TVA Retirees Association

Response: The recommended short-term action plan (see Volume 1, Chapter 10, Figure 10-1) includes a wind turbine project. The first phase of this project includes an investigation of wind resources to evaluate whether the available winds in candidate locations are in fact adequate for power generation. The evaluation will also consider the performance characteristics of the best available wind turbine technology. The second phase includes building a wind turbine, depending on the outcome of the first phase. The results of this project will help decide the potential for a larger commitment to wind resources in the long-term plan.

287

Comment: *There is minimal or no vision in the plan. TVA did a good job of keeping a lot of options and a good job of hedging against the competitive future, but it really has not charted a path for the future.*

Comment by: Howard Switzer (Sun/Earth Tempered Organic Architecture), Stephen Smith (Tennessee Valley Energy Reform Coalition), Dennis Haldeman, Tom Fitzgerald (Kentucky Resources Council, Inc.)

Response: TVA's vision is "to be the recognized world leader in providing energy and related services, independently and in alliances with others, for society's global needs." Energy Vision 2020 enhances TVA's capabilities of achieving this vision.

TVA is expecting important changes in the relationships between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a competitive marketplace. TVA is in the forefront of this change and welcomes the opportunity for growth and improved service and responsiveness to the needs of its current and new customers. TVA has taken steps to position itself for success in this new competitive environment. TVA's rates have remained stable since 1987. Its work force has been streamlined from 34,000 employees in 1988 to 16,500 in 1995. Improved productivity and efficiency, lowered operating and maintenance costs, and reductions in interest expense have resulted in savings of more than $800 million per year.

The result of these efforts is that TVA is financially strong. TVA's power program is self-supporting with revenues from power sales. TVA's electric power production and operating costs are competitive with utilities in the regional market. The same is true for the electric prices paid by consumers in the TVA service area. Energy Vision 2020 will guide TVA in entering this competitive marketplace and beyond by identifying the best energy resource choices for the current and future generations of consumers. However, Energy Vision 2020 goes beyond simply providing competitively priced power. The plan

also considers economic development and the environment as part of TVA's mandate to be a leader in total resource development. Innovative approaches in meeting the demand for energy through new technologies and business arrangements are the means by which TVA can achieve all of these goals: competitively priced power, opportunities for economic growth, and a quality environment rich in natural resources.

288

Comment: *As a member of the Energy Vision 2020 Review Group, I do not endorse the plan as written.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Your comment has been reviewed and noted.

289

Comment: *The utility industry has begun to view resource addition impacts over a much shorter horizon. Although TVA's Energy Vision 2020 considers various strategies over a 25-year horizon, there are too many changes occurring in the industry to think that any single strategy will work over that time frame. Therefore, decision-makers are looking at long-term options but focusing their attention on the economic, environmental, and reliability issues over a shorter horizon such as 5 to 10 years. Within the five-year time frame, it is often difficult to change direction once a resource plan has been selected. However, with current market conditions, flexibility in this short of a time frame is important.*

Comment by: Tennessee Valley Public Power Association

Response: TVA chose to develop a long-term plan consisting of a portfolio of resource options from the final key strategies. This portfolio enables TVA to meet customer needs at an acceptable level of risk and meet the objective of balancing costs, rates, environmental impact, reliability, debt, economic development, and other criteria. To manage risk, the portfolio provides a set of both robust and flexible resource options. These include such flexible options as option purchase agreements, investments in siting and pre-engineering to reduce lead times, and purchases of power from independent power producers and cogenerators. (See Volume 1, Chapter 9, Figure 9-23.)

NUCLEAR DECISION

290

Comment: *I support TVA's decision not to build any more nuclear plants. This includes Watts Bar Nuclear Plant Unit 2, Bellefonte Nuclear Plant Units 1 and 2, and Browns Ferry Nuclear Plant Unit 1.*

Comment by: Jamie Pizzirusso, Jan Jones (Tennessee River Valley Association), David Bowman (Huntsville News), J. Richard Hommrich (Volunteer Barge & Transport, Inc.), Tennessee Valley Public Power Association, Stephen Smith (Tennessee Valley Energy Reform Coalition), Mary Byrd Davis (Ygdrasil Institute), Powell & Sharon Foster, Jim Von Bramer, Philip & Winfred Thomforde, Alan Jones (Tennessee Environmental Council)

Response: Although TVA has decided by itself not to complete or restore these units as nuclear, it is exploring ways to obtain value from these assets.

291

Comment: *The large expenditures and questions about continued reliability make nuclear options questionable in today's market. No other utilities in the country are bringing on nuclear power plants because they do not make good economic sense in a deregulated free market.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Michelle Neal (Tennessee Valley Energy Reform Coalition), Ron Kapavik, Carol Kimmons, Jean Cheney, Sharon Fidler (League of Women Voters), Alexander Dewey

Response: In December 1994, the TVA Board decided TVA would not, by itself, complete Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2, as nuclear units. Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status.

TVA decided to complete and operate Watts Bar Nuclear Plant Unit 1 and return Browns Ferry Nuclear Plant Unit 3 to service. Operating both of these units will provide cost-effective, needed capacity for the TVA system and these units are expected to be in operation by 1996. (See response to comments in the section on Economics/Alternatives of Watts Bar Nuclear Plant Unit 1.)

Performance in the nuclear industry and at TVA continues to improve. A discussion of the improvement of TVA's nuclear performance can be found in the section on Nuclear Generation in Volume 1, Chapter 4 and the section on TVA's Nuclear Plants in Volume 2, Technical Document 3.

292

Comment: *In 1992, 65 percent of people in a Harris poll were opposed to building nuclear power plants.*

Comment by: Al Fritsch (Appalachia–Science in the Public Interest)

Response: There have been many surveys or polls done that have assessed public opinion on nuclear power. A Cambridge Reports survey of 500 opinion leaders, conducted in the spring of 1995, found 62 percent who said that nuclear energy should play an important role in meeting the nation's future energy needs. A Bruskin/Goldring Research survey of a representative sample of the United States population conducted in March 1995 found that 70 percent thought nuclear energy should play an important role in meeting the nation's future energy needs.

Levels of support that are found consistently in national polls follow:

75-85 percent favor keeping existing nuclear plants.

75-80 percent favor keeping the option to build more nuclear energy plants.

67-70 percent support an important future role for nuclear energy to meet the country's electricity needs.

52 percent favor the use of nuclear energy.

35 percent do not favor use of nuclear energy.

293

Comment: *I do not think nuclear power is the answer to all of our energy needs and we need to try and find some other avenues for producing energy because of the danger and radioactive waste of nuclear.*

Comment by: Susan Jata, Dolores Howard, Kathleen O'Donohue, Mike Eastman

Response: One of the major conclusions of Energy Vision 2020 is that TVA by itself will not complete three nuclear units: Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2. Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status. As described in Energy Vision 2020, TVA proposes to rely on several different supply- and demand-side resources to meet future customer needs.

Energy Vision 2020 indicates that TVA will continue to operate five nuclear units. Nuclear plants supply energy reliably, safely, and with little environmental impact.

294

Comment: *TVA should not continue to pursue investors for their nuclear power plants because of the high cost in nuclear waste storage, as well as the incredible social costs.*

Comment by: Elizabeth Garber

Response: TVA will keep open alternatives for the uncompleted nuclear units that would balance the evaluation criteria used in Energy Vision 2020 including minimizing short-term rates, increasing long-term flexibility, minimizing long-term costs, and limiting debt. Alternatives include converting the units to another technology, replacing the capacity, or completing these units as nuclear units with partners.

295

Comment: *No new nuclear facilities should be opened until their impacts on our health are better understood and they can be as safe as the options of solar, wind, and other renewables. Why use toxics when we have clean sources available?*

Comment by: Dara Chernicky, Monique Mollet

Response: Nuclear energy is a mature technology with over three decades of operating history. More than 400 nuclear plants are operating in 27 countries around the world. Nuclear energy is the most researched of all power production technologies. Technical issues and health effects are well understood. The nuclear industry and TVA are dedicated to safe and efficient nuclear plant operation.

Nuclear plants supply energy reliably, safely, and with little environmental impact. Nuclear energy plants produce electricity by the fissioning of uranium, not the burning of fuel. As a result, nuclear plants do not pollute the air with sulfur dioxide, nitrogen oxides, dust, or greenhouse gases like carbon dioxide.

BELLEFONTE CONVERSION

296

Comment: *TVA should convert the Bellefonte Nuclear Plant and other unfinished nuclear units to coal. Coal is low-cost, dependable, and plentiful.*

Comment by: Barbara Altizer (Virginia Coal Council), Jan Jones (Tennessee River Valley Association), J. Richard Hommrich (Volunteer Barge & Transport, Inc.), Ed Brooks (Tennessee Southern Railroad)

Response: Energy Vision 2020 includes several options for the coal-fired conversion of Bellefonte Nuclear Plant. One of these options is an integrated coal gasification combined cycle demonstration project that could be the first phase of converting Bellefonte Nuclear Plant to utilize fossil fuels. An 18 to 24-month study is just starting to further assess and

refine the strategy for converting Bellefonte Nuclear Plant. This study will concentrate on both natural gas and coal-fired options, and the value of possible coproducts.

TVA is keeping its options open with respect to its unfinished nuclear units, and among other things will be considering the use of other technologies, such as the use of other fuels like coal.

297

Comment: *Bellefonte Nuclear Plant should be converted to a coal plant because of the economical resources of coal throughout eastern Kentucky, eastern Tennessee, West Virginia, and Virginia. Other conversion options should also include coal.*

Comment by: Ed Brooks (Tennessee Southern Railroad), William Bowker (Kentucky Coal Marketing and Export Council), James Gillum (Tennessee River Valley Association)

Response: Energy Vision 2020 includes several options for the coal-fired conversion of Bellefonte Nuclear Plant. One of these options is an integrated coal gasification combined cycle demonstration project that could be the first phase of converting Bellefonte Nuclear Plant to utilize fossil fuels. An 18 to 24 month study is just starting to further assess and refine the strategy for converting Bellefonte Nuclear Plant. This study will concentrate on both natural gas and coal-fired options and the value of possible coproducts.

Natural gas combined cycle and integrated coal gasification combined cycle repowering of some of TVA's older pulverized coal-fired plants are also considered in Energy Vision 2020.

298

Comment: *The Kentucky Coal Marketing and Export Council wants to assist TVA in analyzing the conversion of the Bellefonte Nuclear Plant to coal gasification.*

Comment by: William Bowker (Kentucky Coal Marketing and Export Council)

Response: TVA is continuing to evaluate the conversion of Bellefonte Nuclear Plant to a coal-fired technology, as well as other technologies. In the process of the ongoing investigations, we expect to be in contact with entities involved with all phases of the project. This will include potential future fuel suppliers. We will be in contact with the Kentucky Coal Marketing and Export Council as appropriate in these studies.

299

Comment: *Cincinnati Gas and Electric converted a nuclear plant that was about 85 percent complete to coal in about two and a half years. The plant has been operating about two and a half years and has been an outstanding success. This is the same situation TVA is facing today.*

Comment by: Ken Wheeler (Midland Enterprises)

Response: We are familiar with the pulverized coal conversion of the Zimmer plant by Cincinnati Gas and Electric with American Electric Power. The Zimmer and the Midlands plants natural gas combined cycle conversions are good examples of successful conversions of nuclear units to alternative fuels.

300

Comment: *The smaller conventional coal-fired units with their predictable costs, construction schedules, performance, reliability, and greater operating flexibility present a very attractive option. Conversion of the Bellefonte Nuclear Plant to a conventional coal-fired facility would also incorporate proven technology.*

Comment by: TVA Retirees Association

Response: The smaller coal-fired units were included in the options for Energy Vision 2020 because they have known characteristics and their size matched well with system expansion rates. A coal-fired conversion of Bellefonte Nuclear Plant was considered. (See Volume 2, Technical Document 6, Figure T6-1, option 7.1.1.2.)

301

Comment: *The coproducts derived from integrated gasification are similar to the methane-based products made at natural gas processing plants. Not only is TVA forecasting higher natural gas prices, TVA is speculating that natural gas prices will be as forecast. TVA is betting that the cost to produce coproducts through coal gasification will be less than the cost to produce through natural gas-based processing. However, given current forward market prices of natural gas and the current stage of commercial development of integrated gasification technology, natural gas processing of coproduct continues to hold an economic advantage. TVA should consider a staged approach to combustion turbine and combined cycle construction—initially firing these plants with natural gas and adding gasifiers when proven technology and economics dictate.*

If TVA used the low case scenario for gas prices, how would TVA's revenues from coproducts affect total project costs?

Comment by: Tennessee Valley Public Power Association, Henry Nickell (Memphis Light, Gas and Water Division)

Response: TVA recognizes that there are several uncertainties with the integrated gasification combined cycle plant with the production of a chemical coproduct. Two of the key uncertainties are the price of natural gas and the uncertainty in future coproduct prices. The uncertainty in chemical coproduct prices is evaluated with the uncertainty in natural gas prices in Volume 1, Chapter 9, pages 9.28 and 9.29. Lower prices for the chemical coproduct based on the lower natural gas prices reduce the value of the integrated gasification combined cycle with the production of the chemical coproduct as indicated in Volume 1, Chapter 9, Figure 9-18.

Recognizing there are potential risks with an integrated gasification combined cycle with chemical coproducts, the Energy Vision 2020 short-term action plan recommends further investigation of this and other viable options at Bellefonte. These investigations will also examine a staged approach to converting Bellefonte. The investigation should be completed within 18 to 24 months.

302

Comment: *Memphis Light, Gas and Water would prefer to see TVA, a government agency, refrain from such high risk, pioneering type activities as coal gasification and selling of coproduct. Private industry financing is better suited for these types of business risks. What success has TVA had in the methane-based coproducts industry?*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: TVA recognizes that there is a degree of risk associated with coal gasification and coproduction of chemicals. The risks associated with coal gasification and coproduction will be addressed in the proposed evaluation and development of an integrated gasification combined cycle demonstration project under the Clean Coal Technology program of the Department of Energy. In addition, the risks will be assessed in an 18 to 24 month study on various aspects of commercial development of gasification and coproduction. (See Volume 1, Chapter 10, Figure 10-1.) Also, the integrated gasification combined cycle options used in Energy Vision 2020 designated "with partners" (e.g., options 7.1.1.6 and 7.1.1.7, Volume 2, Technical Document 6, Figure T6-1) assumed that the gasification plant was wholly owned and operated by the partner, not TVA, and that TVA purchases syngas from the partner. One of the goals of the 18 to 24 month study will be to recommend any future integrated gasification combined cycle commercial development.

With respect to the risks of chemical coproduction, the 18 to 24 month study in the Energy Vision 2020 short-term action plan will study the various risks of coproduction in more detail. TVA gained some experience in the coproduction of chemicals from synthesis gas from a coal-gasification facility operated at our Muscle Shoals facilities. Another of the goals of the 18 to 24 month study is to determine a recommended course of action with respect to TVA ownership and operation of coproduction facilities in conjunction with future integrated gasification combined cycle commercial development.

303

Comment: *Will the market for methyl tertiary butyl ether be greatly diminished if electric or natural gas-burning vehicles replace gasoline-burning vehicles in non-attainment areas? Will ethanol dominate the market for fuel additives, reducing expected methyl tertiary butyl ether demand? Methyl tertiary butyl ether competes with ethanol additives produced from agricultural products. Significant expansion can occur quickly in agriculture to offset upwardly moving natural gas prices and, hence, increasing costs of methyl tertiary butyl ether.*

Comment by: Tennessee Valley Public Power Association

Response: The short-term action plan recommends an 18 to 24 month study to review the economics and assumptions that have been used for the conversion of Bellefonte, including an integrated gasification combined cycle/coproduction facility. The data presented in Energy Vision 2020 is based on studies performed by reputable consultants in the chemical market and price forecasting field. However, a more detailed evaluation of the potential chemical markets and range of prices will be performed as part of this study. This study will revisit the range of chemicals that can be produced from synthesis gas, prepare a market forecast for the more attractive of these chemicals, and prepare a range of price forecasts for these chemicals based upon market variability. It is likely that a range of coproducts would be selected for production with the intent of providing a hedge on the loss of a particular chemical market by diversity of chemicals being produced.

304

Comment: *The impact statement (see Volume 1, Chapter 9, Figure 9-34, Long-Term Plan) specifies that siting and engineering for a combined cycle plant will supply base-load power. Do you not mean building and operating a combined cycle plant will supply base-load power?*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: Building a combined cycle plant with siting and pre-engineering to supply base-load power is recommended in TVA's short- and long-term action plans. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) Investing in siting and pre-engineering can shorten the lead time for the plant, thus making the option more flexible.

305

Comment: *The natural gas combined cycle option did not prove economically competitive based on the assumptions employed by TVA in the analysis. The natural gas combined cycle option was assumed to have a capacity factor of 40 percent, while the integrated gasification combined cycle and pulverized coal options were assumed to be base-loaded at a capacity factor of 85 percent. Burns & McDonnell was told this was a "dispatching decision," implying that a production cost model such as MIDAS was not allowed to dispatch the option based on relative economics. Based on the TVA estimates for both capital and operating and maintenance costs for these three options, if the capacity factors were equivalent, the natural gas combined cycle would likely prove the most economical.*

Another factor impacting the natural gas combined cycle's economics was the inclusion of selective catalytic reduction for nitrogen oxides control. TVA's selective catalytic reduction trigger level is 25 parts per million nitrogen oxides or less. This can now be routinely achieved through commercially available dry low nitrogen oxides burner technology. Elimination of the selective catalytic reduction requirement would further improve natural gas combined cycle economics.

Comment by: Tennessee Valley Public Power Association

Response: The selection of 85 percent capacity factor for base-load options such as integrated gasification combined cycle and pulverized coal units versus 40 percent capacity factor for natural gas-fired combined cycle units is based on how these various unit types would be economically dispatched on the TVA system. As a result, those units that have low fuel costs and good heat rates will run at a higher capacity factor than units with higher fuel costs and comparable heat rates.

With respect to the installation of selective catalytic reduction controls on a combined cycle unit, TVA recognizes that dry low-nitrogen oxides burners are available that can achieve less than 25 parts per million using natural gas. However, if the unit operates for a significant period of time on fuel oil during a natural gas curtailment, low nitrogen oxides burner controls may not meet emission limitations. Inclusion of selective catalytic reduction controls better ensures compliance. Natural gas combined cycle is a cost-effective option if constructed using a staged construction process. (See Volume 1, Chapter 9, Figure 9-14.)

306

Comment: *Converting Bellefonte Nuclear Plant to natural gas is feasible; future gas prices will be stable enough to allow this. Converting to coal gasification in conjunction with a partner also remains a viable option.*

Comment by: William Pippin (Huntsville Utilities)

Response: Your comment has been reviewed and noted.

307

Comment: *The conversion of Bellefonte Nuclear Plant to a combined cycle plant using natural gas appears to be a desirable option. The possibility of using coal gasification technology, however, is risky, especially in today's highly competitive marketplace.*

TVA's plan for an independent engineering study of the Bellefonte Nuclear Plant conversion option is definitely needed. We hope the use of either coal gasification and/or a coproduct line with this conversion will carefully consider the risks of commercially untried technology and the questionable growth potential of the methyl tertiary butyl ether market.

Comment by: Tennessee Valley Public Power Association

Response: TVA recognizes that the risk of an integrated gasification combined cycle plant is greater than for more conventional technology. Recognizing this risk, the short-term action plan recommends an 18 to 24 month independent study to review the viable Bellefonte Nuclear Plant conversion options.

This study will assess the chemical coproduction market and sales potential. TVA would pursue commercialization of integrated gasification combined cycle technology and coproduction of chemicals only if the project meets TVA's objectives.

308

Comment: *To reduce pollution caused by TVA coal-burning plants, we urge the use of only natural gas, as in converting the Bellefonte Nuclear Plant to a combined cycle plant. Landfill methane and coalbed methane (natural gas) should be considered as clean fuel possibilities for TVA plants.*

Comment by: Powell & Sharon Foster, Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA is considering both natural gas and coal-fired alternatives for conversion of Bellefonte Nuclear Plant. The coal-fired alternatives utilize emissions control technologies that meet or exceed the currently recognized Best Available Control Technology (BACT). As a result, the emissions from any of the coal-fired options would be equivalent to or below the emission rates from any existing TVA coal-fired plant.

Landfill and coalbed methane are not likely fuels for a conversion of other TVA plants due to their locations. However, these options have been identified in the short-term action plan for further investigation. (See Volume 1, Chapter 10, Figure 10-1.)

309

Comment: *When converting Bellefonte Nuclear Plant, TVA should consider the use of biomass as fuel, provided this is not whole logs. Using short rotation woody crops, residual wood waste, and sawdust helps with a solid waste disposal problem and will burn cleaner than coal. Other advantages are that it recycles carbon and helps with the greenhouse warming problem, will decrease forest fragmentation, and will increase use of reserve lands.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: The conversion of Bellefonte Nuclear Plant to an integrated gasification combined cycle plant using biomass was considered early in the Energy Vision 2020 process. However, this option was eliminated from further analysis due to its high cost. TVA is actively investigating other biomass options, and this has been included in the short-term action plan. (See Volume 1, Chapter 10, Figure 10-1.)

CUSTOMER SERVICE

310

Comment: *I am satisfied with the quality of TVA's service and the price. I do not believe TVA should become a national leader in demand-side management/energy conservation. I do not want electricity usage restricted in even a minor way.*

Comment by: L. George Hannye

Response: TVA's objective in Energy Vision 2020 was to enhance the quality of its services and to maintain the competitive price of its electricity. Using a multi-attribute trade-off method, TVA evaluated a large number of supply-side and demand-side options to accomplish this. This resulted in recommended short- and long-term plans that include cost-effective supply- and demand-side management options which perform well across all evaluation criteria, including rates and reliability.

311

Comment: *It is not clear in the plan how much energy savings would or could result from demand-side management options in TVA's long- and short-term plans? What effect would or could these options have on the need for new power plants? If demand-side management negates the need for a new plant or the need to finish a nuclear plant, is the plan flexible enough to allow this?*

Comment by: Naomi Furman Kipp (Legal Services Corporation of Alabama)

Response: The demand-side management programs recommended for implementation in the Energy Vision 2020 short-term action plan represent 650 megawatts of capacity savings by the year 2002. (See Volume 1, Chapter 10, Figure 10-1.) This capacity savings would be in lieu of building 650 megawatts of supply-side options. These demand-side management programs continue to provide additional capacity savings, up to approximately 2,200 megawatts by the year 2010. The capacity savings represented by any demand-side management program are fully integrated into each strategy identified in Energy Vision 2020.

312

Comment: *Options that improve customers' comfort, and energy efficiency and help them save money will improve customer loyalty and satisfaction.*

Comment by: Ann Lamb

Response: The customer service options included in the Energy Vision 2020 short-term action plan and the long-term plan are designed to increase customer value, comfort, and energy efficiency and lower energy bills.

313

Comment: *TVA should build brand recognition in its product and in its corporate name. This can be done by giving the citizens more customer service options.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: As part of Energy Vision 2020, TVA considered many customer service options with a wide range of technologies, promotion strategies, and costs. The options that

were included in the Energy Vision 2020 short-term and long-term action plans were selected based on the evaluation criteria for Energy Vision 2020 including their resource cost, the ability to minimize any rate impact, and their potential to enhance customer value. By selecting options that maximize customer value, TVA will build brand recognition in its product and in its corporate name for itself and for the distributors partnering with TVA to offer the customer service options.

314

Comment: *Most of the power TVA sells to its distributors goes to residential customers. TVA should be more concerned about the residential customers because they are TVA's primary customers. You need to focus more on energy efficiency and be an energy service company.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Debra Jackson

Response: TVA realizes the importance of the residential customers. TVA also realizes that the distributors of TVA power may soon find themselves in a market similar to the long distance telephone industry, with competition based both on price and value-added services.

The long-term plan in Volume 1, Chapter 9, sets forth a range of actions TVA can take to meet future needs of its customers. This portfolio of resource options enables TVA to meet the objective of balancing cost, rates, environmental impact, debt, and economic development. This long-term plan relies on a balance of supply-side options as well as demand-side management and beneficial electrification to meet customers' needs. Some examples of the recommended demand-side management programs include energy efficiency improvements, residential new construction, and commercial and industrial energy services to improve demand-side management. Some examples of beneficial electrification include residential heating, air-conditioning, and water heater programs.

315

Comment: *While there are persistent problems with how demand-side management can be provided equitably and cost-effectively, the long-term plan should explore mechanisms for addressing these problems.*

Comment by: Mary English (University of Tennessee)

Response: TVA has begun to address the issue of providing demand-side management programs equitably and cost-effectively in its short-term action plan. In developing customer service options, TVA studied both the past and current demand-side management activities of other utilities. While aware of the past program successes of other utilities, TVA also notes the current evolution of demand-side programs. This evolution includes moving away from programs with large rebates and cross-subsidies. Many utilities are developing new programs that are more market-driven with greater emphasis on customer value.

TVA plans to test several new demand-side program strategies through programs identified in the short-term action plan. For example, TVA's plan includes an Energy Efficiency Catalog and Retail program to build the infrastructure for energy-efficient technologies and to provide value-added services to residential customers. The short-term action plan also includes an aggressive and innovative program for commercial and industrial customers. The Comprehensive Measure Financing option from Block 1 was expanded to over twice its original level to form the Commercial and Industrial Energy

Services option. This program addresses the expanding market for energy services and includes funding for incentives targeted to lost opportunities in new construction and market transformation activities. Through these and other programs, TVA hopes to test new delivery strategies designed to address the problems of providing demand-side management equitably and cost-effectively over the long term.

316

Comment: *TVA should explain how it will decide to convert a pilot program into a permanent program, particularly with respect to low income programs.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition), Naomi Furman Kipp (Legal Services Corporation of Alabama), Martha McGill

Response: Demand-side management programs can be started at the pilot (reduced scale) level for various reasons. Some programs are started at the pilot level because of equipment concerns or limitations of availability, others to provide flexibility, and others to evaluate uncertain energy and demand impacts. Some programs are started at the pilot level to evaluate a new delivery mechanism or to develop the necessary cooperative relationships for cost-effective implementation as in the case of the low income program. Depending on how these various issues are resolved, a pilot program may be scaled up to a full program.

In Energy Vision 2020, flexible demand-side management programs have replaced pilot programs. The flexible demand-side management options will be implemented at a reduced scale at first, but can ramp up quickly in response to resource needs. Flexible demand-side management programs have been identified. The programs are similar to the flexible supply-side options. These flexible demand-side programs have two phases of development. In the first phase, the programs are tested in the marketplace as experiments or pilot programs. The flexible demand-side management programs would add 50 megawatts by 2002 and potentially 750 megawatts by 2010.

317

Comment: *In the long-term plan, there is no description of implementation of a low income program; in fact, the low income sector is not even mentioned.*

Comment by: Naomi Furman Kipp (Legal Services Corporation of Alabama), Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA is working with community action agencies to implement the Residential Low Income program, which is included in both the long-term and short-term plans of Energy Vision 2020. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) The program will quickly survey a low income residence, install cost-effective weatherization measures, and provide education about saving energy to the homeowner. Included in the program are compact fluorescent lights, low flow showerheads, as well as pipe insulation, water heater tank wraps, heating, ventilation, and air conditioning maintenance, and attic insulation where cost-effective.

318

Comment: *While solar photovoltaics is listed as an option in Volume 1, Chapter 7, page 7.4, it is not included in any of the options considered in Volume 1, Chapter 7, Figures 7-6A*

through D. Contrast this with what other utilities are doing, such as Pacific Gas and Electric and Niagara Mohawk Power Company.

Comment by: Andrew Danzig

Response: Photovoltaics is not among the supply-side options identified in Volume 1, Chapter 7, Figures 7-6 A through D. These figures do not show all of the options considered. The full list of options considered is included in Volume 2, Technical Document 6, Figure T6-1. Figure T6-1 provides summary evaluation information for the large array of supply-side options considered in Energy Vision 2020. Option 1.3.3.1, included in Figure T6-1, is a large solar photovoltaic fixed flat plate power plant.

Photovoltaics was also included in the customer service options as a miscellaneous program. (See Volume 2, Technical Document 8, Figure T8-18, and the description of the program in Volume 2, Technical Document 7, pages T7.66 to T7.69.) Current and expected future (technology advancement) photovoltaic system costs were included.
The recommended short-term plan includes research and development of distributed generation, including end-use solar photovoltaics. (See Volume 1, Chapter 10, Figure 10-1.)

319

Comment: *Beneficial electrification and off-system sales should be reconsidered given their effects on increased carbon dioxide emissions and other emissions.*

Comment by: Arthur Smith, Eric Hirst (Oak Ridge National Laboratory)

Response: Beneficial electrification options include technologies that take advantage of the unique characteristics of electricity and improve productivity and quality for TVA customers. The use of electrotechnologies in manufacturing could reduce adverse environmental impacts. Generally, electrotechnologies limit emissions to those produced by an electric generating plant in contrast to the combustion of fuel oil or natural gas by the end user. Emissions are more easily and efficiently controlled at the generating plant. Energy Vision 2020 reviewed beneficial electrification options, transportation, and electric manufacturing technologies, as well as commercial and residential options for cooking, heating, security lighting, and water heating.

TVA off-system sales provide revenue and help to keep rates low for Valley ratepayers. In addition, off-system power sales allow other interconnected utilities to buy reliable power when experiencing critical peak load conditions. If TVA did not sell power to these utilities, they would purchase it from some other system which may operate more polluting-generating sources than TVA. As mandated by the Clean Air Act, TVA has reduced its emissions of sulfur dioxide by 50 percent between 1976 and 1990 and expects to achieve an 80 percent reduction from 1976 levels when it completes actions to comply with the 1990 Clean Air Act Amendments. It also expects to reduce nitrogen oxides emissions by up to 50 percent.

320

Comment: *TVA may be focusing too much on encouraging load growth, without clearly explaining how this would benefit customers and the region.*

Comment by: Mary English (University of Tennessee), Jason Gurley, Stephen Smith (Tennessee Valley Energy Reform Coalition), Eric Hirst (Oak Ridge National Laboratory), Robert Schreiber (Common Sense), Sam Denham, Sharon Fidler (League of Women Voters)

Response: TVA is encouraging economic development and the efficient use of energy. One method of encouraging economic development is by keeping electric rates low, which attracts industry to the region, thus providing jobs to people in the region. The low electric rates also contribute to the low cost of living, which benefits customers and everyone in the region. These activities result in load growth.

TVA is a non-profit entity, and the revenue produced by the power system is used to cover the costs of producing electricity.

321

Comment: *The restructuring of the electric utility industry will have a tremendous impact on TVA's Energy Vision 2020. Large industrial customers are forcing electric utilities to become more competitive in rates. Utilities all across the country are starting to jettison things that are not competitive. This has caused TVA to rethink recommitments in the areas of energy efficiency and conservation. Rather than committing to 5,500 megawatts of demand-side management, TVA is only looking at 600. TVA feels they have got to do this to be competitive.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: The restructuring of the utility industry is expected to have a significant effect on TVA. Increasing competition will force utilities to be as cost-effective and customer-driven as their individual situations allow. Energy Vision 2020 is helping TVA prepare for this. Energy Vision 2020 took into account the potential effects of increased competition, and TVA has been able to produce a plan that proposes 650 megawatts of demand-side management in year 2002 and up to 2,200 megawatts by 2010.

ENVIRONMENTAL CONTROLS

322

Comment: *TVA should explain how it intends to meet the requirements of the 1990 Clean Air Act Amendments.*

Comment by: David Bordenkircher

Response: TVA's strategy to comply with the 1990 Clean Air Act Amendments is discussed in Volume 1, Chapter 7, pages 7.9 and 7.10. The emission control options are listed as including scrubbers, fuel switches, alternative fuels (e.g., natural gas), repowering with new lower emitting power plant technology, allowances, and increased use of demand-side management options (e.g., conservation) and renewable energy sources. The "reference case" strategy was developed as a basis for comparison of all potential options. This reference case includes a mixture of low sulfur coal switches at most of TVA's fossil plants plus a limited number of sulfur dioxide scrubbers on a few TVA plants, along with the addition of nitrogen oxides reducing burners and burner systems on almost all of TVA's fossil plants. This is one of many strategies developed for TVA compliance with the 1990 Clean Air Act Amendments.

323

Comment: *TVA should not rely just on additional scrubbers for its Phase II Clean Air Act strategy, because they control only sulfur dioxide and make carbon dioxide emissions worse.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Nancy Bell

Response: TVA has not decided to deploy additional scrubbers for Phase II Clean Air compliance. We know scrubber cost, schedule, and performance characteristics very well. Although they contribute to other environmental problems, scrubbers work well. We are assessing other technologies and control strategies in an attempt to identify better performing, lower cost environmental options.

324

Comment: *TVA's Clean Air Strategy simply uses banked credits from installing scrubbers to delay implementation of Phase II controls. This is not an environmental leadership position. Rather, TVA should increase efficiency by bringing on zero emission technologies. It can then sell its credits to pay down the debt. The Environmental Protection Agency has money for utilities that seek to use conservation and renewables to comply.*

Comment by: John van der Harst, Hamp Dobbins, Jr., Stephen Smith (Tennessee Valley Energy Reform Coalition), Catherine Murray (Sierra Club, State of Franklin Group)

Response: TVA's Clean Air Act Phase II strategy has not yet been developed. The addition of scrubbers at Cumberland Fossil Plant in Phase I of TVA's Clean Air Act strategy resulted in overcompliance by TVA earlier than required by the 1990 Clean Air Act Amendments. TVA determined that early installation of scrubbers at Cumberland Fossil Plant benefited the TVA ratepayers. TVA did reserve "bonus" allowances or credits for installing these scrubbers. This provides TVA flexibility in scheduling subsequent sulfur dioxide reduction measures. However, early compliance at Cumberland Fossil Plant means that emissions at the plant were reduced early.

The Environmental Protection Agency does not have money for utilities seeking conservation or renewables, but they do have a conservation and renewable energy reserve of 300,000 special bonus allowances set aside to reward new initiatives in demand-side efficiency and renewable energy. TVA assessed the possibilities associated with the program in the 1992-1994 time period and found that the initiatives were not sufficient to change the strategy toward more conservation or renewable options. TVA's deadline for joining the program and earning these bonus allowances ended January 1, 1995.

325

Comment: *TVA could meet its Phase II Clean Air Act requirements entirely through conservation. Renewables could also play a role. How much would a 1 percent investment in conservation contribute to emission reductions and meeting TVA's Phase II requirements?*

Comment by: Eileen McIlvane (Coalition for Jobs and the Environment)

Response: Assuming an expenditure of 1 percent per year of TVA's 1994 annual gross revenue ($5.4 billion) on conservation program activities spread from 1996 through 1999 (Phase II compliance begins in 2000) and assuming all of the conservation programs are successful, TVA projects an annual savings of 1.8 billion kilowatt-hours of avoided power generation beginning in 2000. Further assuming that all of this avoided power is fossil generation and projecting a TVA fossil system generation load of 101 billion kilowatt-

hours in 2000, this amounts to a 1.8 percent reduction in projected fossil generation and sulfur dioxide, and related emissions. Sulfur dioxide reduction limits under Phase II of the 1990 Clean Air Act Amendments require TVA to reduce sulfur dioxide emissions by almost another 50 percent below present 1995 emission levels. Therefore, a 1 percent investment in conservation would eliminate only 1.8 percent of the required 50 percent additional reduction, or only about 4 percent of the total sulfur dioxide reduction requirement.

326

Comment: *Install more pollution control devices to reduce emissions which contribute to acid rain.*

Comment by: Hamp Dobbins, Jr.

Response: TVA estimates spending for the pollution control measures associated with the 1990 Clean Air Act Amendments will be approximately $2.3 billion for related capital expenditures with annual operating costs (including fuel switches) exceeding $300 million per year. (See Volume 1, Chapter 4, page 4.8.) As a result of these expenditures, TVA's contribution to acid rain will be significantly reduced.

327

Comment: *The buying of allowances rather than scrubbing coal plants affects the image of the South and needs to be considered as an externality.*

Comment by: John van der Harst

Response: The ability to transfer an allowance (the authorization to emit one ton of sulfur dioxide) from one source to another while limiting sulfur dioxide emissions on a national basis is a fundamental innovation of the 1990 Clean Air Act Amendments. The intent of this innovation was to achieve the national objective of reducing atmospheric loadings of sulfur dioxide while allowing the marketplace to determine where the reductions could be achieved most cost-effectively. The approach has worked. Control costs have been reduced by approximately 50 percent over what would have been spent to achieve the same level of reductions under a source-by-source, command-and-control program. The buying and selling of allowances on the open market offers the opportunity for even more savings.

TVA is acutely aware, however, that many of its customers do not support the allowance-trading concept—particularly if the trade involves TVA purchasing allowances from outside its service territory. We participated in the first inter-utility allowance transaction, purchasing 10,000 allowances. Although this purchase represents a small fraction of TVA's annual reduction requirement, it generated a great deal of controversy and adverse reaction from the public. There is opportunity for reducing the cost of compliance by participating in the allowance market. However, public opinion and the potential to harm TVA's image as environmentally responsible will certainly be considered in future decisions to purchase allowances.

328

Comment: *Based on its past experience with allowance purchases, TVA does not appear to be willing to consider sulfur dioxide allowance purchases as a compliance option at this time. TVA plans to comply with sulfur dioxide limitations by making modifications within*

its own utility system. This is a sound approach as long as the cost of reducing sulfur dioxide emissions from TVA's plants is lower cost than the price of sulfur dioxide allowances. If the cost of sulfur dioxide allowances ever drops below TVA's cost of reducing sulfur dioxide emissions from its plants, TVA will be incurring additional costs by fuel switching, for example, rather than purchasing allowances.

Comment by: Tennessee Valley Public Power Association

Response: TVA has assessed the purchase of sulfur dioxide allowances for compliance with the 1990 Clean Air Act Amendments. TVA does not at this time anticipate buying allowances for compliance purposes, but we are continually reviewing our compliance strategies and would consider allowance purchases if this becomes appropriate.

SUPPLY SIDE

329

Comment: *Recognizing every form of electricity generation including nuclear power has positive and negative values, TVA should continue to look for ways to provide its customers reliable and efficient electric power at competitive prices.*

Comment by: Paul Amon (Amon Consulting), Tennessee Valley Industrial Committee

Response: The Energy Vision 2020 long- and short-term plans contain a portfolio of conservation and supply-side generation options which provides the best mix of options to TVA and its customers. These options will provide customers a reliable source of power at competitive prices, perform better environmentally, increase economic development, and mitigate risks.

330

Comment: *Our future is linked to coal in a cost-effective electric society. TVA should continue to look for ways to take advantage of the coal resources in the region.*

Comment by: James Gillum (Tennessee River Valley Association), Barbara Altizer (Virginia Coal Council)

Response: Both traditional technologies (e.g., coal plants, combustion turbines), as well as potential renewable and advanced technology facilities, have their place in TVA's proposed portfolio of resources. This is identified in both the long-term plan and short-term action plan where gas-fired, coal-fired, wind turbine, and hydro-driven resources provide a robust set of resource options allowing TVA diversification among fuel types to help mitigate risk of future fuel prices. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

331

Comment: *The Kentucky Marketing and Export Council strongly supports the options in the plan that utilize coal. We believe that a coal-centered strategy ensures abundant, reliable, low-cost, environmentally sound energy for the region. This also supports TVA's core mission—economic development. Coal provides low-cost power, jobs, coal mining, and transportation, which are vital to the region. Seventy-eight percent of TVA's coal comes from Kentucky, Tennessee, Alabama, and Virginia.*

Comment by: William Bowker (Kentucky Coal Marketing and Export Council)

Response: Both traditional technologies (e.g., coal plants, combustion turbines), as well as potential renewable and advanced technology facilities, have their place in TVA's proposed portfolio of resources. This is identified in both the long-term plan and short-term action plan where gas-fired, coal-fired, wind turbine, and hydro-driven resources provide a robust set of resource options allowing TVA diversification among fuel types to help mitigate risk of future fuel prices. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) Both direct and indirect economic development impacts including jobs were considered for each final strategy.

332

Comment: *The Tennessee River is exceptional for its ability to move coal in an environmentally friendly way. This should be considered as an asset.*

Comment by: Ken Wheeler (Midland Enterprises)

Response: Your comment has been reviewed and noted.

333

Comment: *TVA should support more use of fluidized bed combustion.*

Comment by: Jim Golden

Response: TVA has been a proponent and supporter of fluidized bed combustion technology over the years. TVA built a 20-megawatt atmospheric bubbling fluidized bed combustor pilot plant followed by a 160-megawatt atmospheric fluidized bed combustion plant. The demonstration plant continues to operate successfully as part of TVA's Shawnee Fossil Plant. In addition, atmospheric circulating technology, as well as pressurized fluidized bed technology, are included in the options considered in the Energy Vision 2020 process.

334

Comment: *Energy Vision 2020 includes repowering in the extensive list of options. Repowering or replacement of at least some of the coal-fired units would appear to be likely enough that those options should be specifically included in both the short-term and long-term plans. It would certainly seem prudent to keep Energy Vision 2020 flexible enough to include repowering or replacing at least some of these aging units as the need should arise.*

Comment by: TVA Retirees Association

Response: The long-term plan in Energy Vision 2020 (see Volume 1, Chapter 9, Figure 9-23) includes combined cycle repowering of coal-fired units. The long-term plan provides the guidance and flexibility to revise the short-term action plan as future conditions change.

335

Comment: *Conceptually, the Environmental Protection Agency is supportive of justified power generation alternatives that upgrade existing facilities through repowering, cogeneration, coproduction, and/or conversion. Power purchasing (for base-load or peak power) outside the TVA network or power transmission within the TVA network are also*

noteworthy in lieu of new construction if the power generation infrastructure is already in place and licensed. Therefore, for conventional energy sources such as fossil-fuel and hydroelectric plants, utilization of existing sources is preferred over construction of new generation sources if they are environmentally sound or can be upgraded to be more efficient and therefore environmentally improved.

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Your comment has been reviewed and noted.

336

Comment: *Clean coal technologies such as integrated gasification combined cycle technologies for new power generation or conversion of existing conventional facilities also provide environmental benefits. Integrated gasification combined cycle plants produce less air emissions (pollution prevention), increase efficiency (e.g., heat reuse) and often produce a usable byproduct (recycling) when compared to conventional systems such as a pulverized coal power plant, and still allow the use of domestic coal at a level environmentally competitive with natural gas. As such, if a new coal-fired unit is proposed at Shawnee, consideration should be given to alternatively making it an integrated gasification combined cycle plant for cleaner coal use or making it a natural gas unit which is environmentally superior to coal or fuel oil.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: The use of clean coal technologies for repowering have many desirable features. Typically, they exhibit improved cost of production along with reduction in emissions. However, their viability in repowering an existing facility is specific to the facility involved. In the case of Shawnee, the proposed Unit 11 consists of building a new steam cycle in order to utilize one of the existing boilers that has been taken out of service. When the 160-megawatt atmospheric fluidized bed combustion unit was built, it was connected to the existing Unit 10 steam turbogenerator and to the Unit 10 flue gas handling system. The existing Unit 10 boiler was taken out of service and layed-up in such a way that future recommissioning would be possible. The Unit 11 project would provide the atmospheric fluidized bed combustion unit with its own steam turbogenerator, flue gas handling system, and associated equipment while allowing the old Unit 10 to be returned to its original configuration and resume operation.

337

Comment: *If TVA continues its trend of being heavily committed (57 percent) to burning coal to generate electricity, we recommend that continued refinement of control technologies be employed for new and repowered power plants and that existing plants be retrofitted to minimize emissions such as sulfur oxides, nitrogen oxides, volatile organic compounds, and mercury.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Consistent with applicable environmental requirements, including new source review and new source performance standards that are promulgated by the U.S. Environmental Protection Agency, TVA would employ appropriate, refined emission control technologies at any new or repowered coal-fired plants. TVA is in the process of employing additional emission control strategies at its existing coal-fired units.

Energy Vision 2020 considered several different environmental control options and several options for the repowering of existing coal-fired units. (See Volume 1, Chapter 7.)

338

Comment: *In Volume 1, Chapter 9, Figure 9-3, what does 1.3 percent cofiring mean? Is 1.3 percent of the coal displaced by biomass? Does it apply to all coal units? Why is so little coal displaced by cofiring; the biomass numbers seem very low.*

Comment by: Eric Hirst (Oak Ridge National Laboratory)

Response: In Volume 1, Chapter 9, Figure 9-3, the term 1.3 percent wood waste cofiring refers to the fraction of fuel energy to the TVA coal-fired generating system that would be provided by wood waste. Specifically, 1.3 percent of the coal system's total energy input would be provided by wood waste. This applies to the entire TVA coal-fired system. Based on wood waste resource assessments of the TVA region, this is the amount of currently unutilized wood waste that would be available to TVA. This would displace about 500,000 tons of coal. As TVA further investigates the use of biomass, additional sources of wood waste may be identified.

339

Comment: *TVA should expand the wood residue cofiring project.*

Comment by: Sharon Fidler (League of Women Voters)

Response: Biomass cofiring has been assessed in Energy Vision 2020 and proposed for implementation in the short-term action plan. The precise scope and magnitude of the program will depend on further evaluation of its economic and environmental effects. As TVA learns more about the wood waste market, considerably more wood waste may be available at favorable costs than currently expected. If this situation develops, the program could be expanded.

340

Comment: *TVA is not on the cutting edge of cofiring technology (coal/wood). TVA is late coming to this, but it is still the right thing to do at 4 to 10 percent heat input rates.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: TVA has been closely following and participating in the development of wood cofiring (biomass) at coal-fired power plants. TVA has several mechanisms in place to keep up to date on this technology. These include technical discussions with other utilities including Southern Company, Northern States Power, and Santee-Cooper regarding their experiences with wood cofiring. TVA is also a member of the Southeast Bioenergy Roundtable in which all forms of bioenergy are topics of discussion. TVA has also participated with Electric Power Research Institute in wood cofiring projects.

TVA has completed cofiring test burns at three of its coal-fired units to determine the technical limitations of cofiring biomass at these different types of units (cyclone, wall-fired pulverized coal, and tangentially-fired pulverized coal). TVA has now initiated pre-commercial demonstration cofiring to determine the long-term impacts of cofiring on plant operating and maintenance costs and to verify biomass cost and availability. With the successful conclusion of these demonstrations, TVA expects to initiate permanent

commercial cofiring at one or more plants. The short-term action plan identifies cost-effective biomass use as a recommended option. (See Volume 1, Chapter 10, Figure 10-1.)

341

Comment: *Although use of short growth-cycle products or chipping of products grown on abused or unused land is merited, nothing would prevent chipping our limited forests to meet a large biomass demand.*

Comment by: Clark Buchner (Sierra Club, Tennessee Chapter), Powell & Sharon Foster

Response: These products are referred to as short rotation woody crops in Energy Vision 2020. Monitoring of short rotation woody crops suppliers is one way of safeguarding against the chipping of existing forests. This and other safeguards will be considered by TVA.

342

Comment: *I am opposed to biomass, burning trees. Use of biomass has led to whole-tree removal in the past.*

Comment by: Dolores Howard, Dennis Haldeman, Bruce Wood

Response: Energy Vision 2020 recommends implementation and/or research into several biomass uses. None of these uses recommend whole-tree removal from natural forests. (See Volume 1, Chapter 10, Figure 10-1.) Monitoring of biomass suppliers is one way of safeguarding against the chipping of existing forests. This and other safeguards will be considered by TVA.

343

Comment: *Biomass cofiring and studies should be abandoned. There is no way to keep hazardous chemicals from tires and solid waste out of the stream.*

Comment by: Powell & Sharon Foster

Response: TVA proposes to implement cost-effective biomass cofiring at several of its coal-fired generating plants. The biomass that would be used is currently unutilized wood waste from primary and secondary forest products industries. This wood waste would primarily be in the form of sawdust. Only wood waste from processes using untreated, unpainted wood will be acceptable. This material would be processed and screened so that the material is of the proper size to ensure complete combustion and to eliminate any foreign material. These wood waste specifications and the processing would ensure that no hazardous materials are introduced to the boilers with the fuel.

At the plants in which wood waste cofiring is implemented, wood fuel would displace coal so that less coal would be burned. Since wood has negligible sulfur content and lower ash content than coal, sulfur dioxide emissions and fly ash production from the plant would be reduced relative to the plant being fueled with coal only. The carbon dioxide emitted from burning wood is part of the naturally occurring carbon cycle, so there are no net carbon emissions to the atmosphere. This is not the case when fossil fuels are burned. If the wood waste were not cofired in TVA plants, it would most likely be disposed of by landfilling, where it would decompose into carbon dioxide and methane. These effects show the environmental benefits that would be realized from cofiring wood waste at TVA coal-fired plants.

344

Comment: *By working with community and county governments, TVA should be able to pick up some biogas-fired capacity at landfills and wastewater treatment plants. Many communities are expanding or need to expand their wastewater treatment facilities. By adding anaerobic digestion to their treatment plant, they can improve their effluent quality and generate several megawatts of power, but they are cash strapped. TVA should be investing with them and selling power at an industrial rate and should reduce dependence somewhat on coal-fired power. TVA should also take advantage of methane mitigation credit, which would occur by supporting landfill and water treatment biogas production. The wastewater treatment facilities are solid units which will be here for a long time to come and will produce a consistent supply of gas which could be used in either peaking or base-load mode. Decatur, Alabama has a facility which is an excellent example of anaerobic digester technology with biogas utilization. TVA should be talking to every community about this. TVA would add very little net power to the grid from these type plants, but the partnerships with the communities would be very valuable. There is a potential for many small, but highly reliable methane-fueled generation facilities throughout the Valley at landfills and wastewater treatment plants.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: TVA has done a preliminary investigation of the potential for methane fuel from landfills and wastewater treatment plants. The Energy Vision 2020 short-term action plan (see Volume 1, Chapter 10, Figure 10-1) includes further research and development on use of landfill methane. This would also be applicable to methane from wastewater treatment plants. This research and development program may lead to the consideration of this option for implementation in the long-term plan.

345

Comment: *TVA's mission is one of regional resource development with the goal of economic development coupled with stewardship of the region's natural resources. The production of low-cost power is quite an attractive selling point for recruitment of industry, but the package of reasonable, low-cost power, low-cost water resources (both potable and treated water), and a reasonable solid waste policy is a better recruitment tool. Waste-to-energy plants and biogas plants are not the lowest cost power, but the synergistic effect of their power production and control of environmental problems at the community level places the region in a much more competitive position for the long term.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: TVA evaluated a broad range of supply-side options. The renewable options include several biomass technologies, wind turbines, photovoltaics, landfill and coalbed methane recovery, and technologies that burn garbage as a fuel.

While the cost of power is an important consideration, TVA also considered other criteria including the environmental impacts, rates, reliability, economic development, financial requirements, and risk management. The proposed long-term plan or portfolio (see Volume 1, Chapter 9, Figure 9-23) balanced TVA's goals and objectives, as well as the concerns and values of the public.

346

Comment: *In the report, there is a notable lack of interest in building large base-loaded power stations; recognizing the large capital expenditures and TVA debt, this is understandable. However, an increase in peak load of approximately 16,000 megawatts is no small amount of generating capability, and landfill methane just is not going to cut it.*

Comment by: J. E. Butt

Response: In the long- and short-term action plans, TVA has identified a wide range of resource options to meet future needs through the year 2020. This includes many options that are not capital-intensive and would not increase TVA's debt. These options include power purchased from other producers, power purchased by joint ventures, and demand-side management. TVA's request for proposals for purchase of power resulted in 138 proposals representing 9,800 megawatts of peaking capacity and 12,200 megawatts of base-load capacity. The short-term action plan outlines specific activities to provide reliable power to the Valley through the next 7 years.

347

Comment: *What effect would a 1 percent investment in wind and solar have on rates and the ability to produce power in the long term (10-20 years)?*

Comment by: Eileen McIlvane (Coalition for Jobs and the Environment)

Response: Assuming 1 percent of annual revenues is invested in the construction of solar and wind-powered generating units, mid-term rates would increase 1.7 percent compared to the electric rates in the short-term action plan. In addition, total resource costs would increase $350 million, debt in 2001 would increase by $800 million, and carbon dioxide emissions would decrease by 0.5 percent.

348

Comment: *Coal and nuclear power are dead as future sources of energy and should not be TVA's preferred energy choices.*

Comment by: Larry Smith (Mid-South Peace and Justice Center), Mary Byrd Davis (Ygdrasil Institute), Jim Von Bramer, Catherine Murray (Sierra Club, State of Franklin Group), Beth Wallace, Retha Ferrell

Response: In its preferred strategy, TVA would continue to operate its existing coal and nuclear plants in the future. However, TVA does not plan to complete by itself the Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Unit 2. Browns Ferry Nuclear Plant Unit 1 will continue in its inoperative status. TVA will utilize clean coal technologies in the future. In addition, TVA's preferred strategy includes other resources for meeting energy demand, such as demand-side management and renewable energy such as wind power.

349

Comment: *TVA should phase out its nuclear program. Nuclear power is dangerous.*

Comment by: Hollis Fenn, Bruce Wood, Mary Byrd Davis (Ygdrasil Institute), Barbara Soliday, Jason Gurley, Linda Cataldo Modica, Rela Edwards, Alexander Dewey, Michelle Neal (Tennessee Valley Energy Reform Coalition), Doris Gunn, Beth Speltz, Michelle Carratu, Susan Switzer, Susan Bailey, John Johnson (Earth First), Sanford McGee (Cumberland Center for Justice and Peace), Sheilla Cheyenne, Suzanne Sims, Fred Wright, Edwin Curtis, Dolores Howard, Faith Young

Response: Nuclear power is a vital part of TVA's power mix. In 1994, nuclear generation represented 13 percent of TVA's operating generation and will play an even more important role when Watts Bar Nuclear Plant Unit 1 commences operation and Browns Ferry Nuclear Plant Unit 3 is returned to service. In 2005, nuclear generation is expected to represent almost 20 percent of TVA's generating capacity.

Nuclear plants supply energy reliably, safely, and with little environmental impact. Through careful, conservative planning for safety, the potential risk of nuclear reactors has been reduced to a very low level. The Nuclear Regulatory Commission carefully oversees the operation of nuclear plants in this country.

Two serious accidents have occurred in 30 years of world wide commercial energy production, the Three Mile Island and Chernobyl accidents. At Three Mile Island no one was injured or killed because nuclear energy plants in the United States use a series of physical barriers to prevent the release of radioactivity. About half of the uranium fuel melted at Three Mile Island, but only minute amounts of radioactive material escaped into the environment. The radiation exposure from Three Mile Island was actually much less than most of us receive each year from naturally occurring radioactive materials in soil, rocks, air, food, and water.

The Chernobyl plant in the Soviet Union had design flaws and no containment structure. As a result of the Chernobyl accident, radioactive material escaped and significant environmental damage occurred. More than 200 people were hospitalized for radiation exposure and burns, and approximately 30 people died. Reports suggest that more people may have died later. A plant like Chernobyl could not be licensed in the United States.

350

Comment: *We need to follow the example of post-nuclear Austria, which built reactors and then the citizens had the wisdom to walk away from their investment.*

Comment by: Fred Wright

Response: Nuclear power is a vital part of TVA's power mix. Nuclear plants supply energy reliably, safely, and with little environmental impact. The Nuclear Regulatory Commission monitors operations every day and conducts comprehensive reviews that cover all aspects of the plant. The nuclear industry and TVA are dedicated to safe and efficient nuclear plant operations.

351

Comment: *It is stupid for TVA to burn natural gas at a thermal efficiency of 35 percent in order to generate electricity to heat homes. Even a heat pump only recovers a fraction of that.*

Comment by: Arthur Smith

Response: TVA has a mix of generating plants including nuclear, coal, hydro, and combustion turbines. Natural gas and diesel fuel are used by the combustion turbines, which made up only 8 percent of TVA's generating capacity in 1994. Combustion turbine generation is used mostly during peak load periods, normally having quite low annual capacity factors (1 to 5 percent). Generation capacity must be planned to meet the varying system load demands. While combustion turbines have high operating costs, they have relatively low capital costs to build. New natural gas generation technologies with much higher efficiencies are being studied by TVA.

352

Comment: *Neither the long-term nor short-term plans include hydro pumped-storage for peaking power, although several possible pumped-storage projects were among the supply-side options considered in the initial review. With its rapid start-up and pump-to-generating times, a pumped-storage plant can be a very valuable supplier of operating reserves on the TVA power system. Newly developed variable speed pumped units will add to the attractiveness of this resource to rapidly serve changing load demands.*

Increased local housing development may soon make some of the better of the region's pumped-storage sites unavailable to TVA. Adding near-term acquisition of one or more hydro pumped-storage sites to the short-term action plan would maintain the flexibility to adopt this option for the uncertain future TVA faces, at relatively low capital cost. This would keep this mature, proven option available as an alternative to the less proven compressed air energy storage option.

Comment by: TVA Retirees Association

Response: TVA has evaluated hydro pumped-storage facilities in Energy Vision 2020, but has come to the conclusion that the costs involved are too high and the project lead time too long. (See Volume 2, Technical Document 8.) TVA will continue to consider alternative business arrangements involving hydro pumped-storage facilities.

353

Comment: *TVA's history lies in its development of hydroelectric power. The decision to preserve the hydroelectric resource within the TVA system recognizes the important role hydro plays in meeting the needs to provide ample electricity to the people and industries of the Tennessee Valley, ensuring continued stability, growth, and economic opportunity, while responding to the need to preserve the quality of life in the area through improved technologies and the continued mitigation of the impacts of development. This responsible use of the river system is a wise and efficient use of the resources within the Valley.*

Comment by: Linda Church Ciocci (National Hydropower Association)

Response: Your comment has been reviewed and noted.

354

Comment: *Oil is too valuable to burn.*

Comment by: Jeff Peterson

Response: The TVA system utilizes primarily coal and nuclear fuel, with hydro also making a significant contribution. TVA currently uses natural gas and fuel oil only for start-up and peaking power.

FINANCIAL

355

Comment: *Nuclear power plants were accepted at a time when nuclear was associated with the image of a secure nation. I think that was fallacious. However, TVA's debt is due to its nuclear program, therefore the country should share our problem like the bailout of the savings and loans. I think TVA's nuclear program is tied up with the whole national security issue and Congress should consider this and give us some help.*

Comment by: Susan Switzer

Response: Your comment has been reviewed and noted.

356

Comment: *For Energy Vision 2020, a 30-year write-off of deferred nuclear costs was assigned, depending on the resource strategy and when decisions were made about use of these assets.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

357

Comment: *TVA needs to address more fully how the cost of deferred assets (non-producing nuclear plants) are going to be recovered.*

Comment by: Mary English (University of Tennessee)

Response: TVA will operate both Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3. The generation from these units will produce revenue to cover the costs from these units.

The use of the deferred assets (Bellefonte Nuclear Plant Units 1 and 2) will be reviewed as part of the Bellefonte conversion study which will be completed in 18 to 24 months. The use of Watts Bar Nuclear Plant Unit 2 will be reviewed after the Bellefonte conversion study. TVA is aware of the impact that a write-off of these assets could have on the level of rates, and is considering all possibilities that may lessen the impact of any write-off that may be required.

358

Comment: *The accumulated costs of deferred nuclear generating facilities represent a significant percentage of TVA's assets. If these units are permanently canceled, TVA will have to determine treatment of those costs for rate purposes.*

Comment by: Tennessee Valley Public Power Association

Response: TVA is aware of the impact that a large write-off could have on the level of rates, and is considering all possibilities that may lessen the impact of any write-off that may be required.

359

Comment: *It is likely that at least some portion of the deferred nuclear plant costs will be written off by TVA. Whether they are taken against retained earnings, reinvested, or written off against current operating income, and over what length of time, will have a significant impact on the level of TVA's revenue requirement and its rates.*

Comment by: Tennessee Valley Public Power Association

Response: TVA is aware of the impact that a large write-off could have on the level of rates, and is considering all possibilities that may lessen the impact of any write-off that may be required.

360

Comment: *The costs accumulated to date for Watts Bar Nuclear Plant Unit 2 and Bellefonte Nuclear Plant Units 1 and 2 have been deferred until their final disposition is decided. These deferred costs totaled approximately $6.2 billion as of the end of fiscal year 1994. TVA's policy for the period over which to write off its deferred nuclear costs was ten years. That is the period in which it wrote off the deferred costs associated with the first eight canceled units during the 1980s. TVA had discussed changing this policy and writing off the $6.2 billion in deferred nuclear costs over a period of thirty years rather than only ten years. This decision, when finalized, also could have substantial impact on the level of TVA's and the distributors' rates.*

Comment by: Tennessee Valley Public Power Association

Response: TVA is aware of the impact that a large write-off could have on the level of rates, and is considering all possibilities that may lessen the impact of any write-off that may be required.

361

Comment: *Unless the unfinished, unneeded, and uneconomical nuclear plants are charged off in rates, then the current process of sweeping them under the carpet will lead to financial difficulties requiring taxpayer bailout and calls for privatization.*

Comment by: Powell & Sharon Foster, Bryan Deel, Ann Harris

Response: TVA's Nuclear Plants provided 13 percent of TVA's generating capacity mix in 1994. TVA has taken an important step to substantially limit the size of its nuclear program and TVA's financial exposure. TVA's decision not to complete, by itself, three of its unfinished nuclear plants reduces the financial risks associated with its nuclear program and enables TVA to cap its debt below the $30 billion level. This action will improve TVA's cash flow and financial strength.

Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 are expected to begin generating power in 1996. These units will provide an additional 2,235 megawatts of generating capacity. Operating them will help meet projected future loads on the TVA power system at a very competitive cost. Both will be revenue-producing assets when they go into operation. The construction expenditures on these units will be depreciated, and the depreciation costs, along with other costs, such as fuel and operating and maintenance costs, will be recovered in revenues.

Compared to purchasing power or meeting demand with coal-fired generation or combustion turbine units, operation of these two nuclear units will be among TVA's low-

est cost generating sources. Operating costs for Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 are projected to be approximately 1.7 cents per kilowatt-hour (fuel and operation and maintenance cost). In contrast, the operating costs of alternative generating sources would range from 2 to 6 cents per kilowatt-hour. (See Volume 1, Chapter 4, page 4.4.)

For further information, see "Operation of Watts Bar Nuclear Plant Supplemental Environmental Review," TVA, June 1995.

362

Comment: *I am concerned about TVA's debt. TVA should reduce the debt.*

Comment by: Garry Shores, Joan Prewitt, Robert Peeples, Sahara, C. Strain, Tohert, Hermann, Sheilla Cheyenne, K. Varnum, Richard Simmers, Kathy Priore, Karah Bates, Kathy Dowbiggin, M. Case, Alan Ball, Paul Elliott, Mary Schwarz, Lynn Leach (Alabama Environmental Council), Kim Grube, N. E. Whitfield, Dolores Howard, Susana Harwood, John Harwood, Salo, Ray Williams, Isahl Hemm, Philip & Winfred Thomforde, Karl Grotke, Patricia Chapman, John Schwarz, Jr., Susan Bailey, Stephen Stedman, C. T. Brewster, Yvonne Seperich, John Sharp, Jr., Dottie Hodges, Shirley Schaaf, Sharron Eckert, Ben & Winn Welch, Karen Lovell, Mary Carton, Walter & Dorothy Stark, Ruth Peeples, Ann & Mike Sanders, Myles Jakubowski (Sunbeam Household Products), Katherine Osborn, Robert Schreiber (Common Sense), Michelle Neal (Tennessee Valley Energy Reform Coalition), Faith Young, F. W. Munson, Chris Gulick, Mary Anne Terry, A. B. Evans, Luther Gulick, William Emmott, Jo Anne Clark, M. Nathan Perry, R. & G. Ludwig, Bruce Wood, Clark Buchner (Sierra Club, Tennessee Chapter), Scott Banbury, L. M. Johnson, Sr., Amy Perry, Hamp Dobbins, Jr., Marion Zachiel, Deborah Cuva

Response: TVA is also concerned about the level of debt, but it expects to effectively manage its debt. Debt is one of several evaluation criteria used in Energy Vision 2020. (See Controlling the TVA Debt section of Volume 1, Chapter 4, and the Financial Requirements section of Volume 1, Chapter 5.) The debt was a major consideration in TVA's decision not to complete several nuclear units. (See the Decision on Nuclear Power section of Volume 1, Chapter 9.) Debt was also a criteria for selecting the best long- and short-term strategies. (See the Final Strategy Evaluation and the Final Evaluation sections of Volume 1, Chapter 9, and Chapter 10.)

When TVA's debt is compared to the overall capitalization of neighboring investor-owned utilities, it is not out of line with its competitors in the utility industry. TVA can finance capital projects largely by issuing debt. Investor-owned utilities, in addition to issuing debt, raise approximately one-half of their capital through issuing stock. Debt is a recognized necessity of large corporations, and TVA has consistently met its very stringent bond tests. (See "The Ties that Bind: TVA in a Competitive Electric Market.")

TVA's debt limit, as set by Congress in the TVA Act, is $30 billion. TVA's current debt is some $3 billion below this debt ceiling. The TVA Board has announced plans to establish a self-imposed debt limit $2 to $3 billion below the $30 billion allowed by Congress. To achieve this, the level of capital spending is scheduled to be reduced by $1 billion over fiscal years 1995 to 1997.

363

Comment: *During the last 8 years, TVA has held its rates constant, but its debt has increased over $9 billion and TVA has paid over $14 billion in interest expense, a third of its power revenue. To be honest, TVA should tell people that it did not save $800 million a year; rather, it borrowed an extra billion. That is how TVA has been holding rates constant. This*

is not a mark of a financially strong organization. TVA has not amortized its debt. How does TVA plan to handle its financial situation?

Comment by: Sam Denham, Maggie Kalen (Tennessee Valley Energy Reform Coalition), Frank Holm, Bryan Deel, Stan Gloeckner (Sierra Club)

Response: During the last 8 years, TVA has held its rates constant by reducing all costs by over $800 million. These costs include the costs of interest on TVA debt. Even though debt has increased, over the last eight years, TVA has been able to pay all the interest on the debt and hold rates constant.

When TVA's debt is compared to the overall capitalization of investor-owned utilities, it is not out of line with its competitors in the utility industry. TVA can raise capital only by issuing debt. Investor-owned utilities, in addition to issuing debt, raise approximately one-half of their capital by selling common and preferred stock. Debt is a recognized necessity of large corporations. See "The Ties that Bind: TVA in a Competitive Electric Market" by Palmer Bellevue.

TVA's debt limit, as set by Congress in the TVA Act, is $30 billion. TVA's current debt is some $3 billion below this debt ceiling. The TVA Board has announced plans to establish a self-imposed debt limit $2 to $3 billion below the $30 billion allowed by Congress. As TVA completes its major capital program to expand capacity the level of capital spending is scheduled to be reduced by $1 billion over fiscal years 1995 to 1997.

364

Comment: *Debt service is driving the resource plan.*

Comment by: Susan Switzer, Alan Jones (Tennessee Environmental Council), Stan Gloeckner (Sierra Club)

Response: Energy Vision 2020 considers debt, along with a number of different evaluation criteria in its consideration of energy resource strategies. The multi-attribute trade-off method allowed all of these criteria to be considered on a consistent basis. All of TVA's final strategies recognize the importance of continued debt management.

TVA's debt, which totals some $27 billion, is not out of line with the total capitalization of other utilities. More importantly, TVA's yearly revenues of more than $5.4 billion are well able to pay the debt service, which was about $1.9 billion last year. This debt does not keep TVA from being competitive. See "TVA's Comments on the General Accounting Office Report" dated June 15, 1995, for further information.

365

Comment: *Short-term solutions currently favored by TVA, such as debt refinancing, can only result in its long-term financial collapse, taxpayer bailout, and privatization.*

Comment by: Howard Switzer (Sun/Earth Tempered Organic Architecture), Arthur Smith, Michael Karp (Northwest Conservation Act Coalition), Alan Ball, Powell & Sharon Foster

Response: The results of the implementation of the short-term plan (see Volume 1, Chapter 10, pages 10.11 to 10.14) do not indicate financial collapse, taxpayer bailout, or privatization. The refinancing that TVA has completed has resulted in a reduced interest cost of $317 million a year.

For the long term, TVA continues to examine a portfolio of resource options that were part of the best strategies identified through the Energy Vision 2020 evaluation process. This portfolio will give TVA the flexibility it needs to respond to the uncertain-

ties of the future. The best options have been determined to meet customer needs by balancing all evaluation criteria including cost, rates, debt, environmental concerns, and economic development, while also managing risk. The short-term plan is based on the long-term plan and describes the specific actions TVA proposes to undertake to meet customer needs through the year 2002. TVA estimates it will need an additional 3,500 megawatts of capacity to meet customer needs through the year 2002. The short-term plan emphasizes those resource options which balance all criteria and minimize the risk associated with uncertain load growth and other key uncertainties.

366

Comment: *The fact that TVA has debt in excess of $25 billion, in and of itself, does not adversely affect TVA's ongoing viability. Continuous growth in the amount of debt that a utility has often is a sign of economic growth of the entity. As the business expands, so do its assets, its equity, and its debt. What is significant, however, is the relationship between the amount of debt of a utility and the total of its assets. The ratio of debt to assets can have a significant impact on a utility's ability to obtain additional financing. TVA's debt ratio of 80 percent may place constraints on TVA's ability to issue new low-cost debt.*

Comment by: Tennessee Valley Public Power Association

Response: TVA's debt ratio may be high compared to other utilities, but it is important to consider that TVA's only option to obtain capital funds other than those generated internally is through issuance of debt. Other utilities have other sources of capital such as equity.

367

Comment: *A consideration in evaluating the amount of debt for a utility like TVA is the ratio of the total debt outstanding to the utility's total assets. TVA's debt level as of fiscal year-end 1994 of $25.5 billion represented 80 percent of its total assets, including short-term debt (short-term debt counts toward the statutory limitation on TVA's debt). Although investor-owned utilities with generation have traditionally targeted their debt ratio to be in the range of 40 to 60 percent, the average debt to assets ratio for publicly-owned utilities with generation is around 74 to 75 percent. The debt ratio is important as it is used by debt rating agencies to evaluate the ability of a utility to service additional debt and to sustain operating losses without affecting the interests of the creditors. This ratio can have a significant impact on a utility's ability to obtain, and its cost to obtain, additional financing. TVA's debt ratio of 80 percent may place constraints on TVA's ability to issue new low-cost debt.*

Comment by: Tennessee Valley Public Power Association

Response: TVA's debt ratio may be high compared to other utilities, but it is important to consider that TVA's only option to obtain capital funds other than those generated internally is through issuance of debt. Other utilities have other sources of capital such as equity. Also, TVA is required by law to charge rates sufficient to ensure full payment of annual debt service (interest expense), and it has accomplished this without a rate increase for nine years.

368

Comment: *If TVA follows through on its plans to not complete Watts Bar Nuclear Plant Unit 2 and Bellefonte Nuclear Plant Units 1 and 2, the level of TVA's debt should come under some amount of control and TVA can work toward reducing its debt ratio.*

Comment by: Tennessee Valley Public Power Association

Response: One of the major reasons for not completing the nuclear units was to help control TVA's debt.

369

Comment: *There appears to be a discrepancy between the publicly stated position of the TVA Board and the preliminary results from Energy Vision 2020 as to whether TVA can hold its debt below either the federally mandated ceiling or the internally set ceiling because TVA's Energy Vision 2020 strategies appear to exceed TVA's debt limits.*

Comment by: Tennessee Valley Public Power Association

Response: As shown in Volume 1, Chapter 9, Figure 9-4, Strategy Trade-Off for Debt in Year 2001 vs. Total Resource Costs, all seven of the key strategies remain well below the internal debt ceiling. Past the year 2001, the long-term resource plan includes recommendations for unique energy supply arrangements such as partnerships with investors supplying capital as well as options to purchase power which have no effect on debt while providing the needed generating capacity.

370

Comment: *Does TVA plan to collect decommissioning costs at the Nuclear Regulatory Commission minimum level or at the medium case level outlined in Energy Vision 2020?*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: TVA's current estimated decommissioning costs are close to the medium case level outlined in Energy Vision 2020. (In 1995 dollars TVA's current estimates are: $282 million for pressurized water reactors and $319 million for boiling water reactors.

PRICE

371

Comment: *TVA has held its rates constant and raised its debt. How is this going to impact rates and ratepayers in the future?*

Comment by: Lynn Leach (Alabama Environmental Council), Ann Harris, John Johnson (Earth First)

Response: TVA intends to maintain the lowest feasible rates in the future. Rates have remained unchanged since 1987 due to improved productivity and efficiency, lowered operating and maintenance costs, refinancing of debt, and reductions in the work force. TVA has more recently taken actions to reduce future borrowings. TVA's debt limit, as set by Congress in the TVA Act, is $30 billion. TVA's current debt is some $3 billion below that debt ceiling. The TVA Board has announced plans to establish a self-imposed debt limit $2 to $3 billion below the $30 billion allowed by Congress. To achieve this, the level of capital spending is scheduled to be reduced by $1 billion over fiscal years 1995

to 1997. Although TVA's debt has increased, the servicing of this debt (interest payments) is fully included in TVA's rates or price of power. TVA expects to be able to continue to successfully manage its debt, and all of the strategies in Energy Vision 2020 enhance TVA's ability to do this.

Like all utilities across the country, TVA is experiencing competitive pressures. For the moment, this pressure stems principally from TVA's largest retail customers and some distributors of TVA power. Large industrial customers are competing in global product markets and, in order to prosper, these firms must aggressively explore options to reduce their costs of production. Energy costs are often a key target. In many circumstances, large industrial customers can lower their costs by installing cogeneration facilities to generate their own electricity. In other circumstances, energy-intensive industries decide to shift production or permanently relocate to areas with lower energy costs. For TVA to retain these price-sensitive industries as customers, its electricity prices must be competitive on a regional and even global basis.

372

Comment: *Several issues were identified during the review of the assumptions and considerations included in Energy Vision 2020 that may cause some degree of upward pressure on TVA's rates in the future, depending on how TVA resolves them. On the other hand, TVA is likely to continue to experience downward pressure on its average system rates as the new competitive environment develops over the next few years.*

Comment by: Tennessee Valley Public Power Association

Response: It is true that since there is currently a surplus of base-load capacity in the industry and the cost of new combined cycle capacity is less than average embedded rates for many utilities, the market will continue to place downward pressure on the price of electricity.

373

Comment: *TVA should increase its rates commensurate with inflation or customer costs to reduce debt.*

Comment by: Don Perry, Catherine Murray (Sierra Club, State of Franklin Group), Sam Denham, Frank Holm

Response: In developing Energy Vision 2020, TVA has considered many criteria, including rates and debt. The long- and short-term plans would result in competitive electric prices and a debt level $2 to $3 billion below the statutory debt limit of $30 billion, which was a goal established by the TVA Board. TVA is continually reviewing approaches to maintain competitive electric prices and manage its debt.

374

Comment: *Raising rates would stimulate conservation and should be considered.*

Comment by: Dolores Howard, Richard Simmers, Patricia Chapman

Response: The effect of changes in TVA's rates was considered in the Energy Vision 2020 analyses. Increasing TVA's rates sufficiently high would likely stimulate more energy conservation, at least in the short term. However, this would adversely affect TVA's ability to be competitive in the future and unduly impact low income customers. Consequently, the Energy Vision 2020 process attempted to strike a balance between various evaluation criteria, including costs, rates, environmental impacts, economic development, reliability,

risk management, debt, and equity among customers. This resulted in short- and long-term plans that include a mix of supply- and demand-side management resources. Demand-side management resources could provide up to 2,200 megawatts by 2010.

375

Comment: *Raising rates to pay off debt, as noted by the United States General Accounting Office, would make TVA less competitive in a deregulated economy.*

Comment by: Bryan Deel

Response: Raising rates for any purpose will make TVA less competitive, although not necessarily unable to compete. The United States General Accounting Office report, which also expresses concerns about TVA's competitiveness due to its debt, asserts that once the costs of non-producing nuclear assets for completing Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 are figured into TVA's revenue requirements "it will be difficult for TVA to offer rates competitive with its neighbors." This statement is incorrect. The General Accounting Office incorrectly translates revenue requirements into electric rates. Energy Vision 2020 indicates that increases in sales will cover the cost of bringing the new units into service.

376

Comment: *For lowest rates, there are four criteria: short-term rates, mid-term rates, long-term rates, and the rate impact measure. Burns & McDonnell/XENERGY and TVA prefer using two of these measures, short-term rates and rate impact measure. Short-term is defined as average rates between now and 2001. Because impacts beyond that time period are more speculative, short-term rates should receive greater focus than medium or long-term rates. The rate impact measure is defined as the present value of rates over the planning horizon and as such includes all rate periods.*

Comment by: Tennessee Valley Public Power Association

Response: In Energy Vision 2020, the long-term plan or portfolio, (Volume 1, Chapter 9, Figure 9-23), balances both short- and long-term rate impacts.

377

Comment: *Despite the use of a multi-attribute process, the only thing that mattered in the evaluation of energy strategies in Energy Vision 2020 was rates.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Mandy Tiesler

Response: Rates were not the only important factor; a number of different criteria were used in the evaluation of energy resource strategies in Energy Vision 2020. These included long-run cost/value, rates, reliability, environment, economic development, financial requirements, risk management, and equity among rate classes. As can be seen in the trade-off graphs in Energy Vision 2020, Volume 1, Chapter 9, Figures 9-4 to 9-10, many strategies were considered in trying to create a balance among all the evaluation criteria. TVA believes the long-term and short-term resource plans achieve this balance in the form of a portfolio of resource options.

Like other utilities, TVA is expecting important changes in the relationship between utilities and their customers. Consumer, legislative, and utility actions across the nation are changing the electric utility industry from a regulated monopoly to a more competi-

tive marketplace. TVA is at the forefront of this change and welcomes the opportunity for growth with improved, responsive services to best meet the needs of its current and new customers.

Competitiveness, as defined in Energy Vision 2020, goes beyond being the lowest cost electricity producer. It also means that TVA must be competitive in the quality and value of its electric services delivered to its customers. Competitiveness is also measured in terms of TVA's contribution to economic development in the region and the region's environmental quality.

378

Comment: *TVA is going to do a cost-of-service study that will force the residential ratepayer to begin to cross subsidize lower industrial rates. TVA is doing this because industrial customers have more leverage.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA's residential ratepayers do not subsidize industrial ratepayers. TVA regularly analyzes the cost of providing electricity to customer classes. Over time, it may be necessary to adjust the way in which revenues from each class of customer cover their costs of service.

Uncertainties

GENERAL

379

Comment: *TVA's practice of narrowing the number of environmental uncertainties to a smaller number is advisable. By selecting only those uncertainties which have the potential to greatly impact future resource decisions, unnecessary analyses of insignificant uncertainties were avoided.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

380

Comment: *With the assistance of the Energy Vision 2020 Review Group, TVA developed an extensive list of uncertainties. For each uncertainty, TVA used its best judgment to derive high, medium, and low estimates.*

The TVA approach to integration avoids the optimization trap and attempts to evaluate a wide variety of strategies using decision analysis techniques. TVA's modeling philosophy is that any reasonable plan must address as many future uncertainties as possible. In addition, plans should contain a "portfolio" of options that provide a hedge against unforeseen events, thereby minimizing risk. Optimization models such as EGEAS and PROSCREEN tend to produce a rush to an extreme whereby the winning supply option is relied upon almost exclusively. TVA's philosophy supports flexibility by creating a planning framework where it is relatively simple to shift between strategies as future events dictate. TVA believes that by carefully re-engineering the process of designing and building resources, decisions can be delayed, thus reducing the chance that subsequent events will judge the resource to be unnecessary.

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

381

Comment: *To its credit, TVA took a comprehensive approach to the development of uncertainties including consultation with outside experts and interested parties. It is not clear that TVA studied non-quantifiable uncertainties such as: (1) will Congress make TVA into a private entity?, (2) will the current Clinton Administration be reelected in 1996, or (3) what will be the regulatory role of state commissions after the TVA wall is removed? It is not always necessary to quantify a variable to include it in Energy Vision 2020. Recreating TVA as a private entity, for example, could be evaluated through extensive study of competition, resulting in a more flexible plan with short lead times and an ability to change direction quickly. Clearly, TVA's planning philosophy is based on a "gut feel" for some of these non-quantifiable uncertainties; but Burns & McDonnell/XENERGY feel that explicitly addressing them would be better.*

Comment by: Tennessee Valley Public Power Association

Response: We agree that it is not always necessary to quantify uncertainties in order to address them in integrated resource planning. Some of these uncertainties were discussed only qualitatively, such as some aspects of wholesale and retail open access, a

changing electric industry structure, and several environmental impacts. Privatization was not explicitly addressed in Energy Vision 2020.

Energy Vision 2020 will guide TVA in this emerging competitive market in making business decisions to meet the long-term energy needs of its customers. Being competitive in price, service, and reliability will allow TVA to meet customers' needs.

382

Comment: *There is little or no documentation of how the ranges for each uncertainty were developed or whether there was an attempt to make the probability that the future lies within each range equal for each uncertainty. Many futures analyses rigorously research each uncertainty and prepare essays that define the uncertainty, describe its history, and speculate as to alternative futures that could occur and why. These essays constitute an "environmental scan" that can be updated as new information becomes available. These essays also form a corporate knowledge base that facilitates communications between planners, managers, and executives. Burns & McDonnell/XENERGY recommend that TVA begin to document their research on uncertainties by preparing and maintaining these essays. With a few exceptions, TVA's uncertainty ranges provided seem reasonable. These exceptions include (1) gas escalation rates after 2005 are higher in the low case than in the high case, (2) the market price of coproduct is the same in the medium and high cases, (3) decommissioning costs are the same in the low and medium cases, and (4) spent fuel storage cost is the same in the low and medium case.*

Comment by: Tennessee Valley Public Power Association

Response: We agree with your comment except that: (1) The gas price forecasts predict volatility in short-term prices and steady escalation for each uncertainty case. The low, medium, and high cases were forecast to be 256 cents per million Btu with a 2.4 percent escalation, 342 cents per million Btu with a 5.3 percent escalation, and 418 cents per million Btu with a 7.9 percent escalation, respectively. (See Volume 1, Chapter 9, Figure 9-2.) (2) The market price of coproduct is different for the high, medium, and low cases as shown in Volume 2, Technical Document 8, Figure T8-24, Range of Values for Coproduct. (3) Decommissioning costs are different in the low and medium cases as shown in Volume 2, Technical Document 8, Figure T8-26, TVA Estimates of Nuclear Plant Decommissioning Cost. (4) The spent fuel storage cost uncertainty considered two cases, first, as a medium case, the current fee of $1 per megawatt-hour is paid to the Department of Energy, and as a high case, the fee is doubled to $2 per megawatt-hour.

383

Comment: *In the materials provided to the Energy Vision 2020 Review Group, several other uncertainties were identified for later quantification. These included a write-off schedule of nuclear unit cancellations, fuel costs for new technologies, interest rates, purchased power, specific environmental costs, and independent power producers/cogeneration. It is not clear that these uncertainties were ever included in later analyses.*

Comment by: Tennessee Valley Public Power Association

Response: Many uncertainties were evaluated in Energy Vision 2020. Most of these uncertainties were reviewed by the Energy Vision 2020 Review Group, but there were several uncertainties that were identified for later quantification.

Fuel costs, the price and quantity of purchased power, environmental costs, and the cost and availability of purchases from independent power producers and cogenerators were evaluated and were included in Volume 2, Technical Document 8, Figures T8-30 to T8-33.

For the remaining uncertainties, internal studies were performed. A study was performed regarding the optimal write-off schedule of nuclear unit cancellation. The recommendation of this study was to pursue a 30-year write-off of unused nuclear assets if and when the deferred nuclear units are abandoned. Interest rates were modeled as an uncertainty, but the results were inconclusive.

384

Comment: *The TVA analysis shows that flexibility is beneficial regardless of strategy.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

MARKET UNCERTAINTIES

385

Comment: *Recent cost-cutting measures, as well as the proposals detailed in this report, should allow TVA to remain competitive and ensure TVA's future success.*

Comment by: R. D. Newman (Bowater Newsprint)

Response: Your comment has been reviewed and noted.

386

Comment: *TVA is already seeing the impact of the Energy Policy Act and its provisions for wholesale wheeling and transmission access. At least one of its distributors has given contract cancellation notice and others have seriously considered doing so. There have been discussions in the Tennessee Valley about the potential for removing the service territory "fence." This would expedite the development of competition for both wholesale and retail customers. This could have either positive or negative impacts on TVA, depending on the aggressiveness of other utilities in the region. However, either way, it will definitely add to the downward pressure on rates. Based on its ranking as one of the lower cost providers of electricity, TVA would appear to be in a relatively good position to compete with other utilities. TVA is positioning itself to be ready for the competition.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

387

Comment: *One of the key factors identified by TVA in its load forecasting process is competition. What will happen if the anti-cherry picking rule is rescinded and the fence removed? While the current forecast includes a discussion of competition, it does not include an in-depth analysis of the issue. The current high, medium, and low competition scenarios are based on a customer survey where large customers were asked if they were very likely, likely, unlikely, or very unlikely to switch to another utility if they were allowed to do so.*

These responses were converted into probabilities and a distribution of possible losses produced. Obviously, this approach is very subjective and does not include customers not currently served by TVA or the Tennessee Valley Public Power Association. There seems to be no comprehensive analysis of competitive conditions, nor has the impact of the wall coming down or of TVA becoming a private entity been adequately addressed in Energy Vision 2020.

Comment by: Tennessee Valley Public Power Association

Response: TVA requested the report by Palmer Bellevue, "The Ties that Bind: TVA in a Competitive Electric Market." This comprehensive analysis discusses TVA's power and non-power programs, the Energy Policy Act of 1992, the forces of competition facing TVA, and obstacles to a competitive TVA.

Energy Vision 2020 specifically addresses competition in many ways including uncertainty in the load forecasts and by identifying options which allow TVA greater flexibility in planning. These options include option purchase agreements, business partnerships for energy resources, and pre-siting and engineering to provide flexibility to implement new technologies.

388

Comment: *The Federal Energy Regulatory Commission issued Dockets RM 95-8-000, "Promoting Wholesale Competition through Open Access Nondiscriminatory Transmission Services by Public Utilities," and RM 94-7-001, "Recovery of Stranded Costs by Public Utilities and Transmitting Utilities." The Federal Energy Regulatory Commission's goal is to issue a final order by December 31, 1995, with transmission tariffs becoming effective 60 days following issuance of the final order.*

While the Federal Energy Regulatory Commission has limited authority over TVA, TVA recognizes that "these proposed rules could have a substantial impact on TVA's conduct of business in the future" (page 1 of TVA's filed comments to the Federal Energy Regulatory Commission). However, TVA plans to implement a 25-year plan without a clear picture of the opportunities and hazards created as a result of this soon-to-be-restructured environment.

Why has TVA not considered modifying the timetable for selecting and implementing its resource strategies to more closely coincide with the implementation of the Federal Energy Regulatory Commission's open access transmission?

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: In Energy Vision 2020, the changing structure of the electric utility industry on both the supply and demand side of the market have been considered. One element of this changing industry structure is the Federal Energy Regulatory Commission's open access proposal. Energy Vision 2020 is not contingent on a single event affecting the electric utility industry, but attempts to consider the major uncertainties facing TVA and the electric utility industry. TVA's proposed long-term plan that uses a portfolio approach and short-term plan that emphasize flexibility will permit TVA to adapt to a variety of changes in the electric utility industry.

On the demand side of the market, TVA's load forecasts recognize the uncertainty in future load growth due to the uncertainty in the future competitive markets (see Volume 1, Chapter 6, pages 6.4 to 6.5 and Volume 2, Technical Document 5). In Technical Document 5, page T5.20, TVA's future competitive success is recognized as the second most important uncertainty in future load and sales levels. The uncertainty in TVA's sales certainly recognizes that at some time in the future, the "fence" and "anti-cherry-picking

amendment" will not exist, opening the TVA market to wholesale competition. Further considerations in this analysis included the current 10-year cancellation notice provision in TVA contracts with its distributors, the potential for both full and partial requirements contracts, and provisions for stranded investment. The potential for retail open access was only considered qualitatively.

On the supply side, the long-term plan utilizes a portfolio approach so that TVA can adapt to the changing marketplace. Additional needs of 3,500 megawatts by 2002 and 16,500 megawatts by 2020 will be met by the supply- and demand-side options identified in the portfolio. (See Volume 1, Chapter 9, Figure 9-23.) The short-term action plan in Energy Vision 2020 recognizes the need for flexibility in the face of market price and quantity uncertainty. The recommended options include both flexible internal and external options. (See Volume 1, Chapter 10, Figure 10-1.) These flexible options are the basis for the short-term action plan.

389

Comment: *We remain concerned that TVA has failed to fully consider the implications associated with competition and open access. It is clear now with the ongoing discussion between TVA and its largest distributors that many will seek unbundled electrical services in future contracts. This will decrease the need for additional TVA power. TVA should not engage in large costly power projects, i.e., Watts Bar Nuclear Plant Unit 1.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: In Energy Vision 2020, the changing structure of the electric utility industry on both the supply and demand side of the market have been considered. One element of this changing industry structure is the Federal Energy Regulatory Commission's open access proposal. Energy Vision 2020 is not contingent on a single event affecting the electric utility industry, but attempts to consider the major uncertainties facing TVA and the electric utility industry. TVA's proposed long-term plan that uses a portfolio approach and short-term plan that emphasize flexibility will permit TVA to adapt to a variety of changes in the electric utility industry.

On the demand side of the market, TVA's load forecasts recognize the uncertainty in future load growth due to the uncertainty in the future competitive markets (see Volume 1, Chapter 6, pages 6.4 to 6.5 and Volume 2, Technical Document 5, Load Forecasts). In Volume 2, Technical Document 5, Load Forecasts, page T5.20, TVA's future competitive success is recognized as the second most important uncertainty in future load and sales levels. The uncertainty in TVA's sales certainly recognizes that at some time in the future, the "fence" and "anti-cherry-picking amendment" will not exist, opening the TVA market to wholesale competition. Further considerations in this analysis included the current 10-year cancellation notice provision in TVA contracts with its distributors, the potential for both full and partial requirements contracts, and provisions for stranded investment. The potential for retail open access was only considered qualitatively.

On the supply side, the long-term plan utilizes a portfolio approach so that TVA can adapt to the changing marketplace. Additional needs of 3,500 megawatts by 2002 and 16,500 megawatts by 2020 will be met by the supply- and demand-side options identified in the portfolio. (See Volume 1, Chapter 9, Figure 9-23.) The short-term action plan in Energy Vision 2020 recognizes the need for flexibility in the face of market price and quantity uncertainty. The recommended supply-side options include both flexible inter-

nal and external options. (See Volume 1, Chapter 10, Figure 10-1.) These flexible options are the basis for the short-term action plan.

Watts Bar Nuclear Plant Unit 1 is needed to meet both the current and projected need for power.

390

Comment: *TVA should address more fully the potential effects of taking down the fence.*

Comment by: Mary English (University of Tennessee)

Response: Please refer to "The Ties that Bind: TVA in a Competitive Electric Market" by Palmer Bellevue. This document discusses the effects of taking down the fence, as well as providing an overview of TVA, an assessment of competition in the electric industry, and obstacles to a competitive TVA. TVA's Energy Vision 2020 addresses the deregulation of the electric industry in Volume 1, Chapter 6 as TVA's Competitive Success. The high, medium, and low load forecasts reflect possible gains and/or losses of customers both inside and outside its present service territory.

391

Comment: *When the TVA fence is removed, the ratepayers stand to be the recipients of a lot of stranded debt when industries and consumers go elsewhere.*

Comment by: Jonathan Scherch, Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA is positioning itself to be competitive in the event that the "fence" is removed. TVA is and expects to be competitive for existing and new customers and will continue to manage its debt.

Energy Vision 2020 recognizes the uncertainty that competition brings to the marketplace. The short-term action plan and the long-term plan (see Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1) include resource options that will provide flexibility to adapt to the uncertain marketplace.

392

Comment: *If TVA allowed free market access, you would see a number of smaller, cheaper power producers.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Energy Vision 2020 recognizes that the market for electricity will become increasingly competitive (see Volume 1, Chapter 1). Recognizing this increased uncertainty created by increased competition, the short-term action plan emphasizes smaller, more flexible options. (See Volume 1, Chapter 10, Figure 10-1.) These smaller, more flexible options are described as flexible external and internal supply-side options in Volume 1, Chapter 7, pages 7.5 and 7.6 and in Volume 1, Chapter 8, pages 8.14 to 8.17 as distributed generation or self-generation and renewable generation. For example, TVA issued a request for proposals to help identify the lowest price power producers in the market today. Responses to this request were received from other utilities, independent power producers, and power marketers.

393

Comment: *Some utilities are offering electricity at the rate of 1.6 cents per kilowatt-hour. In light of that rate and TVA's debt as reported by the United States General Accounting Office, how can TVA be competitive?*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition), Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Sales in the bulk power market occur at many different prices and locations depending on the type of power bought or sold. The price of this power is influenced by time of day, season of the year, and degree of interruptibility of the power. Most of this power is traded on the basis of the marginal cost of power and not the average cost of power. TVA's marginal cost is competitive with many other utilities, and TVA buys and sells power in the bulk power market on an hourly and daily basis. Over the past several years, TVA has been a net seller of power. Thus, TVA expects to remain competitive in these important markets.

394

Comment: *What has been the five-year price trend and historical volatility for bulk power in the Southeastern Electric Reliability Council and surrounding regions?*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: Although TVA has estimates of both the trend in prices and volatility, it does not have access to actual historical price and volatility data because price and other terms and conditions of specific transactions are kept confidential for competitive reasons.

395

Comment: *TVA is not ready for a competitive market. It is very much at the rear of the pack and has a lot of catching up to do.*

Comment by: Monique Mollet, Arthur Smith

Response: TVA recognizes that the electric industry is becoming more competitive. Energy Vision 2020 helps to position TVA to meet the competition. This issue is discussed in Volume 1, Chapter 1.

TVA's long- and short-term plans discussed in Volume 1, Chapters 9 and 10 emphasize the need to provide flexibility in meeting future customer electric needs. This flexibility will allow TVA to adapt to uncertainty in future power markets created by the increasingly competitive environment.

TVA's current competitive position is thoroughly addressed in another report by independent consultants, "The Ties that Bind: TVA in a Competitive Electric Market."

396

Comment: *Over the past 20 years, on the average, coal prices have gone up 5 percent, while natural gas prices have gone up 180 percent, and crude oil has gone up 55 percent.*

Comment by: Barbara Altizer (Virginia Coal Council)

Response: TVA has included price forecasts for coal, natural gas, and fuel oil for the period covered by Energy Vision 2020's analysis process. These forecasts have been prepared in conjunction with nationally recognized consultants in the field of fuel price forecasting.

The methodologies used in generating these forecasts are consistent with the methods used in our fuel procurement process.

397

Comment: *Energy Vision 2020 lists natural gas prices as a key uncertainty. TVA's projected delivered price of natural gas in the year 2000 ranged from $2.90 per million Btu, low case, $3.42 per million Btu, medium case, to $4.13 per million Btu for the high case scenario. TVA's low, medium, and high case escalation rates for natural gas from 2000 to 2020 were 5.1, 5.3, and 4.8 percent, respectively. Given TVA's reference case scenario, the estimated price of natural gas delivered in the year 2020 is $9.61 per million Btu.*

Forward natural gas prices can be fixed using futures or the over-the-counter markets. TVA can currently fix the wellhead price of natural gas (basis Henry Hub), delivered in 2000, at $2.10 per million Btu. The estimated cost of fuel, transport, and distribution charges are $0.06, $0.30, and $0.20 per million Btu, respectively, for delivery to TVA's Allen Plant. The $2.66 per million Btu delivered price is $0.76 per million Btu below TVA's reference price. The 2020 over-the-counter price for gas delivered to TVA's Allen Plant (assuming $0.15 per million Btu fuel, $0.84 per million Btu transport, and $0.56 per million Btu distribution) is $7.01 per million Btu or $2.60 per million Btu less than TVA's reference price. These known forward prices are also below TVA's low case estimates. Much of TVA's bias against natural gas-based generation technologies would be removed if currently quoted forward market prices were used instead of estimates of what prices may be in the future.

If TVA used the low case scenario for gas prices, how would TVA's supply portfolio be affected?

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: The gas prices used to evaluate options and strategies in Energy Vision 2020 are reported correctly in Volume 1, Chapter 9, Figure 9-2 . The gas prices reported in Volume 2, Technical Document 8 are reported incorrectly and will be corrected in the final Energy Vision 2020 document.

The correct prices for the low, medium, and high forecasts for the year 2000 and 2020 are:

Natural Gas Prices ($ per million Btu)

Year	Low	Medium	High
2000	2.56	3.42	4.18
2020	4.11	9.60	19.10

For planning purposes, a range of forecasts of natural gas prices is used in Energy Vision 2020 to represent the uncertainty in future prices. It is recognized that various market and contracting mechanisms can be used to hedge future gas price uncertainty for specific projects. TVA will certainly consider all such mechanisms when actual projects are proposed for implementation. The commenter's projections of $2.66 per million Btu in 2000 and $7.01 per million Btu in 2020 are within the range of forecasts used in Energy Vision 2020.

The low case scenario for future gas prices is evaluated in Energy Vision 2020. These evaluations are presented in Volume 1, Chapter 9, Figure 9-18, and pages 9.28 and 9.29. Lower gas prices would not significantly alter the long-term supply portfolio. (See Volume 1, Chapter 9, Figure 9-23.) The portfolio already contains many supply-side options that use natural gas such as some option purchase agreements, combined cycle plants, combustion turbines, combined cycle repowering of coal plants, and fuel cells.

398

Comment: *TVA's assumptions for future natural gas prices appear to be too high relative to its coal price assumptions. As a potential consumer of large amounts of natural gas, TVA would be able to negotiate competitively priced deliveries and long-term supplies of natural gas at costs lower than those assumed in Energy Vision 2020. The result of a price assumption bias against natural gas could be an under-reliance in Energy Vision 2020 on natural gas-fired technologies such as combined cycle.*

Comment by: Tennessee Valley Public Power Association

Response: Independent consultants have been used to develop the TVA natural gas price forecast. High, medium, and low forecasts were developed for Energy Vision 2020. In Energy Vision 2020, the short-term action plan includes recommendations to further investigate natural gas-fired technologies. This includes the combined cycle repowering of Bellefonte Nuclear Plant and the development of siting and engineering studies for the construction of a greenfield combined cycle plant. (See Volume 1, Chapter 10, Figure 10-1.)

399

Comment: *Although natural gas is a great fuel, I am concerned that too much demand is being placed on the resource despite assurances from the suppliers that there is plenty. With many states going to compressed natural gas as an alternative transportation fuel and many utilities going to combined cycle units fired by natural gas, I think there may be too much dependence on a single resource and TVA could be looking at 1973 again with a different energy source.*

If TVA wants a gas-fired unit, gasify coal or biomass.

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: The long-term plan in Energy Vision 2020 (see Volume 1, Chapter 9, Figure 9-23) recommends several different resource options. These include natural-gas based options, coal-fired options, renewables, and demand-side management. The long-term plan does not overly rely on natural-gas fired generation.

400

Comment: *TVA's estimate of load growth among the residential and commercial customer classes include appliance saturations that are based upon TVA's forecasts of natural gas prices. These prices are higher than currently quoted forward prices. Gas utilities have the ability, in the current market environment, to manage gas price risks for their customers. The city of Clarksville, Tennessee recently entered into a 10-year, prepaid gas contract for one-third of the city's gas needs (Natural Gas Focus, April/May 95). TVA's load growth modeling practices may not reflect changes in pricing opportunities that have resulted from gas industry restructuring.*

If TVA used the low case scenario for gas prices, how would TVA's load growth projections be affected?

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: In Energy Vision 2020, TVA uses a range of load forecasts which represents the uncertainty in economic growth, prices of electricity, TVA's competitive success, and the price of natural gas. The range of load forecasts is shown in Volume 1, Chapter 6, Figures 6-1 and 6-2.

The gas price forecasts used in Energy Vision 2020 bracket the quoted forward price of natural gas (see response to comment number 397). Utilizing state-of-the-art forecasting models and techniques (see Volume 2, Technical Document 5, Load Forecast), the effects of lower natural gas prices are shown in Figures T5-28 and T5-29. With the low forecast of natural gas prices, electricity sales would be 2.6 percent lower in 2000 and 7.8 percent lower in 2015.

401

Comment: *There is currently a glut of natural gas that should continue, and this does not take into account all the gas that is coming out of landfills, coal mines, and all other sources. This should be considered.*

Comment by: John van der Harst

Response: In Energy Vision 2020, the uncertainty in both the future quantity and price of natural gas has been considered. (See Volume 1, Chapter 9, pages 9.28 and 9.29.) It is also recognized that there are other sources of methane. Energy Vision 2020 has considered the production of electricity from landfill methane and coalbed methane as supply options. These options have been included in the long-term plan. (See Volume 1, Chapter 9, Figure 9-23.)

402

Comment: *Leading coal and utility experts are stating that, as restructuring of the United States electric utility industry goes forward, coal-based systems will increasingly enjoy competitive advantage, and those with highly efficient clean coal technologies will be especially well-positioned.*

Comment by: William Bowker (Kentucky Coal Marketing and Export Council), Steven Walsh

Response: TVA's Energy Vision 2020 identifies several clean coal technologies such as integrated gasification combined cycle as being competitive with other supply-side options such as natural gas combined cycle.

In Energy Vision 2020 one of the important aspects of being competitive is having the flexibility to adapt to an uncertain future. Thus, the short-term action plan (see Volume 1, Chapter 10) in Energy Vision 2020 relies heavily on supply-side options which provide flexibility such as option purchase agreements (see Volume 1, Chapter 7, page 7.5) and flexible internal supply-side options (see Volume 1, Chapter 7, page 7.6).

403

Comment: *Once you buy tons of coal, what are you going to do with it when you find there are better ways to generate electricity?*

Comment by: Sheilla Cheyenne

Response: TVA coal contracts are not of a length that would extend beyond the time necessary to install a new technology for energy production.

REGULATORY/ENVIRONMENTAL UNCERTAINTIES

404

Comment: *TVA is not experiencing any of the environmental problems that created a reduction in hydroelectric production at Bonneville Power Administration, Western Area Power Administration, and Southwestern Power Administration. The primary reason TVA is not experiencing any of these problems is because it does not have anadromous fish such as salmon. TVA has also handled all of its dissolved oxygen and minimum flow problems, which it has been researching since 1980 at Norris Dam. TVA does not anticipate losing capacity or energy from its hydro system due to environmental problems in the future.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

405

Comment: *We appreciate TVA's consideration of carbon dioxide emissions in its uncertainty analysis (should carbon dioxide emissions become regulated).*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Your comment has been reviewed and noted.

406

Comment: *While the Energy Vision 2020 report shows improvements in many environmental indices, carbon dioxide emissions increase over time in all strategies. This could be a problem for TVA if Congress imposes limits on carbon dioxide emissions.*

Comment by: Sharon Fidler (League of Women Voters), Eric Hirst (Oak Ridge National Laboratory), Linda Ewald, Stephen Smith (Tennessee Valley Energy Reform Coalition), Eileen McIlvane (Coalition for Jobs and the Environment), Sheila Holbrook-White (Sierra Club, Alabama Chapter)

Response: TVA considered the uncertainty in carbon dioxide regulations in all strategies. The analysis assumed either one of two scenarios would occur: either no additional carbon dioxide regulations or a cap on carbon dioxide emissions, with purchases and sales of carbon dioxide allowances at $10 per ton of carbon dioxide. (Carbon dioxide regulations have been modeled similar to current acid rain regulations, which permit buying and selling of sulfur dioxide allowances). (See Volume 1, Chapter 9, page 9.29.)

The analysis indicates that the lower cost strategies (including the short-term action plan) are robust; they remain lower cost, even with carbon dioxide regulations. These strategies were robust relative to carbon dioxide regulations because they contain options with low carbon dioxide emissions or options which offset carbon dioxide emissions, such as natural gas-based combined cycle plants, fuel cells using landfill methane, renewables, and demand-side management options.

If carbon dioxide or other environmental regulations change, TVA could implement more conservation, more fuel switching, and more renewable resources as identified in the long-term plan portfolio. (See Volume 1, Chapter 9, Figure 9-23.) TVA believes that risk management is an essential part of the planning process and that a successful plan is one that remains robust and flexible to deal with uncertain futures such as carbon dioxide regulations.

407

Comment: *In order to avoid paying carbon taxes, TVA should reduce its carbon dioxide emissions.*

Comment by: Nancy Bell

Response: TVA has and will continue to implement actions that reduce its carbon dioxide emissions below what they would be if certain alternative actions were taken. For example, these actions will reduce carbon dioxide emissions in the year 2000 by 22.7 million tons below what they would otherwise have been.

Carbon taxation was proposed as legislation in 1993 in Congress, but this did not garner much support. Current national policy, which TVA supports, is trending toward more flexible, less economically damaging methods to reduce carbon dioxide and other greenhouse gas emission. For example, President Clinton's Climate Change Action Plan relies heavily on cost-effective and voluntary measures to return national greenhouse gas emissions to the 1990 levels by the year 2000. One part of the Action Plan is the Climate Challenge Program in which TVA has committed to a 22.7 million ton reduction in carbon dioxide emissions.

The possibility of future carbon dioxide regulation was evaluated in Energy Vision 2020 as an uncertainty. It was assumed for purposes of this uncertainty that there would be a cap on carbon dioxide emissions beginning in the year 2000 at 1990 levels. Any carbon dioxide emissions above this cap could be purchased at $10 per ton of carbon dioxide, and any emissions below the cap could be sold for the same price. Because of this cap, there would be a direct reduction of carbon dioxide emissions of 2 million to 3 million tons per year on the TVA system. Also, long-term costs were increased sufficiently to reduce emissions to 1990 levels assuming a cost of $10 per ton of carbon dioxide. The cost of this emission reduction averaged $257 million per year for TVA.

408

Comment: *TVA has grossly underestimated the liabilities associated with global climate change. After this summer there is a consensus within the scientific community that human-induced climate change is undeniable.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Not all respected scientists agree that the climate is being changed by human activities. However, carbon dioxide emissions was one of the criteria against which each of the energy strategies was evaluated. As an example of the effect of carbon dioxide emissions in the evaluation process, the low-cost producer strategy was eliminated during the final evaluation because of its high emissions. (See Volume 1, Chapter 9, page 9.20.) While the minimum carbon dioxide emission strategies did not emerge from the final evaluation, each of the seven key strategies that did emerge has lower carbon dioxide emissions than the reference case.

When the uncertainty in possible future carbon dioxide regulations was considered, several of the seven key strategies remain low-cost compared to other strategies. (See Volume 1, Chapter 9, page 9.29.) These strategies include low carbon dioxide emitting and carbon dioxide off-setting options. The portfolio of options from the seven strategies incorporate the needed flexibility to accommodate possible future liabilities associated with carbon dioxide emissions.

409

Comment: *In conducting its thermal uncertainty analysis, did TVA consider other alternatives for its heated discharges such as cooling ponds?*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: At TVA plants where cooling water treatment is now necessary, other alternatives including cooling lakes were initially considered, but cooling towers were chosen in each case as the best option from an environmental and/or economic perspective. For plants which now have once-through cooling systems, no such analysis has been done at this point. Only cooling towers were considered in the Energy Vision 2020 thermal uncertainty analysis because TVA considers that technology to be the maximum that will be necessary and the one most likely to be applied in specific cases based on TVA experience.

410

Comment: *As TVA may be aware, the Environmental Protection Agency recently published a final regulatory determination on certain wastes from the combustion of coal by electric utility power plants (58 FR 42466-42482 [August 9, 1993]). Several wastes generated at power plants were temporarily exempted from Resource Conservation and Recovery Act Subtitle C until April 8, 1998, pending evaluation by the Environmental Protection Agency. However, it should be noted that if the Environmental Protection Agency decides to regulate these wastes, it could have a potential impact on TVA's waste management planning.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA considered the potential for increased cost in handling and disposing of solid wastes from coal-fired generating facilities as a regulatory uncertainty related to protection of ground and surface waters because of the Environmental Protection Agency's reclassification of utility wastes.

In Energy Vision 2020, the cost for all new coal-fired facilities included provisions for solid waste handling and storage that would comply with an anticipated regulation. For example, new pulverized coal facilities would include dry waste transport and handling systems, impermeably lined storage areas, and leachate collection systems with water treatment capabilities. For the 11 existing coal-fired generating stations, it was assumed that new regulation in the area would require reclaiming currently stored waste, installing new systems (impermeably lined storage areas, leachate collection, and treatment systems), and returning the material to storage.

In Energy Vision 2020, TVA considered the uncertainty of future environmental regulations. (See Volume 2, Technical Document 8, page T8.43.) Consideration of this uncertainty then favored all strategies that included retiring existing plants or repowering existing plants with natural gas-fired technology. It also indirectly favored strategies that minimized new coal-fired generation, since the costs of new coal-fired facilities were increased to include the water protection systems.

411

Comment: *Although not required by the Environmental Protection Agency for power plants at this time, analysis of indirect exposure risk has environmental significance and could potentially become a requirement during the 25-year horizon of Energy Vision 2020.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA considered the uncertainty of future regulations of air toxics as part of the environmental air regulatory uncertainty. (See Volume 2, Technical Document 8, Figures T8-30, T8-31, and T8-32, and pages T8.43 to T8.45.)

ABILITY OF OPTIONS/TECHNOLOGIES TO ADDRESS UNCERTAINTY

412

Comment: *Why is demand-side management not included as a flexible option in Volume 1, Chapter 9, Figure 9-14, Value of Flexibility?*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: In response to public comments, the final Energy Vision 2020 plan identifies several flexible demand-side management options, similar to the flexible supply-side options. These flexible demand-side management options are included in the short-term action plan. (See Volume 1, Chapter 10, Figure 10-1.)

413

Comment: *TVA's approach to using smaller units to meet future growth will provide it with additional flexibility in siting and scheduling the units for construction.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

414

Comment: *TVA's plans to use smaller generating units should have a positive benefit to the loss-of-load probability of the system. In the move to lower generation margins as TVA is planning, smaller generating units will also provide more flexibility during contingencies. The past reliance on large nuclear and coal plants provides certain economies of scale. However, the loss of an on-line unit requires numerous other machines to pick up the loss. At certain dispatch levels, the system may be paying a penalty due to having to back off from optimal operating points in order to have sufficient on-line reserves if a machine trips. Movement to smaller machines may allow machines to be loaded to a more optimal level.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

UNCERTAIN CHARACTERISTICS OF OPTIONS/TECHNOLOGIES

415

Comment: *Nuclear power prevents reliance on imported oil.*

Comment by: Charlie Hopkins (GENESCO)

Response: Energy from United States nuclear energy plants cut demand for foreign oil by over 300 million barrels a year—reducing our dependence on foreign oil suppliers and cutting our trade deficit.

416

Comment: *During the early 1980s Nuclear Regulatory Commission-required design changes were responsible for very high additions and improvements costs and long outages throughout the industry. The costs of these modifications decreased significantly during the mid-1980s and have been more or less constant (at about $10 million per unit per year) for the last seven or eight years. Essentially all the major Nuclear Regulatory Commission issues affecting plant design have been addressed at the TVA units or will be addressed before a unit starts up.*

Comment by: Tennessee Valley Public Power Association

Response: The Nuclear Regulatory Commission has conducted comprehensive inspections on recovery and construction activities of TVA's nuclear units. Extensive operational readiness inspections by the Nuclear Regulatory Commission and TVA were conducted prior to TVA certifying to the Nuclear Regulatory Commission that it was ready to load fuel and begin safe operation. All issues were resolved to the satisfaction of TVA and the Nuclear Regulatory Commission prior to fuel load at Browns Ferry Nuclear Plant Unit 3 and Watts Bar Nuclear Plant Unit 1.

417

Comment: *It is reasonable to assume that the impacts of Nuclear Regulatory Commission-required design changes will remain at current levels in the future.*

An argument can easily be made that existing Nuclear Regulatory Commission requirements are unnecessarily burdensome and that more rational requirements could allow plants to cut costs by as much as 50 percent without reducing safety. In fact, the Nuclear Regulatory Commission has taken some steps to reduce the impact of its requirements. It is expected that industry-average costs will drop by a small amount over the next few years and remain constant thereafter.

Comment by: Tennessee Valley Public Power Association

Response: During the 1980s most modifications to nuclear facilities were driven by new regulations, many of which were issued following the 1979 Three Mile Island accident. A number of these regulations involved expensive modifications to plant systems and equipment. However, the number of new regulations has decreased in recent years, and in general, new regulations have had lower financial impact. This trend is expected to continue. It reflects the maturing of the nuclear industry and increased knowledge about nuclear safety.

418

Comment: *The impacts of known nuclear equipment problems have generally decreased over the last decade while the rate at which new problems have been discovered has also decreased. This has been a major reason for improved capacity factors and reduced additions and improvements costs.*

Comment by: Tennessee Valley Public Power Association

Response: Performance in the nuclear industry and at TVA continues to improve. A discussion of the improvement of TVA's nuclear performance can be found in the section on Nuclear Generation in Volume 1, Chapter 4 and the section on TVA's Nuclear Plants in Volume 2, Technical Document 3.

419

Comment: *TVA has several programs underway that are designed to eliminate some of the unnecessary regulatory requirements at its nuclear plants and to improve the efficiency with which the plants meet the remaining requirements. TVA believes these programs have the potential to reduce the annual operating and maintenance costs at a twin-unit plant by up to ten or twenty million dollars. TVA has been improving the quality of outage planning and maintenance at the operating plants. This also has the potential to reduce operating and maintenance costs significantly.*

Comment by: Tennessee Valley Public Power Association

Response: TVA has a Cost Beneficial Licensing Action Commitment Reduction Program in effect which investigates elimination of unnecessary regulatory requirements that do not affect safety at all of its nuclear power plants. The program identifies and investigates potential cost savings from all possible avenues, but priority is given to outage and maintenance cost and time reductions.

420

Comment: *The costs of modifications at TVA's Nuclear Plants have been very high in recent years. For example, the total outage times—and additions and improvements expenditures—at Browns Ferry Nuclear Plant have been on the order of five times industry averages.*

It appears that TVA plant maintenance and outage planning were below average in the past. TVA personnel believe they have made significant progress improving the quality of maintenance and of outage planning at their units. During the last decade, many units throughout the industry have improved their performances in these areas, and this is one reason that capacity factors have improved while costs have leveled off. It remains to be seen whether future capacity factors (and costs) at the TVA plants are likely to be average, better than average, or worse than average. While it is possible that TVA may improve from worse than average in the past to better than average in the future, very few units have managed to do this in the past. It is uncertain whether the factors that led to high costs and long outages are likely to persist in the future.

Comment by: Tennessee Valley Public Power Association

Response: Physical improvements and modifications to recover TVA's nuclear units have been costly, but the impacts on safety and reliable performance have been positive. Alterations in design, processes, and hardware have improved safety, performance, and costs of nuclear unit operation at Browns Ferry Nuclear Plant Unit 2 and Sequoyah Nuclear Plant. The duration of the Browns Ferry Nuclear Plant Unit 2, cycle 6 outage was 125 days. The duration of the last outage for Browns Ferry Nuclear Plant Unit 2, cycle 7, was 53 days. The projected duration for Browns Ferry Nuclear Plant Unit 2, cycle 8, is 35 days. TVA recovery efforts will be completed with the return to service of Browns Ferry Nuclear Plant Unit 3 in late 1995.

The quality of maintenance and outage planning has improved as noted in the significant improvement in outage duration. TVA is confident that it will be among the best in the nuclear industry in light of the physical improvements and modifications that have already been made or identified to recover its nuclear units. Recognizing the uncertainty of forecasting nuclear capacity factors, TVA has used a range for this in Energy Vision 2020. (See Volume 2, Technical Document 8, page T8.27.)

421

Comment: *It is unlikely that TVA would be able to reduce average operating and maintenance costs to the $55 per kilowatt it has assumed for the low cost case.*

Comment by: Tennessee Valley Public Power Association

Response: The Energy Vision 2020 analysis assumed a 10 percent probability of occurrence for the low estimate of operating and maintenance, which is based on nuclear industry targets.

422

Comment: *Stress-corrosion cracking of recirculation piping has been the single biggest problem affecting boiling water reactors. Most of the piping has been, or will have been, replaced at each of TVA's boiling water reactors (Browns Ferry Nuclear Plant Units 1, 2, and 3), so there should not be major pipe cracking problems at these units in the future.*

Stress-corrosion cracking of the reactor pressure vessel internals could potentially cause long outages and high costs at boiling water reactors in the future. At present, it appears that cracking of the core shroud will not cause major problems. However, the possibility exists for more extensive cracking in the future. This is of particular concern because TVA has not installed hydrogen water chemistry (which can suppress stress-corrosion cracking) at Browns Ferry Nuclear Plant and does not now plan to do so.

Comment by: Tennessee Valley Public Power Association

Response: TVA is currently evaluating the feasibility of installing hydrogen water chemistry at Browns Ferry Nuclear Plant. Operating and maintenance decisions are based on cost-effectiveness of actions to maximize performance.

423

Comment: *Even though TVA is currently getting reasonably good marks from the Nuclear Regulatory Commission, there is no guarantee that its nuclear plants may not have Nuclear Regulatory Commission problems in the future. This is especially true since several plants that have been shut down in recent years appeared to have been doing well, and even had received favorable Nuclear Regulatory Commission reviews prior to shutdown. Therefore, projections of future capacity factors (and costs) for the TVA plants must include some allowances for the possibility of future Nuclear Regulatory Commission-ordered outages.*

Comment by: Tennessee Valley Public Power Association

Response: The capacity factor for expected performance, 67 percent, was based on TVA's actual performance since the outages in the late 1980s. This period included a regulatory outage at Sequoyah Nuclear Plant. In Energy Vision 2020, a range of capacity factors is identified to represent the possibility for a longer regulatory-imposed outage. The low estimate for capacity factors is 55 percent; the high estimate is 86 percent.

424

Comment: *Burns & McDonnell/XENERGY generally agree with TVA's assumptions concerning the costs to complete and operate the unfinished nuclear units. Some of TVA's assump-*

tions appear to be somewhat conservative, while others are somewhat optimistic. However, none of the assumptions is beyond being reasonable.

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

425

Comment: *TVA's medium estimate for additions and improvements cost is $20 million per nuclear station per year with an additional $5 million per unit per year. Thus, estimated additions and improvements costs for a two-unit station are $30 million per year. TVA states this is based on recent industry experience. However, Burns & McDonnell's analyses indicate that recent costs for a two-unit station have been averaging about $40 million per year.*

Comment by: Tennessee Valley Public Power Association

Response: National Economic Research Associates, Inc. and R. J. Rudden Associates, Inc. were retained for the Energy Vision 2020 Review Group to evaluate the key assumptions related to the cost and performance of TVA's nuclear units. Their conclusion regarding addition and improvement costs is that the TVA estimates are reasonable and somewhat higher than their estimates. The details of the analysis and conclusions regarding TVA's estimates of addition and improvement costs are found on pages 6 to 8 of the report titled "An Evaluation of the Nuclear-Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan."

426

Comment: *During the last twenty-five years, actual capital costs for all nuclear units in the United States have been much higher than originally estimated. Cost overruns were almost entirely because of changing regulatory requirements. These regulatory changes affected plant designs (e.g., fire protection and Three Mile Island requirements) and also design and construction practices (e.g., configuration management).*

Comment by: Tennessee Valley Public Power Association

Response: During the 1980s most modifications to nuclear facilities were driven by new regulations, many of which were issued following the 1979 Three Mile Island accident. A number of these regulations involved expensive modifications to plant systems and equipment. In recent years, however, new regulations have decreased, and in general have had a lower financial impact. This trend reflects the maturing of the nuclear industry and increased knowledge about nuclear safety.

427

Comment: *There has been some concern expressed (by MHB, a consultant which reviewed TVA's nuclear program at the request of an Energy Vision 2020 Review Group member) that the costs quoted by TVA do not include some significant overhead expenses (administrative and general). Burns & McDonnell/XENERGY's preliminary inquiries indicate that all significant costs are included in TVA's numbers.*

Comment by: Tennessee Valley Public Power Association

Response: We agree that all significant costs are in the TVA analysis.

428

Comment: *Nuclear decommissioning costs are unacceptably high.*

Comment by: Philip & Winfred Thomforde

Response: Decommissioning costs were fully considered in the integrated resource planning analysis for nuclear options as illustrated in Volume 2, Technical Document 6, Figure T6-1.

TVA and the Energy Vision 2020 Review Group retained National Economic Research Associates, Inc. and R. J. Rudden Associates, Inc. to evaluate the key assumptions related to the cost and performance of TVA's nuclear units. The overall conclusions regarding TVA's estimates of decommissioning and waste disposal costs are that the range of costs estimated by TVA is reasonable, and decommissioning costs represent a relatively small part of nuclear generating costs. Therefore, large increases in the estimated costs would have a very small impact on the overall operating costs of a nuclear plant.

The details of the analysis and conclusions regarding TVA's estimates of decommissioning and waste disposal costs are found on pages 13 to 15 of the report titled "An Evaluation of the Nuclear-Related Assumptions Used in the Tennessee Valley Authority's Integrated Resource Plan."

429

Comment: *TVA's latest estimates for decommissioning its nuclear reactor units that were used in the Energy Vision 2020 analysis were as follows:*

Browns Ferry	*$250 million per unit*	*$750 million total*
Watts Bar	*200 million per unit*	*200 million total*
Sequoyah	*150 million per unit*	*300 million total*
Total		*$1,250 million total*

The source and age of these estimates was unclear; however, they were not taken from the last official decommissioning cost estimates for TVA. Cost estimates of decommissioning for other nuclear units around the country have increased substantially in recent years. TVA has indicated that the lack of experience nationally in actual decommissioning of nuclear reactors made it difficult to project these costs on an objective basis.

Comment by: Tennessee Valley Public Power Association

Response: In Energy Vision 2020, TVA used a medium decommissioning cost estimate in all base case strategies. TVA used a range to represent the uncertainty in decommissioning costs. All estimates are for the decontamination and dismantlement option for prompt removal and dismantling. The low values are based on the Nuclear Regulatory Commission formula of $105 million for pressurized water reactors and $130 million for boiling water reactors in January 1986 dollars, escalated to 1994 dollars. The medium values represent the average of industry estimates escalated to 1994 dollars. The high values are twice the average of industry estimates.

Value	Pressurized Water Reactor	Boiling Water Reactor
Low	$200 million per unit	$250 million per unit
Medium	$300 million per unit	$350 million per unit
High	$600 million per unit	$700 million per unit.

430

Comment: *TVA has provided for the accumulation of funding for the eventual decommissioning of its nuclear power stations since 1982. Investor-owned utilities are required by the Nuclear Regulatory Commission to have decommissioning funds set aside in a trust. However, TVA has a government exemption from the Nuclear Regulatory Commission requirement. Therefore, it has established its decommissioning fund as an internally-managed fund. In 1993, TVA took advantage of an opportunity to sell its decommissioning fund investments at a substantial gain over their book value. TVA has not returned the proceeds to the decommissioning fund and has delayed doing so, pending an analysis of different investment options with higher long-term yields. The remaining balance in the decommissioning fund was $150 million.*

The amount of funding for decommissioning each year is collected from the ratepayers through the current rates. If the decommissioning cost projections were to change significantly, there could be substantial impact on TVA's rates.

Comment by: Tennessee Valley Public Power Association

Response: TVA currently has $260 million invested for its decommissioning fund and plans to invest another $123 million by the end of fiscal year 1996. According to current decommissioning cost estimates, this amount is sufficient, depending on the return on investments, to meet TVA's future decommissioning requirements. TVA continues to review its decommissioning requirements and manages the decommissioning fund investments in accordance with current cost estimates.

431

Comment: *TVA needs to factor in the risks and contingencies of spent fuel storage and the possibility that a high-level repository may never be available. This issue needs to be better discussed.*

Comment by: Dennis Haldeman, Jennifer Lapidus & Hannah Bennett, Geoffrey Crandall (MSB Energy Associates)

Response: The risks and contingencies of spent fuel storage and the possibility that a high level repository may never be available is discussed in Volume 1, Chapter 3, page 3.30. The uncertainty in the cost of spent fuel storage is also addressed in Volume 2, Technical Document 8, page T8.28 and Figures T8-30 to T8-33.

432

Comment: *Are the costs of a catastrophic nuclear accident factored into Energy Vision 2020? For example, the USSR estimated that it would cost $400 billion over a 10-year period for Chernobyl relocation costs alone.*

Comment by: Richard Simmers, Michael Karp (Northwest Conservation Act Coalition)

Response: The costs of a catastrophic nuclear accident are not directly considered in Energy Vision 2020. The design of American nuclear plants is much safer than that of the Chernobyl plant and there is little or no risk of a similar accident occurring in the United States. However, the effect of such an accident on TVA's energy resource planning has been indirectly considered in that one of the possible future events considered in Energy Vision 2020 is a moratorium on generation from nuclear plants. (See Volume 2, Technical

Document 8, Figures T8-30 to T8-33.) Although a nuclear moratorium could have large cost consequences to TVA, such an event is considered to have a very low probability of occurrence.

433

Comment: *Nuclear units should be capable of 80 to 85 percent capacity factors. Industry performance so far has been far below this, although it has improved substantially in recent years.*

Four factors contributed more or less equally to the reduced nuclear industry average capacity factors (58 percent actual versus 80 to 85 percent possible) during the 1970s and 1980s. These were:

- *Generic equipment problems such as pipe cracking in boiling water reactors and steam generator tube corrosion at pressure water reactors*
- *Design modifications and increased testing in response to changing Nuclear Regulatory Commission requirements*
- *Less than optimum outage planning and maintenance at many plants*
- *Nuclear Regulatory Commission-ordered plant outages*

Starting in the early 1980s, the industry has seen significant improvements in the areas of generic equipment problems, design modifications, and outage planning and maintenance.

Comment by: Tennessee Valley Public Power Association

Response: The top quartile of operating nuclear units has achieved capacity factors greater than 82 percent since 1992 with an increasing trend.

434

Comment: *If TVA' s high and low estimates for capacity factor (86 percent and 55 percent) are correct, then the medium estimate should be considerably higher than the 67 percent it has used. The inconsistency arose because the high and low estimates were based on recent industry experience while the medium estimate was based on recent TVA experience, which was below industry averages because of the recent outages at Sequoyah Nuclear Plant.*

Comment by: Tennessee Valley Public Power Association

Response: An evaluation by National Economic Research Associates, Inc. and R. J. Rudden Associates, Inc. concludes that the TVA estimate of 67 percent capacity factor is somewhat lower than their estimates. Your statements concerning the derivation of the capacity factor estimates are accurate. The medium estimate is based on recent TVA performance. In order to band future occurrences, a larger and broader sample based on nuclear industry performance was used to develop the high and low estimates. In developing the range for the nuclear capacity factor, it is not necessary that the low and high estimates deviate equally from the medium estimate.

435

Comment: *An evaluation of the nuclear performance assumptions led to a questioning of the ability of TVA to increase the nuclear plant availability to the level assumed in Energy Vision 2020.*

Comment by: Tennessee Valley Public Power Association

Response: Since return to service from the outages in the late 1980s, Sequoyah Nuclear Plant Units 1 and 2 and Browns Ferry Nuclear Plant Unit 2 have recorded, respectively, a 66 percent, 65.4 percent, and 80.6 percent equivalent availability through September 1995. Energy Vision 2020 assumed an average equivalent availability of 67 percent for its nuclear plants. (See Volume 2, Technical Document 3, Existing Power System.)

436

Comment: *The Energy Vision 2020 Review Group retained various consulting firms to analyze in detail certain issues related to Energy Vision 2020. For nuclear issues, the Review Group retained National Economic Research Associates, Inc. and R. J. Rudden to evaluate the key assumptions related to the cost and performance of TVA's nuclear units. National Economic Research Associates, Inc.'s conclusions are summarized as follows:*

- *TVA's medium case projections for operating and maintenance costs for Sequoyah, Watts Bar, and Bellefonte Nuclear Plants are reasonable.*
- *TVA's estimates of operating and maintenance costs for Browns Ferry Nuclear Plant appear to be a bit low.*
- *TVA's estimates of additions and improvements costs appear reasonable.*
- *TVA's capacity factor estimates for Sequoyah, Watts Bar, and Bellefonte Nuclear Plants appear to be reasonable and are somewhat lower than National Economic Research Associates, Inc. estimates. On the other hand, TVA's estimates for Browns Ferry Nuclear Plant appear to be a little high, about 5 percentage points higher than National Economic Research Associates, Inc. estimates.*
- *National Economic Research Associates, Inc.'s analyses show a wider range in operating costs and performance than are reflected in TVA's low and high cases.*
- *TVA's estimates for decommissioning and waste disposal costs seem to be somewhat low.*
- *TVA's estimates of the cost and schedule for the recovery of Browns Ferry Nuclear Plant Unit 1 appear reasonable.*
- *TVA's estimates of nuclear fuel costs are reasonable.*

Burns & McDonnell/XENERGY's nuclear specialist reviewed the National Economic Research Associates, Inc. report, and some concern was expressed over the methods used by National Economic Research Associates, Inc. to review TVA's assumptions. Specifically, it appears National Economic Research Associates, Inc. attempted to objectively review TVA's assumptions by relying heavily on statistical analyses of historical nuclear unit performance and costs. A weakness of this methodology is that it fails to address, in some instances, key issues specific to TVA not reflected in the statistical data. Despite these concerns over National Economic Research Associates, Inc.'s methods, Burns & McDonnell/XENERGY generally concur with National Economic Research Associates, Inc.'s conclusions.

Comment by: Tennessee Valley Public Power Association

Response: Any differences between National Economic Research Associates' conclusions and TVA's analysis are relatively minor and therefore do not affect analytical conclusions.

437

Comment: *The ability to build new capacity is in jeopardy due to environmental concerns and the high cost of long lead times.*

Comment by: Ed Brooks (Tennessee Southern Railroad)

Response: It is true that the cost of building new electrical generating capacity is high today. This is due to the high cost of environmental compliance, materials of construction, and labor. It is also true that conventional project planning and execution of a generation project would result in a long lead time between project approval and commercial operation.

We are taking steps to ensure that the costs for new generation capacity will be as low as possible by selecting generating technologies that are the most environmentally friendly and least costly to construct and operate. We are also planning these projects with an emphasis on taking the steps necessary to reduce the lead time between the decision to proceed and commercial operation. These efforts will provide supply-side options that have good environmental characteristics and can be implemented in a cost-effective manner.

The short-term plan emphasizes flexibility. (See Volume 1, Chapter 10, Figure 10-1.) Flexibility can be achieved by reducing the lead time for project construction.

438

Comment: *Both the short-term and long-term plans rely on call options for peaking and base-load power. These are innovative and, to date, largely untried power supply arrangements. In adopting this vehicle, TVA must ensure not only that this power is competitively priced but also that it can be relied upon when the need arises. If TVA is going to count on this power as a firm power source, it must be backed up either by reserves maintained on the TVA system or by reserves provided by the supplier. How these call options will work in practice remains to be seen. It seems to us that only if the power is a call option from another electric utility, and this segment of power is treated by that utility as equivalent to firm load served by that utility, can TVA be truly assured of its future availability.*

Comment by: TVA Retirees Association

Response: Option purchase agreement proposals received by TVA have been evaluated on the basis of their price, flexibility, and transmission capability, as well as their financial, technological, environmental, and economic development attributes. This considers project feasibility and the ability to deliver power to TVA. From the results of these evaluations, the proposals were ranked, and TVA developed a "short list" of the best candidates. TVA will negotiate the price, amount of capacity, and premiums with these candidates.

In option purchase agreement contracts, financial provisions are included that will require the supplier to reimburse TVA for any power not delivered. In addition, all option purchase agreements require 100 percent availability.

439

Comment: *TVA needs to consider the effect of losing hydroelectric generation due to reservoir siltation and dam failure.*

Comment by: Dennis Haldeman

Response: In Energy Vision 2020, TVA's forecast of hydroelectric generation considers many factors including current and expected capacity, expected rainfall, current and expected operating constraints, and current and future flood constraints on generation. TVA does not expect siltation to effect hydroelectric generation during the time period of Energy Vision 2020. TVA continually reviews the safety of the dams and does not expect dam failure.

Evaluation Process

440

Comment: *It is our opinion that TVA went the extra mile to ensure an unbiased evaluation of all possible power supply options and considered a generous range of probabilities. The process of retaining all options until the integration phase eliminated potential bias in the evaluation process, but created an almost overwhelming mass of comparisons. Without patient TVA staff interpretation and graphic presentations of trade-off criteria evaluations, it would have been impossible for the Tennessee Valley Public Power Association to assess the relative merits of the many plans.*

Comment by: Tennessee Valley Public Power Association

Response: Thank you; we appreciate the comments supporting the process of developing Energy Vision 2020.

441

Comment: *The Environmental Protection Agency appreciates the multi-attribute trade-off analysis employed by TVA to refine resource integration alternatives several times (trade-off analysis) to reduce both environmental impacts and costs and to develop reasonable resource strategies. We can also appreciate the complexity of the subject matter and the difficulties/uncertainties in projecting TVA energy sources for the next 25 years.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Your comment has been reviewed and noted.

442

Comment: *Of particular note is TVA's multiple objective approach, whereby demand-side management technologies and programs are considered in light of many corporate and customer service goals. This approach diverges somewhat from the traditional utility approach of viewing demand-side management simply as cost-effective resource acquisition. As a result, TVA is carefully considering other objectives such as rate minimization, customer value, market transformation, and environmental impact reduction. This allows TVA to more carefully consider demand-side management as part of an overall strategy to prepare it, and its wholesale distributors, for greater industry competition.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

443

Comment: *Demand-side management and renewable technologies should be considered on a level playing field with supply-side options.*

Comment by: David Bordenkircher, Clark Buchner (Sierra Club, Tennessee Chapter)

Response: TVA identified and characterized both supply-side options and demand-side management programs, then ranked all these resource options together based on costs, rates, debt, and environmental emissions. All of the cost estimates were based on industry-accepted practices for evaluating demand-side management and supply-side resources. Using the multi-attribute trade-off method, TVA was able to consider supply-

and demand-side options on a level playing field. The best resource options, either supply-side or demand-side, were combined into strategies to meet projected load and other criteria, as well as to address key uncertainties. (For an explanation of the Energy Vision 2020 process and evaluation criteria, see Volume 1, Chapters 2 and 5.)

444

Comment: *It appears that TVA made a significant effort to include a broad range of options that meet a variety of measurement criteria without weighting the criteria to bias the outcome.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

445

Comment: *In general, TVA's approach to developing and analyzing strategies is acceptable. It incorporates numerous uncertainties, solicits a range of perspectives from outside parties, and addresses the fact that many criteria are involved in making a good decision.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

446

Comment: *It is to the Tennessee Valley Public Power Association's benefit that TVA has chosen a broad-based planning approach that considers multiple objectives, with a particular focus on providing customer value, maintaining low rates, and positioning TVA and its wholesale distributors strategically for future industry competition. While this approach has so far resulted in a somewhat unfocused demand-side management plan, it allows for consideration of many options—including load building—without preconceived ideas about which ones should or should not be pursued.*

Comment by: Tennessee Valley Public Power Association

Response: TVA anticipates diverse and changing needs for consumers of TVA power. The wide variety of customer service options considered in Energy Vision 2020 and included in the short-term action plan were designed to accommodate the different needs of residents and businesses served by TVA. (See Volume 1, Chapter 1, Figure 10-1.)

447

Comment: *In the utility industry today, there are numerous approaches to the integration phase of resource planning. The most common approach is "optimization" using products such as EGEAS (an Electric Power Research Institute product supported by Stone and Webster Management Consultants) or PROSCREEN (one of the Energy Management Associates family of models that includes PROMOD and PROVIEW).*

For years, these models have been used to optimize capacity expansion and compute production costs for supply-side strategies. The term optimization itself is an advantage for these models because it implies "best" to many managers and regulators. In fact, it is this assumption which is also a serious weakness of this approach. These models optimize only one criterion at a time, such as lowest rates. They often ignore or understate the impor-

tance of other criteria such as environmental emissions, total resource costs, or reliability because only one variable at a time is optimized.

The TVA approach to integration avoids the optimization trap and attempts to evaluate a wide variety of strategies using decision analysis techniques. TVA's modeling philosophy is that any reasonable plan must address as many future uncertainties as possible. In addition, plans should contain a "portfolio" of options that provide a hedge against unforeseen events, thereby minimizing risk. Optimization models such as EGEAS and PROSCREEN tend to produce a rush to an extreme whereby the winning supply option is relied upon almost exclusively. TVA's philosophy supports flexibility by creating a planning framework where it is relatively simple to shift between strategies as future events dictate. TVA believes that by carefully re-engineering the process of designing and building resources, decisions can be delayed, thus reducing the chance that subsequent events will judge the resource to be unnecessary.

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

448

Comment: *In reviewing the Energy Vision 2020 results, the impacts of low and high load growth on the relative performance of the strategies was tested. TVA's approach to evaluating strategies for alternative futures was to assume that any decisions made in 1996 or 1997 would be locked in and therefore the same regardless of future. After 1997, the MIDAS model would be allowed to select those resources that best fit the new future. While TVA's assumption that any decisions made in 1996 and 1997 would be locked in is reasonable, it assumes that TVA will follow the middle future until at least 1998.*

Comment by: Tennessee Valley Public Power Association

Response: We agree with this assessment, but the more flexible strategies, Q and R, allow decisions made in 1996 and 1997 to be changed depending on future load growth and other events. (See Volume 1, Chapter 9, pages 9.27 and 9.28.)

449

Comment: *With respect to emissions, Burns & McDonnell/XENERGY and TVA focused on carbon dioxide emissions. Nitrogen oxides, sulfur dioxide, and the other environmental measures are also important, but seem to be highly correlated with carbon dioxide. In other words, technologies that produce high carbon dioxide emissions also seem to produce high levels of other emissions.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

450

Comment: *The multi-attribute system was not useful because it did not weigh the environmental externalities appropriately, for example aesthetics, and rates were the driving force.*

Comment by: Mary Carton, Stephen Smith (Tennessee Valley Energy Reform Coalition), Danielle Droitsch

Response: The multi-attribute methodology used for evaluating various strategies for Energy Vision 2020 is a quantitative methodology that does not weigh various evaluation criteria. Instead, it allows the consideration of multiple evaluation criteria and focuses on changing strategies to improve their performance on all evaluation criteria. The evaluation criteria included both rates and environmental impacts.

The multi-attribute analysis used for Energy Vision 2020 did not include aesthetics. The aesthetic considerations for nuclear plants, wind, and other resources were considered qualitatively. Aesthetics for various supply-side options, including nuclear plants and wind energy, are addressed in Volume 2, Technical Document 2.

451

Comment: *When estimating the cost of power for nuclear plants, TVA has not included the capital outlay costs, but it does for renewables. This is dishonest and unscientific.*

Comment by: Eileen McIlvane (Coalition for Jobs and the Environment)

Response: The economic comparisons of the cost of power in Energy Vision 2020 rely on time tested and proven economic analysis techniques. All costs are based on an incremental cost concept. Thus, when comparing the costs of an unfinished nuclear plant to renewables, the capital cost to complete the nuclear plant and the total capital costs of renewable energy are included in the economic analysis. Likewise, if TVA had an unfinished renewable plant, only the cost to complete the renewable plant would be embedded in the economic analysis.

Any money already spent, sunk cost, would not be embedded in the analysis since that money has been spent regardless of whether the nuclear plant is built or a renewable energy option is completed.

452

Comment: *TVA's commitment to bringing on Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3 provides a disincentive to seriously considering demand-side management.*

Comment by: John Johnson (Earth First), Olivia Lim (Southeast Center for Ecological Awareness), Sheila Holbrook-White (Sierra Club, Alabama Chapter), Linda Ewald

Response: TVA has an immediate need for the power from both Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3. In addition, TVA forecasts a need for an additional 3,500 megawatts by the year 2002.

To meet this need, TVA evaluated hundreds of supply- and demand-side options and included in the short-term action plan (see Volume 1, Chapter 10). The short-term action plan includes 650 megawatts of demand-side management by 2002 and as much as 2,200 megawatts in 2010. The demand-side management and other options included in the short-term action plan best balanced several criteria including long-term costs, electric rates, debt, environmental emissions, and economic development.

453

Comment: *In general, TVA's approach to developing and analyzing strategies is acceptable. It incorporates numerous uncertainties, solicits a range of perspectives from outside parties, and addresses the fact that many criteria are involved in making a good decision. Issues that TVA should improve in future analyses include:*

- *Creating alternative futures from which to develop and assess strategies.*
- *Incorporating reliability as an evaluation criterion.*
- *Addressing strategic issues related to competition and the TVA "wall".*
- *Synthesizing results of optimization models such as EGEAS into the results.*

Comment by: Tennessee Valley Public Power Association

Response: TVA's Energy Vision 2020 used a six-step process to develop preferred strategies. Step one identified public issues and relevant concerns. Step two translated these issues and concerns into evaluation criteria, resource options, and uncertainties. Step three crafted resource options into strategies to meet particular criteria or to address key uncertainties. Step four identified possible futures which, for example, could include high load growth, high cost of natural gas, and increasing regulations of emissions. Step five constructed scenarios by combining a single strategy for a single future. Step six, the last step, used trade-off analysis to find the best strategies for the future.

In Energy Vision 2020, TVA identified 972 futures. TVA created these futures based on those uncertainties that could have the greatest impact on the resource strategies TVA might choose to implement.

One of the evaluation criteria used in Energy Vision 2020 was reliability. Since the same reliability requirements must be met by all strategies considered in Energy Vision 2020, system reliability is treated as a constraint on each strategy. Therefore, all strategies considered during this process had adequate and comparable levels of reliability.

TVA has incorporated assumptions about competition into its electricity demand forecast. In the range of forecasts, TVA has identified the potential for the gain or loss of both wholesale and retail markets. For more information on TVA's load forecasts, see Volume 1, Chapter 6 and Volume 2, Technical Document 5. In addition, TVA has identified three different types of resource options well suited to address competition: (1) bulk power purchases and sales from other utilities, (2) purchases of power from cogenerators and independent power producers, and (3) market-based alternatives, such as call options on future capacity additions.

TVA has chosen to develop a long-term plan which consists of a portfolio of resource options from the seven key strategies. Much like a portfolio of stocks that is chosen to manage risk and accomplish specific objectives, the portfolio of resource options enables TVA to meet customer needs at an acceptable level of risk and meet the objective of balancing costs, rates, environmental impact, debt, and economic development. The problem with using an optimization model such as EGEAS, is that the "optimal resource plan" created with particular resources in particular years changes drastically as the future begins to unfold. A portfolio, on the other hand, remains flexible to adapt to changing conditions.

454

Comment: *There is a heavy reliance on unverified assumptions throughout the plan such as nuclear plant performance, coal suppliers and prices, and the competitiveness of emerging renewables.*

Comment by: Dennis Haldeman

Response: The assumptions used in the Energy Vision 2020 process were developed using the best information available and the best resources including TVA personnel, non-TVA experts, and consultants.

Many of these assumptions cannot be forecast with certainty. The most important assumptions were characterized as uncertain, and a range of forecasts was used for each of these uncertain assumptions. Information about these uncertainties is described in Volume 2, Technical Document 8. The evaluation of strategies with these uncertain assumptions is described in Volume 1, Chapter 9.

The key assumptions used in Energy Vision 2020 were extensively reviewed both within TVA and outside of TVA. Within TVA, a Forecast Review Board composed of TVA executives and senior managers reviewed all key assumptions.

The review of the assumptions outside TVA was made by several parties. First, members of the Energy Vision 2020 Review Group reviewed and commented on the key assumptions. Second, two consultants were hired for the Energy Vision 2020 Review Group: one to review the load forecasts and one to review the assumptions related to nuclear plant performance and cost. Third, the Tennessee Valley Public Power Association hired Burns & McDonnell to review all the assumptions and results of Energy Vision 2020. The Burns & McDonnell review appears in a report titled "Report to the Tennessee Valley Public Power Association Power Supply Planning Committee on TVA's Preliminary Integrated Resource Plan." Consultants for the Energy Vision 2020 Review Group and the Tennessee Valley Public Power Association determined that TVA's assumptions were reasonable.

455

Comment: *The various departments within TVA provided input and assumptions regarding the generation plan, load forecasts, fuel price projections, different resource and capital spending scenarios, etc. for the corporate planning process. Many of the assumptions represented simple escalation of historical costs based on educated estimates of growth rates.*

Comment by: Tennessee Valley Public Power Association

Response: This integration of all of TVA's planning assumptions provided a sound basis to begin the integrated resource planning process.

Many of these assumptions cannot be forecast with certainty. The most important assumptions were characterized as uncertain and a range of forecasts was used for each of these uncertain assumptions. Information about these uncertainties is described in Volume 2, Technical Document 8. The evaluation of strategies with these uncertain assumptions is described in Volume 1, Chapter 9.

The key assumptions used in Energy Vision 2020 were extensively reviewed both within TVA and outside of TVA. Within TVA, a Forecast Review Board composed of TVA executives and senior managers reviewed all key assumptions.

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456

Comment: *TVA uses selective science to justify a predisposed position of the profiteers.*

Comment by: Dennis Haldeman

Response: Highly qualified professional scientists and engineers from departments throughout TVA prepared Energy Vision 2020. (See Volume 2, Technical Document 9, List of Preparers.) The wide range of literature cited indicates the openness and breadth of the work underlying the plan. A review of the Energy Vision 2020 assumptions outside TVA was made by several parties. First, the Energy Vision 2020 Review Group reviewed and commented on the key assumptions. Second, two consultants were hired for the Energy Vision 2020 Review Group: one to review the load forecasts and one to review the assumptions related to nuclear plant performance and cost. Third, the Tennessee Valley Public Power Association hired Burns & McDonnell to review all the assumptions and results of Energy Vision 2020. The Burns & McDonnell review appears in a report titled "Report to the Tennessee Valley Public Power Association Power Supply Planning Committee on TVA's Preliminary Integrated Resource Plan." Consultants for the Energy Vision 2020 Review Group and the Tennessee Valley Public Power Association determined that TVA's assumptions were reasonable. In addition numerous experts were used in the development of Energy Vision 2020. These included Barakat and Chamberlin; Clint Andrews, Princeton University; and Steve Connors, Massachusetts Institute of Technology.

457

Comment: *Based on a review of TVA's reliability planning, it appears that:*

1. *Energy Vision 2020 includes planning for reasonable levels of reliability for generation. The assumptions for improvements in nuclear availability are aggressive and need to be carefully monitored.*
2. *The locations of the generating units considered for Energy Vision 2020 strategies should be in the west end of the TVA service territory to minimize transmission reliability benefits and reduce system losses during peak conditions.*
3. *From a system reliability aspect, a reserve level of 13 percent appears to be the minimum that should be considered for the TVA system. This level should include the generation and system interconnection capabilities.*

Comment by: Tennessee Valley Public Power Association

Response: We generally agree with these statements and recommendations. However, as standard industry practice, TVA includes long-term firm power purchases in its reserve margin as well as generation, but short-term non-firm purchases are not included.

458

Comment: *TVA's overall approach to generation and transmission reliability planning involves typical studies performed to determine the need for improvements on the system. TVA uses state-of-the-art planning software. Its approach to assessing reliability is typical of utility planning.*

Comment by: Tennessee Valley Public Power Association

Response: TVA used best industry practices in evaluating generation and transmission reliability.

459

Comment: *At the beginning of this study, the generation and transmission planning groups operated independently from each other for the purposes of developing Energy Vision 2020. This independence could create system inefficiencies, since the system reliability depends on the response of the transmission and generation components during contingencies. Often, improvements in one area may improve overall reliability and could have additional benefits if joint planning between the two units were more closely coordinated.*

Comment by: Tennessee Valley Public Power Association

Response: Energy Vision 2020 looked at reliability on a long-term and short-term programmatic level. As sites are considered for generation projects, the transmission and generation planning groups will work closely to provide the best reliability for the TVA system. In addition, the short-term action plan recommends research and development of distributed or dispersed generation. (See Volume 1, Chapter 10, Figure 10-1.)

460

Comment: *With the current layout of the system generation and customers, any improvements should be analyzed for their total benefit for both the generation and transmission systems.*

Comment by: Tennessee Valley Public Power Association

Response: Since Energy Vision 2020 is programmatic in structure, site-specific decisions will be made later. Where specific conditions are necessary to conduct the review, such as for estimating transmission costs and effects, TVA considered a location at milepost 160 on the Tennessee River, which is in the western part of the TVA system.

461

Comment: *When performing long-range financial forecasting, most utilities use some type of corporate financial model to evaluate the impact of their estimated annual operating results on their year-end financial position over a specified planning period. TVA used two corporate financial modes, FINESSE and MIDAS. Both of these models are comprehensive financial planning tools.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

462

Comment: *Other models such as LMSTM, IRP Manager, and MIDAS have been developed by the Electric Power Research Institute to address the need to model demand-side programs more efficiently and to test a wider range of alternatives. MIDAS has been used extensively by TVA in Energy Vision 2020.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

SHORT-TERM ACTION PLAN

This section includes comments and responses about:
- the merits of proposed actions
- the details of Energy Vision 2020's short-term action plan
- the merits of using more demand-side management options in the plan
- the merits of using more renewable energy options in the plan, including the recommendations of the National Renewable Energy Laboratory
- the purchase of options to purchase energy resources
- the investigation of and research into various options

This section includes two comprehensive responses to a number of comments about the merits of using more demand-side management and renewable options in the plan.

General

463

Comment: *In the short-term action plan, the proposed action will allow TVA to remain competitive and provide low rates to valid customers.*

Comment by: William Pippin (Huntsville Utilities)

Response: Your comment has been reviewed and noted.

464

Comment: *The text describes a "fence" around TVA's market area and states that TVA is "prevented from selling power outside its existing service area…" (see Executive Summary, pages 8 to 9). However, the section on "What Are the Short-Term Actions?" in the "Questions and Answers" bulletin states that "TVA plans to continue to sell power to utilities and others outside its power system…" These statements appear contradictory.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: The "fence" describes the area and other restrictions that were a part of the self-financing provisions enacted in the late 1950s. The "fence" essentially restricts the area in which TVA can sell power, but permits TVA to sell power to utilities with which it was interconnected in 1957. There are 13 utilities to which TVA can sell power in interchange markets. This has been clarified in the final Energy Vision 2020 document.

465

Comment: *In general, the Tennessee Valley Public Power Association is satisfied that TVA has considered a broad range of options in the first five years of the plan. Future options are varied enough that TVA has flexibility in the options to pursue. Unit sizes are small enough that no one approach for expansion dominates TVA's future, as the nuclear program did in the past.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

466

Comment: *Sacramento Municipal Utility District believes TVA's plan correctly identifies the need for a short-range action program that relies heavily on flexible strategies.*

Comment by: Edward Smeloff (Sacramento Municipal Utility District)

Response: Your comment has been reviewed and noted.

467

Comment: *The strategies under consideration by TVA have, in general, a common use of gas-fired combustion turbines and combined-cycle units installed during the first five to seven years. Also, various levels of demand-side management programs are added. Therefore, the strategies, in the early years, have similar risk levels and economics.*

Comment by: Tennessee Valley Public Power Association

Response: In the short-term, TVA must rely on resource options with short lead times. The short-term action plan relies heavily on call options, hydro modernization, and demand-side management programs to meet the needs of its customers in the short term.

468

Comment: *The short-term action plan is far too general to know what TVA plans to do. Interested parties want specific details year-by-year in terms of activities, milestones, and budgets moving from the research and development phase into implementation.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Benjamin Stewart (Faith Lutheran Church), Eileen McIlvane (Coalition for Jobs and the Environment), Michelle Neal (Tennessee Valley Energy Reform Coalition), Geoffrey Crandall (MSB Energy Associates), Naomi Furman Kipp (Legal Services Corporation of Alabama), Eric Hirst (Oak Ridge National Laboratory)

Response: The short-term action plan (see Volume 1, Chapter 10, Figure 10-1) has been revised to specify the activities and key milestones year by year. A timeline for these activities is also shown graphically in Volume 1, Chapter 10, Figure 10-2.

469

Comment: *Without divulging details of individual bid offers, the short-term plan should provide more information about these offers, and power purchases such as capacity, load factor, availability, cost, and timing.*

Comment by: Eric Hirst (Oak Ridge National Laboratory)

Response: TVA is reviewing proposals for option purchase agreements in the form of call options. These proposals include offers for base-load, cycling, and peaking electric energy ranging in capacity from 140 to 1,800 megawatts. The proposed option purchase agreements offer electric energy beginning in 1999 for peak load offers, while some base-load offers extend out 30 years.

Summary information on option purchase agreements and power purchases is contained in the Characterization of Supply-Side Options section of Volume 1, Chapter 7. To identify the specific characteristics of the option purchase agreements or power purchases being considered in the short-term plan would reveal competitive and proprietary information.

Implementation of Customer Service Options

The following comments are addressed in a comprehensive response that appears after comment number 521. Any portions of the comments below related to renewable energy that are not addressed in the comprehensive response have responses in the next section, Implementation of Renewables.

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470 **Comment:** *TVA should promote energy efficiency through demand-side management. This region wastes more electricity than the national average. Additionally, other nations with similar standards of living have half the per capita energy use as the United States.*

Comment by: Larry Smith (Mid-South Peace and Justice Center), L. M. Johnson, Sr., Lynn Leach (Alabama Environmental Council), Karen Lovell, C. Strain, Sahara, Yvonne Seperich, Jim Von Bramer, Sam Denham, C. T. Brewster, Walter & Dorothy Stark, Sharron Eckert, Isahl Hemm, Mary Schwarz, John Schwarz, Jr., Robert Peeples, Deborah Cuva, Marion Zachiel, Katherine Osborn, R. & G. Ludwig, Ben & Winn Welch, F. W. Munson, N. E. Whitfield, M. Nathan Perry, Jo Anne Clark, William Emmott, Luther Gulick, A. B. Evans, Mary Anne Terry, Chris Gulick, Faith Young, Myles Jakubowski (Sunbeam Household Products), Ann & Mike Sanders, Ruth Peeples, Stephen Stedman, Ann Lamb, Mandy Tiesler, Robert Schreiber (Common Sense), Alan Jones (Tennessee Environmental Council), Fred Wright, Susana Harwood, John Harwood, Salo, Ray Williams, Karl Grotke, Dottie Hodges, Shirley Schaaf, Tohert, Hermann, Kim Grube, K. Varnum, Garry Shores, Kathy Priore, Karah Bates, M. Case, Amy Perry

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471 **Comment:** *TVA should be a showcase for energy saving programs.*

Comment by: Mary Carton, Beth Wallace, Alan Jones (Tennessee Environmental Council)

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472 **Comment:** *TVA needs to do more demand-side management. Add many more demand-side management (conservation) action items from Blocks 2 and 3.*

Comment by: Powell & Sharon Foster, Sheila Holbrook-White (Sierra Club, Alabama Chapter), Sharon Fidler (League Woman Voters), Jim Snell, Olivia Lim (Southeast Center for Ecological Awareness), Patricia Chapman, Kathy Dowbiggin, Dolores Howard, Andrew Danzig, Richard Simmers, Kirk Johnson, Carol Kimmons, Dennis Haldeman, Sheilla Cheyenne, Jennifer Lapidus & Hannah Bennett

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473 **Comment:** *TVA should practice, teach, and reward energy efficiency and energy conservation.*

Comment by: Suzanne Sims

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474 **Comment:** *TVA should rely more on demand-side management and less on supply-side options (such as power plants). Demand-side management is good for TVA and its consumers. In the short-term plan, supply-side megawatts ranged from 1,950 to 2,750. Demand-side only has 600.*

Comment by: Hollis Fenn, Wilson Prichett (Tennessee Valley Energy Management Association), Jamie Pizzirusso, Arthur Webb, Dennis Henke, Kathryn McCoy (Tennessee Energy Education Network), Clark Buchner (Sierra Club, Tennessee Chapter), John Noel, Debra Jackson, Roan Carratu, Maggie Kalen (Tennessee Valley Energy Reform Coalition), Bruce Wood, Geoffrey Crandall (MSB Energy Associates), John Johnson (Earth First), Dolores Howard, Jennifer Lapidus & Hannah Bennett, Michelle Neal (Tennessee Valley Energy Reform Coalition)

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475 **Comment:** *Some experts say fossil fuels will be gone in 25 years or the price of getting them out will be equal to having them. Adaptation to this will require a lot of public education and TVA should increase demand-side management measures above the few in the plan.*

Comment by: Nancy Bell

476 **Comment:** *By using energy more efficiently and conserving it, there will be less impact on the region's environment.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

477 **Comment:** *More demand-side management options will help reduce short-term rate impacts.*

Comment by: Sheila Holbrook-White (Sierra Club, Alabama Chapter), Sharon Fidler (League of Women Voters)

478 **Comment:** *The high sales/low rates emphasis of Energy Vision 2020 diminishes the role of demand-side management.*

Comment by: Mary English (University of Tennessee), Robert Schreiber (Common Sense), Sharon Fidler (League of Women Voters), Stephen Smith (Tennessee Valley Energy Reform Coalition), Dolores Howard, Alan Ball

479 **Comment:** *TVA should grow by stimulating growth within the region through promoting energy efficiency and becoming a provider of energy services and not just electricity.*

Comment by: Arthur Smith, Bruce Wood

480 **Comment:** *This plan is a paradigm for consumption.*

Comment by: Dennis Haldeman, Sheilla Cheyenne

481 **Comment:** *TVA does not support demand-side management because it is in the business of making money.*

Comment by: Monique Mollett

482 **Comment:** *Energy conservation and efficiency improvements can replace the need for the nuclear plants in the planning stage.*

Comment by: Patrick Byington (Alabama Environmental Council), Michelle Carratu, Fred Wright, Dolores Howard, Sanford McGee (Cumberland Center for Justice and Peace)

483 **Comment:** *Many United States utilities already have demand-side management levels exceeding those projected by TVA—equivalent to only 4.7 percent of peak demand and 2.5 percent of annual sales in 2010.*

Comment by: Eric Hirst (Oak Ridge National Laboratory)

484 **Comment:** *TVA needs to implement Blocks 1 and 2 of its demand-side management programs. Yet TVA is not even doing all of Block 1.*

Comment by: Danielle Droitsch

485 **Comment:** *TVA should implement all 39 of the identified energy efficiency options, thus saving 5,500 megawatts of electricity. Implementing only Block 1 is anemic. Unimplemented demand-side management options are stranded benefits.*

Comment by: Linda Ewald, Monique Mollet, Hamp Dobbins, Jr., Patrick Byington (Alabama Environmental Council), Michelle Neal (Tennessee Valley Energy Reform Coalition), Jamie Pizzirusso, Stephen Smith (Tennessee Valley Energy Reform Coalition), Powell & Sharon Foster, Mary Byrd Davis (Ygdrasil Institute)

486 **Comment:** *We are aware that not all of the 39 conservation programs developed are cost-effective using today's accounting, but more programs than currently appear in the draft*

are cost-effective and serve the long-term interest of the Valley. What is needed is a clear signal from you, that more conservation measures should be in the final plan.

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

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487 **Comment:** *Increase rates to encourage conservation and reduce debt.*

Comment by: Linda Cataldo Modica, Hamp Dobbins, Jr., Steven Walsh, Elizabeth Garber, Dolores Howard

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488 **Comment:** *Providing incentives or tax credits for solar energy and conservation did not work last time because as soon as the money stops, they stop participating. The answer is to raise rates to encourage energy conservation.*

Comment by: Dolores Howard

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489 **Comment:** *We are impressed with the creativity that TVA staff showed pursuing the request for proposals for option purchase agreements, refinancing of TVA's debt, and new technologies such as partnering on integrated gasification combined cycle with coproducts. Unfortunately, we have not seen the same enthusiastic response to the challenges and opportunities of demand-side management. Although we are impressed with the work done by Craig Smith and his staff, we challenge TVA to use the Energy Vision 2020 process to produce the same kinds of creative demand-side management programs that have been produced on the supply side. Demand-side management is a stated focus area of the Energy Vision 2020 process, yet if only Block 1 of the proposed demand-side management options "make the cut," we feel TVA will have missed an opportunity to apply the same creative thinking highlighted above to future programs geared at improving energy efficiency in the TVA region.*

Comment by: Sharon Fidler (League of Women Voters)

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490 **Comment:** *If TVA had not eliminated its energy conservation program, it would have saved as much energy as two nuclear plants would produce.*

Comment by: Sharon Force

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491 **Comment:** *TVA needs to revive its residential conservation programs.*

Comment by: David Bordenkircher, Phillip & Winfred Thomforde, Kathleen O'Donohue, Richard Bond, Sharon Force, Kathyrn McCoy (Tennessee Energy Education Network), Carolyn Novkov, Dianna Young, Beth Wallace, Arthur Smith, Catherine Murray (Sierra Club, State of Franklin Group), Hollis Fenn, Michelle Carratu, Michelle Neal (Tennessee Valley Energy Reform Coalition), Mary Carton

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492 **Comment:** *The amount of insulation in buildings in Tennessee and throughout the United States is inadequate. Weatherization improves air quality and the quality of housing, and improved retail value of homes. TVA should dedicate more resources to this area.*

Comment by: Don Scharf (Sierra Club, Middle Tennessee Group)

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493 **Comment:** *The demand-side management programs proposed by TVA focus narrowly on minimizing rate increases. Because of its large size, federal status, and the ability to influence state and local building codes and manufacturing decisions, TVA should expand its programs to include more market transformation.*

Comment by: William Arney, Sharon Fidler (League of Women Voters), Stephen Smith (Tennessee Valley Energy Reform Coalition), Eric Hirst (Oak Ridge National Laboratory), Debra Jackson, Sheila Holbrook-White (Sierra Club, Alabama Chapter), Carol Kimmons

494 **Comment:** *TVA should attack poverty in the region by improving the efficiency of the housing stock. We suggest that 70 percent of all low income homes in TVA's service area be targeted for this over the next 10 years.*

Comment by: Geoffrey Crandall (MSB Energy Associates)

495 **Comment:** *It is nice that TVA has a pilot program (although only $50,000 is allocated) for low income customers, but it should have a full-scale program.*

Comment by: Martha McGill, Stephen Smith (Tennessee Valley Energy Reform Coalition), Geoffrey Crandall (MSB Energy Associates)

496 **Comment:** *TVA should work on cooperative ventures with local agencies to identify the needs of low income customers and implement weatherization, energy audits, grants, inspections, retrofitting, fuel funds, and credit transfers that focus on weatherization rather than pilot them. This should be coordinated with community action to prevent duplication.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition), Michael Karp (Northwest Conservation Act Coalition), Martha McGill, Naomi Furman Kipp (Legal Services Corporation of America)

497 **Comment:** *TVA should link its plan to the Weatherization Assistance Program, although that program is in serious question in Washington. We want to work with TVA to obtain more funding for weatherization.*

Comment by: Geoffrey Crandall (MSB Energy Associates), Elaine Stancil, Richard Bond

498 **Comment:** *TVA's new homes energy efficiency program will not provide efficiency incentives to the majority of homes and businesses.*

Comment by: Shelia Holbrook-White (Sierra Club, Alabama Chapter)

499 **Comment:** *I understand the position television faces with respect to demand-side management strategies. On one hand, TVA needs to sell power to generate revenues to deal with problems like its debt. On the other hand, from a public interest point of view, TVA should be pursuing energy conservation.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition), Sheilla Cheyenne, Michael Karp (Northwest Conservation Act Coalition), Alan Jones (Tennessee Environmental Coalition), Linda Ewald

500 **Comment:** *Rather than buying commercials on television that tell me to consume, I want to be rewarded for being efficient. TVA should be promoting energy conservation. Low income customers cannot afford more consumption.*

Comment by: Richard Bond, Stephen Smith (Tennessee Valley Energy Reform Coalition), Michelle Neal (Tennessee Valley Energy Reform Coalition), Catherine Murray (Sierra Club, State of Franklin Group), Arthur Webb, Hamp Dobbins, Jr., Dennis Henke, Eric Lewis (Solar Works), Susan Bailey, Olivia Lim (Southeast Center for Ecological Awareness), John Johnson (Earth First), Paul Elliott, Maggie Kalen (Tennessee Valley Energy Reform Coalition)

501 **Comment:** *During the public meetings, there has been an overwhelming call for a greater investment in energy conservation, efficiency, and the sustained orderly development of renewables.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

502 **Comment:** *TVA should rely more on energy efficiency and renewables. This will help reduce carbon dioxide and other emissions. It appears that TVA in the area of demand-side management and renewables together would provide only 4 percent of its generation.*

Comment by: Eric Hirst (Oak Ridge National Laboratory), Stephen Smith (Tennessee Valley Energy Reform Coalition), Dara Chernicky, Anne Redwine, Bruce Wood, Don Scharf (Sierra Club, Middle Tennessee Group), Hester Cope (Alabama Environmental Council), Leith Patton, Linda LaForest (Tennessee Citizens for Wilderness Planning), Jason Gurley, Mary Bryd Davis (Ygdrasil Institute), Michelle Neal (Tennessee Valley Energy Reform Coalition)

503 **Comment:** *Because of the public support for the environment and less pollution, TVA can compete by providing customers renewables and conservation options.*

Comment by: Eileen McIlvane (Coalition for Jobs and the Environment), Alan Ball

504 **Comment:** *TVA should invest in more resources like demand-side management and renewables that have zero emissions rather than on technologies such as cascaded humidified advanced turbines.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

505 **Comment:** *There are global limits to non-renewable resources and health effects associated with the use of coal. There is acid rain, a hole in the ozone layer, deforestation caused by acid rain, and smog. Hydroelectric power causes the flooding of ecosystems. Too much coal is being used, and we would like to see more commitment to non-hydro renewable resources and encouragement of individual energy conservation.*

Comment by: Benjamin Stewart (Faith Lutheran Church), Rodney Webb, Beth Wallace, Sheila Holbrook-White (Sierra Club, Alabama Chapter)

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Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Michelle Neal (Tennessee Energy Reform Coalition)

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Comment by: Geoffrey Crandall (MSB Energy Associates), Michelle Neal (Tennessee Valley Energy Reform Coalition), Carol Kimmons

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Comment by: Susan Switzer

COMPREHENSIVE RESPONSE ON CONSERVATION

In Energy Vision 2020, TVA carefully evaluated demand-side management resources. Increasing energy efficiency and using energy more wisely will better promote a sustainable future and help to reduce environmental impacts. Accordingly, TVA has included 650 megawatts of demand-side management options in the short-term action plan covering almost 20 percent of the projected needs by the year 2002. This could increase to 2,200 megawatts in the year 2010. TVA identified 39 energy efficiency and load management options for consideration in the Energy Vision 2020 planning process. These options are described in Volume 1, Chapter 8. The options targeted the residential, commercial, and industrial sectors and addressed all the major electric end uses. TVA is implementing two types of demand-side management options. First, demand-side management options will be immediately implemented to meet customer needs. Second, TVA will implement flexible demand-side management options similar to the flexible supply-side options.

Over 2,000 energy resource strategies were created from the identified supply- and demand-side management resource options. These strategies, including strategies which emphasized demand-side management options, were evaluated across a number of different criteria, using the multi-attribute trade-off method. The criteria included long-run cost/value, short- to long-term rate impacts, reliability, environmental impacts, economic development including jobs, financial situation/debt, risk management, and equity among rate classes. (Additional information about these evaluation criteria can be found in Volume 1, Chapter 5.) The strategies which performed best across all criteria were then used to formulate TVA's proposed short-term action plan and long-term plan (the portfolio of options).

TVA's long-term plan, shown in Volume 1, Chapter 9, Figure 9-23, focuses on a portfolio of resource options designed to balance several criteria including costs, rates, environment, debt, and economic development. This portfolio provides a set of options with the flexibility to adapt to uncertain load growth, future market prices, changes in environmental regulation, and changes in markets.

TVA's proposed short-term action plan, summarized in Volume 1, Chapter 10, Figure 10-1, supports its long-term goals. The short-term action plan has been revised to include options which would be implemented immediately and future resource options whose role would be analyzed to meet future needs. Through actions taken in the short-term action plan, TVA will be developing a marketing infrastructure along with knowledge of program concepts, technologies, and delivery strategies to enable TVA to meet changing market conditions. TVA will build capabilities and develop partnerships with distributors, trade allies, and local agencies to deliver large scale demand-side management programs. The plan focuses on market transformation in tandem with the customer service options for longer lasting and more widespread efficiency impacts in the Valley. Full scale and flexible programs implemented in the short-term action plan will provide the foundation of programs that can be relatively quickly scaled up or down as conditions warrant.

All of the customer service options that performed well across the Energy Vision 2020 evaluation criteria are included in TVA's proposed plan. TVA prioritized the options in Blocks 1 and 2 because of their low cost and low impact on rates, but also included options from Block 3 in its short-term action plan following comments on the preliminary plan from members of the Energy Vision 2020 Review Group. Customer service options from Block 2 and Block 3 were included to address lost-opportunities for efficiency improvements (e.g., new construction), market transformation activities (e.g., trade ally incentives to promote commercialization of efficient new technologies), and equity (e.g., low income efficiency). The energy efficiency options not included in the proposed plan had higher levels of uncertainty, cost, or rate impacts and were not deemed viable as part of the short-term strategy. The blocks of customer service options are explained in Volume 1, Chapter 8, Figures 8-19 and 8-20.

The short-term action plan calls for the continuation and expansion of TVA's current programs as well as implementation of several new programs. These options use education, incentives, and development of an enhanced market infrastructure to promote increased energy efficiency. TVA currently offers the Residential Energy Efficiency Program. The Residential Energy Efficiency Program has four components; *energy right* New Homes, Heat Pump Financing and the Quality Contractor Network, and Manufactured Housing. The *energy right* New Homes program offers builders and new home buyers technical assistance and incentives for higher-efficiency building envelopes and heating and cooling equipment. New programs for residential customers include a home audit for students and residents and a low income program.

For commercial and industrial customers, the plan includes a large-scale Commercial and Industrial Energy Services option. This option is based on the Comprehensive Measure Financing option from Block 1. It has been expanded to over twice its original level to include new construction, process efficiency improvements, and equipment replacement for a broader group of customers. The expanded program addresses new markets for energy services and includes funding for incentives targeted to lost opportunities and market transformation activities. The expanded option captures much of the energy efficiency potential identified in Block 2 with significantly lower rate impacts.

The customer service options identified for immediate full scale implementation provide 600 megawatts of capacity in 2002 and 1,450 megawatts in the year 2010.

TVA is also implementing several flexible demand-side management options. The options will be implemented at a reduced scale at first, but will allow TVA to ramp up quickly in response to resource needs. The flexible customer service options provide 50 megawatts of capacity in 2002 and can provide as much as 750 megawatts in 2010 if needed. The total savings from energy efficiency and load management activities could be up to 2,200 megawatts. These options provide the most cost-effective demand-side resources available, with positive environmental and economic development impacts. When combined with the supply-side resources identified in the short-term action plan, these options support TVA's long-term goal to provide reliable, flexible, environmentally-sound low-cost energy at competitive rates.

522

Comment: *I encourage TVA to continue its demand-side management programs.*

Comment by: Michael Browder (Bristol Tennessee Electric System)

Response: TVA welcomes support of demand-side management programs. The Energy Vision 2020 short-term action plan recommends implementation of programs that can help both businesses and households increase the efficiency of their energy consumption.

523

Comment: *TVA should be implementing rather than piloting programs that have been tried and found effective by other utilities or TVA in the past.*

Comment by: Michael Karp (Northwest Conservation Act Coalition), Powell & Sharon Foster, Richard Bond, Eric Hirst (Oak Ridge National Laboratory), Mary English (University of Tennessee), Beth Zilbert (Greenpeace), Geoffrey Crandall (MSB Energy Associates)

Response: Demand-side management programs can be started at the pilot (reduced scale) level for various reasons. Some programs are started at the pilot level because of equipment concerns or limitations of availability, others to provide flexibility, and others to evaluate uncertain energy and demand impacts. Some programs are started at the pilot level to evaluate a new delivery mechanism, or to develop the necessary cooperative relationships for cost-effective implementation as in the case of the low income program. Depending on how these various issues are resolved, a pilot program may be scaled up to a full program.

In Energy Vision 2020, flexible demand-side management programs have replaced pilot programs. The flexible demand-side management options will be implemented at a reduced scale at first, but can ramp up quickly in response to resource needs. The programs are similar to the flexible supply-side options. These flexible demand-side programs have two phases of development. In the first phase, the programs are tested in the marketplace as experiments or pilot programs. The flexible demand-side management programs would add 50 megawatts by 2002 and potentially 750 megawatts by 2010.

524

Comment: *Doing conservation in the short term will help bridge from coal and nuclear to renewables. We can live well and grow without using more electricity.*

Comment by: Retha Ferrell

Response: Coal and nuclear generation will continue to be important components of TVA's generation mix in the future. Collectively, they are currently responsible for 70 percent of TVA's generating capacity. Demand-side management can also play an important role in meeting additional needs in the future. Conservation programs help in meeting this need with up to 2,200 megawatts of potential savings projected by 2010.

TVA has included a number of renewable options, up to 2,500 megawatts, in its proposed short- and long-term plans. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) TVA is also proposing in the final Energy Vision 2020 plan additional research into and development of a number of renewable resources.

Three additional investigation or research activities in renewables are recommended. First, TVA will develop a wind turbine project in two phases. The first phase will investigate wind resources. The second phase will build a wind turbine at one site depending on the results of the first phase. Second, TVA will investigate a biomass refinery that will produce fuel and chemical coproducts. This biomass refinery could burn refuse-derived fuel, wood waste, and energy crops. Third, TVA will investigate a biomass energy facility that will burn a combination of garbage (compost) and wood waste.

525

Comment: *TVA should show planned expenditures, customer participation, and energy and demand effects year-by-year for each customer service program or each customer class and incorporate a process to evaluate how actual implementation compares to plans.*

Comment by: Eric Hirst (Oak Ridge National Laboratory), Lynn Leach (Alabama Environmental Council), Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Planned expenditures, customer participation, and energy and demand effects are available year by year for each customer service option in Volume 2, Technical Document 7. Evaluation of demand-side management programs is very important to improve the delivery and tracking processes over time and enhance program cost-effectiveness. TVA has established an evaluation organization to develop plans and procedures for this function. Detailed evaluation plans for specific programs will be developed when the programs are approved for implementation.

526

Comment: *I am concerned about TVA's selling power outside the region.*

Comment by: Yvonne Seperich

Response: TVA exchanges, or buys and sells power, with neighboring electric systems through 57 interconnections. Off-system sales to the thirteen utilities to which TVA can sell power provide an opportunity to use TVA's generating resources when they are not needed to meet TVA customer needs. Off-system sales provide additional revenue to reduce the costs of power to TVA customers. The purchase of power is sometimes necessary to meet heavy demand; at other times, it may be more economical for TVA to purchase excess power from a neighboring utility than to generate it. TVA also "wheels" power at a fee for other utilities. Wheeling is transporting power from one utility to another through TVA's transmission system.

Implementation of Renewables

The following comments are addressed in a comprehensive response that appears after comment number 573. Portions of the comments below related to conservation/demand-side management that are not addressed in the comprehensive response have responses in the previous section, Implementation of Customer Service Options.

527 **Comment:** *TVA should be implementing renewable energy options such as solar and wind power rather than studying the options. Right now there is a host of renewable resources on the cusp of being cost-effective. It is suggested that TVA invest 1 to 2 percent of its annual budget in renewable technologies. According to Kenetech Windpower, TVA could generate 2,000 megawatts from wind machines situated outside of national park and national forest lands.*

Comment by: Beth Wallace, Olivia Lim (Southeast Center for Ecological Awareness), Ruth Peeples, Susan Switzer, Sharon Force, Anne Redwine, Betty Martin (Friends of the River), Suzanne Sims, Catherine Murray (Sierra Club, State of Franklin Group), Stephen Smith (Tennessee Valley Energy Reform Coalition), Brian Bury, Mark Johnson, Michelle Neal (Tennessee Valley Energy Reform Coalition), Walter & Dorothy Stark, Powell & Sharon Foster, Hamp Dobbins, Jr., Kim Grube, Howard Switzer (Sun/Earth Tempered Organic Architecture), Amy Perry, M. Case, Karah Bates, Kathy Priore, Monique Mollet, K. Varnum, John Harwood, Hermann, Tohert, Shirley Schaaf, Dottie Hodges, Karl Grotke, Ray Williams, Salo, Garry Shores, Jim Von Bramer, L. M. Johnson, Sr., John Schwarz, Jr., Mary Schwarz, Isahl Hemm, Sharron Eckert, Deborah Cuva, C. T. Brewster, Robert Peeples, Yvonne Seperich, Mary Byrd Davis (Ygdrasil Institute), Sahara, C. Strain, Karen Lovell, Lynn Leach (Alabama Environmental Council), Ann & Mike Sanders, Susana Harwood, Stephen Stedman, Jo Anne Clark, Myles Jakubowski (Sunbeam Household Products), Faith Young, Chris Gulick, Mary Anne Terry, A. B. Evans, William Emmott, Larry Smith (Mid-South Peace and Justice Center), M. Nathan Perry, N. E. Whitfield, F. W. Munson, Ben & Winn Welch, R. & G. Ludwig, Katherine Osborn, Marion Zachiel, Luther Gulick, Sharon Fidler (League of Women Voters)

528 **Comment:** *TVA should rely more on renewable energy.*

Comment by: Edwin Curtis, Dolores Howard, Susan Bailey, Fred Wright, Kathy Dowbiggin, Jeff Peterson, Mike Eastman, Tom Fitzgerald (Kentucky Resources Council, Inc.), Linda Ewald, Kathleen O'Donohue, Patricia Chapman, Susan Jata, Andrew Danzig, John Hurgeton, Jim Sells, Rela Edwards, Jonathan Scherch, Sheilla Cheyenne, Mandy Tiesler, Bruce Wood, Lee Gable, Dennis Henke, Clark Buchner (Sierra Club, Tennessee Chapter), John Noel, Debra Jackson, Alan Jones (Tennessee Environmental Council), Doris Gunn, Maggie Kalen (Tennessee Valley Energy Reform Coalition), John van der Harst, Calvin Moore, Steven Walsh

529 **Comment:** *The next 25 years need to be years of alternative power sources—less profit and more compassion.*

Comment by: Paul Elliott

530 **Comment:** *Why is there not funding for renewable resources in amounts that match the funding that has gone into nuclear and coal?*

Comment by: Calvin Moore

531 **Comment:** *The plan should have specific goals for renewables as recommended by the National Renewable Energy Laboratory, and its May 31, 1995 letter should be added to the record.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Sharon Fidler (League of Women Voters), Danielle Droitsch

532 **Comment:** *TVA should rely on renewables in lieu of coal-fired and nuclear capacity. The millions saved from this can be used to pay off some TVA debt and to support clean power programs and the development of hydrogen and electric vehicles.*

Comment by: Linda Cataldo Modica, Scott Banbury, John Johnson (Earth First), Myles Jakubowski (Sunbeam Household Products)

533 **Comment:** *I would like to see a contrast between alternative energy resources and nuclear in terms of their effect on the economy. You would have to include decommissioning and spent fuel storage costs. On the other hand, alternative energy would produce a lot of jobs for small businesses.*

Comment by: Rowland Huddleston

534 **Comment:** *Sacramento Municipal Utility District has substantial commitments to renewable resources. This has allowed us to meet peak power needs in a diversified manner and stimulate the commercialization of these technologies. By making early and sustained investments, we help drive down these technology costs, making them cost-effective. Sacramento Municipal Utility District encourages TVA to make moderate but sustained investments in these technologies.*

Comment by: Edward Smeloff (Sacramento Municipal Utility District)

535 **Comment:** *In the past, TVA implemented passive solar and solar water heater programs using architects and manufacturers from outside the Valley. Then Marvin Runyon cut all these programs. Reimplement these successful programs rather than researching them.*

Comment by: Paul Elliott, Howard Switzer (Sun/Earth Tempered Organic Architecture)

536 **Comment:** *At one time TVA had a very successful residential solar program. Participants could take the amount of money saved over a 10-year period from use of the system and apply this to offset installation costs. The cost to TVA was nothing. They stopped this program; now solar water heaters are being taken off of roofs because people do not know how to operate them. Now TVA is promoting the sale of power to make money. TVA should revive these programs.*

Comment by: Eric Lewis (Solar Works), Michelle Carratu

537 **Comment:** *I already have solar panels on my roof. It is a viable technology. Solar energy should be pushed up in TVA's priorities.*

Comment by: Sanford McGee (Cumberland Center for Justice and Peace), Dolores Howard

538 **Comment:** *There should be more discussion of solar energy in the document.*

Comment by: Al Fritsch (Appalachia–Science in the Public Interest)

539 **Comment:** *TVA should prepare a separate report on renewable technologies to be stacked up against Energy Vision 2020.*

Comment by: Jonathan Scherch

540 **Comment:** *TVA should employ more people in the renewable energy field.*

Comment by: Beth Wallace, Stephen Smith (Tennessee Valley Energy Reform Coalition)

541 **Comment:** *TVA should provide incentives (e.g., rebates, prizes, and grants) to encourage the use of alternative energy sources because of the benefits that accrue to the entire system.*

Comment by: Mike Eastman, Powell & Sharon Foster, Eileen McIlvane (Coalition for Jobs and the Environment), Larry Smith (Mid-South Peace and Justice Center), Hollis Fenn, Walter Stenberg

542 **Comment:** *To be an environmental leader, TVA needs to be more active in small-scale solar thermal and photovoltaics projects.*

Comment by: Sheila Holbrook-White (Sierra Club, Alabama Chapter), Richard Simmers, Kathryn McCoy (Tennessee Energy Education Network), Sharon Fidler (League of Women Voters)

543 **Comment:** *Encourage insulation made of post-consumer newsprint as an alternative to landfilling or burning newsprint.*

Comment by: Don Scharf (Sierra Club, Middle Tennessee Group)

544 **Comment:** *Gasified garbage, whole-tree biomass, and grass biomass would provide all of the energy needed through 2020.*

Comment by: C. L. McKinney (Creret, Inc.)

545 **Comment:** *If municipalities generate electricity using refuse-derived fuel and biomass, TVA would not have to incur debt to add capacity.*

Comment by: Don Perry

546 **Comment:** *TVA needs to look at biomass (grass, weeds, hay). Two tons of biomass will give you a ton of coal Btus cheaper than a ton of coal and will give all farmers in the Valley another cash crop.*

Comment by: C. L. McKinney (Creret, Inc.), Don Perry

547 **Comment:** *TVA needs to look at gasified garbage to produce electricity. This will help lower garbage fees.*

Comment by: C. L. McKinney (Creret, Inc.), Don Perry

548 **Comment:** *TVA has considered the competitive environment first and alternative energy resources last. I consider this backwards. Other utilities are looking toward other energy resources to deal with this uncertain environment.*

Comment by: Danielle Droitsch

549 **Comment:** *There is a potential for many small, but highly reliable methane-fueled facilities throughout the Valley at landfills and wastewater treatment plants.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

550 **Comment:** *TVA should take into account future environmental regulations such as the carbon tax when it mitigates risks in the plan. Risks can be mitigated by building renewable plants and investing in energy conservation.*

Comment by: Linda Ewald, Stephen Smith (Tennessee Valley Energy Reform Coalition), Eileen McIlvane (Coalition for Jobs and the Environment), Sheila Holbrook-White (Sierra Club, Alabama Chapter), Sharon Fidler (League of Women Voters)

551 **Comment:** *When the fence comes down, TVA needs to be able to produce energy that is cost-effective and cost-competitive. But to be a leader in the utility industry, TVA needs to promote alternative energy systems.*

Comment by: David Bordenkirch, Jonathan Scherch, Barbara Soliday

552 **Comment:** *Renewable energy cannot replace coal and nuclear, but we have to get started. TVA should do some demonstration projects.*

Comment by: Alan Jones (Tennessee Environmental Council)

553 **Comment:** *TVA needs to emphasize solar and renewables in lieu of nuclear power.*

Comment by: Andrew Danzig

554 **Comment:** *During the public meetings there has been an overwhelming call for a greater investment in energy conservation, efficiency, and the sustained orderly development of renewables.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

555 **Comment:** *TVA should rely more on energy efficiency and renewables. This will help reduce carbon dioxide and other emissions. It appears that TVA in the area of demand-side management and renewables together would provide only 4 percent of its generation.*

Comment by: Hester Cope (Alabama Environmental Council), Dara Chernicky, Anne Redwine, Bruce Wood, Stephen Smith (Tennessee Valley Energy Reform Coalition), Leith Patton, Linda LaForest (Tennessee Citizens for Wilderness Planning), Jason Gurley, Michelle Neal (Tennessee Valley Energy Reform Coalition), Mary Byrd Davis (Ygdrasil Institute), Eric Hirst (Oak Ridge National Laboratory), Don Scharf (Sierra Club, Middle Tennessee Group)

556 **Comment:** *TVA should meet 25 percent of its future demands with energy conservation and renewables.*

Comment by: Beth Wallace, Sharon Force

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Comment by: Powell & Sharon Foster, R. G. Ford (Energy Design Corporation), Steven Walsh, Michelle Neal (Tennessee Valley Energy Reform Coalition)

565 **Comment:** *Additionally, implementation of conservation methods such as demand-side management, beneficial electrification, green lights programs, etc., would further reduce the need for new generation. However, new/newer forms of energy generation (e.g., wind, photovoltaics, geothermal, and tidal renewables) should also be pursued since they conceptually appear to be more environmentally friendly to air and water resources than conventional fossil-fuel power plants.*

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Comment by: Susan Switzer

COMPREHENSIVE RESPONSE ON RENEWABLES

In Energy Vision 2020, TVA carefully evaluated renewable energy resources. Renewable resources can help reduce potential environmental impacts, help mitigate the risk of more stringent environmental regulations affecting use of TVA fossil units, and foster a more sustainable use of energy. Accordingly, TVA has included a number of renewable options, up to 2,500 megawatts, in its proposed short- and long-term plans. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) TVA is also proposing in the final Energy Vision 2020 plan additional research into and development of a number of renewable resources.

Three additional investigation or research activities in renewables are recommended. First, TVA will develop a wind turbine project in two phases. The first phase will investigate wind resources. The second phase will build a wind turbine at one site depending on the results of the first phase. Second, TVA will investigate a biomass refinery that will

produce fuel and chemical coproducts. This biomass refinery could burn refuse-derived fuel, wood waste, and energy crops. Third, TVA will investigate a biomass energy facility that will burn a combination of garbage (compost) and wood waste.

TVA evaluated many renewable resource options in Energy Vision 2020. These included: a refuse-derived fuel stoker, a large solar photovoltaic fixed flat plate power plant, landfill methane, 33- and 39-meter variable speed advanced wind turbines, a refuse-derived fuel companion boiler at TVA's Watts Bar Fossil Plant, a biomass whole tree (short rotation woody crops) energy boiler power plant, and biomass cofiring at TVA coal-fired units. Other options evaluated included: additional hydro generation at existing projects, modernization of existing hydro units, and new hydro generation projects. In addition to supply-side renewable options, TVA considered a number of renewable customer service options: a residential solar water heater program, a commercial new construction program emphasizing renewables, and customer-owned renewable energy generation including landfill gas/fuel cells, small-head hydro, biomass/wood waste, end-use solar photovoltaics, and photovoltaics/technology advancement. (Additional information about these options can be found in Volume 2, Technical Document 7.)

Over 2,000 energy resource strategies were created from the identified supply- and demand-side management resource options. These strategies, including strategies which emphasized renewable options, were evaluated on a number of different criteria, using the multi-attribute trade-off method. The criteria included long-run cost/value, short- to long-term rate impacts, reliability, environmental impacts, economic development including jobs, financial situation/debt, risk management, and equity among rate classes. (Additional information about these evaluation criteria can be found in Volume 1, Chapter 5.) The options from the strategies that performed well on all criteria were then used to formulate TVA's proposed short-term plan and long-term plan (the portfolio of options). Options from Strategy T, which contained a number of renewable resources, were used in the portfolio. (See Volume 1, Chapter 9, Figure 9-3.) Renewable energy options will help mitigate the risks associated with the uncertainty of additional environmental regulations including those dealing with greenhouse gases.

TVA's proposed portfolio includes up to 2,500 megawatts of renewable energy. Landfill methane and refuse-derived fuel are two of the nine options proposed as base-load power options for 1996 to 2005. Wind turbines are one of the five options proposed as base-load power options for the years 2005 to 2020. (See Volume 1, Chapter 9, Figure 9-23.) The proposed short-term plan includes implementation of both cost-effective biomass cofiring at TVA coal-fired units and biomass facilities that use refuse-derived fuel and wood waste, and the modernization of existing hydro units. The short-term plan also includes research and development of a wind turbine project, a landfill methane recovery with a fuel cell project, and several biomass projects. On the demand side, the short-term plan proposes further research into and development of end-use solar photovoltaics. (See Volume 1, Chapter 10, Figure 10-1.)

At the request of members of the Energy Vision 2020 Review Group, TVA asked the National Renewable Energy Laboratory (NREL) to review resource options that TVA was evaluating for Energy Vision 2020 and to recommend actions that TVA could take to improve its approach to the consideration of renewable resources. TVA was able to take most of NREL's recommendations into account as it completed work on the draft Energy Vision 2020 plan. The following table sets forth NREL's recommendations and TVA's response.

NREL Recommendations	TVA's Response
Seek out and exploit all currently cost-effective applications of renewable energy on the TVA system, where cost-effectiveness tests would include potential "non-cost" benefits of renewables in addition to direct monetary measures.	Energy Vision 2020 evaluated renewable options for a number of criteria, including cost-effectiveness. The long- and short-term resource plans include all renewable options which performed well across all of the evaluation criteria.
Develop a corporate renewable energy strategy. Such a strategy would articulate the longer-term importance of pursuing development of renewable energy resources and how the activities that TVA is involved in today are readying and positioning the company to access these resources as they become more widely cost-effective. This strategy might also include the establishment of both short-term and long-term goals for renewables, e.g., a short-term goal (5 to 10 years) of 2 percent of installed capacity from non-hydro renewables and a long-term goal (20 years) of 5 to 10 percent of installed capacity. An initial step toward meeting the short-term goal would be to conduct a "green RFP."	TVA thinks that a separate renewable energy strategy is unnecessary and that it is preferable to include renewables as an element of its overall energy strategy.
TVA should develop a more formalized structure within the company with responsibility for planning, integration, oversight, and reporting on all renewables-related activities.	TVA currently has a department whose responsibility is the long-range planning and integration of all resource activities, including renewable supply-side options. Other groups in TVA such as its Technology Advancement department are responsible for investigating and developing new technologies, such as new renewables. This department provides data to TVA's planning process.
Continue improvements in the identification and modeling of renewable energy attributes for planning purposes.	TVA will continue to identify and model all renewables, as well as other energy resources.
TVA has taken a national leadership role in investigating the utilization of wood resources for utility applications. TVA should become involved in other renewable energy industry groups and collaboratives, such as the National Wind Coordinating Council (NWCC), the Utility Photo Voltaic Group (UPVG), and the USH$_2$O (solar water heating) Utility Interest Group.	As part of TVA's research into renewable energy, TVA is a member of the Utility Biomass Energy Commercialization Association and the Electric Power Research Institute's (EPRI) Renewable and Storage Business Unit. The EPRI business unit provides information on wind, photovoltaics, and other renewables. Both these groups were chartered with the intent of developing renewable energy.
Undertake wind energy monitoring activities at the most attractive sites, both within and in close proximity to the TVA service territory.	TVA has received proposals for wind energy projects which contain detailed wind energy monitoring information. TVA's short-term action plan includes further wind resource investigation as part of a wind turbine project.
Investigate the potential to use photovoltaics in both off-grid and targeted grid-connected applications.	Research and development of photovoltaics, including dispersed generation, have been included in Energy Vision 2020's short-term action plan.
Initiate a survey activity to assess the level of customer interest in renewables, including customer willingness to pay more, if necessary, to acquire these resources.	TVA will take this recommendation into consideration.
Continue activities to assess distributed valuation, including the potential values of distributed renewables options.	Research and development of programs to target distributed generation have been included in the short-term action plan.

NREL Recommendations	TVA's Response
Initiate a study of how the operation of the TVA system might be reoptimized to enhance the value of different renewables options, particularly intermittents.	Research and development of renewables, including wind, have been included in the short-term action plan. Modeling the effects of the intermittent renewables on the TVA system will be part of the analysis to value these options.
Conduct a "lessons learned" review of the earlier residential solar hot water program to assess what types of TVA-specific data and information can be applied to an updated analysis of solar water heating potential.	The table in Volume 2, Technical Document 7, page T7.7, shows a rebate program for solar water heaters to have a high total resource cost of 22.1 cents per kilowatt-hour for relatively small projected beneficial system impacts (11 megawatts in winter and 4 megawatts in summer). This option was characterized taking into account both TVA's historical experience and recent national experience.

574

Comment: *To gain experience and create market pull, TVA should implement solar and wind resources in the short-term action plan.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Paul Elliott, Elizabeth Garber, Linda Cataldo Modica, Eric Hirst (Oak Ridge National Laboratory), Carolyn Novkov

Response: During the 1980s, TVA conducted a wind energy program which included wind monitoring and operation of wind turbines. The resulting experience and data indicated that wind energy was not viable in this region with the wind resources and technology that were known then. While technology has advanced since then, there is no actual site data to confirm the existence of a viable wind resource in this region. The investigation of a wind turbine project, which is part of the short-term action plan, together with knowledge of the latest technology, will help TVA to determine whether the prospects for wind energy justify building this wind turbine. The short-term action plan also includes investigation into end-use solar photovoltaics.

575

Comment: *Alternative energy means in the Investigation/Research and Development section of the plan need to be moved to implementation with tangible goals and budgetary commitments.*

Comment by: Susan Bailey, Jamie Pizzirusso, Powell & Sharon Foster

Response: Renewable energy resources in the Investigation/Research and Development section of the short-term action plan are not mature technologies. As these technologies

mature, the cost and reliability should improve, making them better options for both TVA and its customers.

For each activity in the short-term action plan, TVA has developed milestones and will track key milestones and budget commitments during implementation.

576

Comment: *With respect to renewable resources, TVA should provide implementation schedules and tangible goals.*

Comment by: Sheila Holbrook-White (Sierra Club, Alabama Chapter), Olivia Lim (Southeast Center for Ecological Awareness), James Barr, Sharon Fidler (League of Women Voters), Patrick Byington (Alabama Environmental Council), Peggy Snow, Eric Lewis (Solar Works)

Response: Key milestones or goals have been included in the final short term plan. (See Volume 1, Chapter 10, Figure 10-1.)

Implementation of Supply-Side Options

577

Comment: *I support the modernization of hydroelectric plants as a part of the short-term action plan. This produces more kilowatts without new environmental damage.*

Comment by: Alan Ball, Michelle Carratu, Bruce Wood, Steven Walsh, Stephen Smith (Tennessee Valley Energy Reform Coalition), Ann Lamb

Response: Your comment has been reviewed and noted.

578

Comment: *Installation of gas-fired combustion turbines and combined cycle units, and the use of low-cost purchases if available, appear to be the best short-term options. We are pleased that TVA has accepted our recommendation to consider siting these units in the western portion of the TVA system to reduce losses and improve transmission reliability.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

579

Comment: *Due to the large amount of base-load resources currently operated by TVA and the expected completion of Browns Ferry Nuclear Plant Unit 3 and Watts Bar Nuclear Plant Unit 1, it appears prudent for TVA to consider additions of combustion turbine peaking units as its next resource addition.*

Comment by: Tennessee Valley Public Power Association

Response: The results of Energy Vision 2020 show that TVA will need to acquire sources for peaking power before any new base-load capability is required. Combustion turbines are included in Energy Vision 2020.

580

Comment: *We approve of buying the call options as a clean option compared to building additional current-technology plants.*

Comment by: Bruce Wood, Powell & Sharon Foster

Response: Your comment has been reviewed and noted.

581

Comment: *I am concerned about TVA's plans to contract with independent power producers because of TVA's history of poor management of contractors.*

Comment by: Stan Gloeckner (Sierra Club)

Response: Option purchase agreements give TVA the right but not the obligation to receive power from other sources, including independent power producers who have submitted successful proposals. A principal advantage of an option purchase agreement with an independent power producer is that the risks associated with the finance, construction, and operation of the electric power facility rest entirely with the independent power producers developing the facility.

582

Comment: *As an independent power producer, we are building plants that use wood chips and mill byproducts that coincidentally generate between 50 and 80 megawatts of exportable energy. However, TVA and other utilities are not providing realistic wheeling rates to transmit this power to customers who want alternative sources of power. TVA should be part of the process that makes this happen, rather than a victim.*

Comment by: Scott Pogue

Response: TVA and other utility systems develop transmission rates based on the costs of providing the service. TVA offers such rates for the movement of energy produced by others across or through the TVA system. Rates that are developed for the transmission of wholesale power are often subject to review by the Federal Energy Regulatory Commission, which is concerned with the regulation of the wholesale market of electric energy under the Federal Power Act, including the price for transmission service. Transmission rates being developed by private investor-owned utilities subject to the authority of the Federal Energy Regulatory Commission that are going into effect are those found to be consistent with the cost-based methodology approved by that regulatory commission. TVA, while not an investor-owned system, has generally followed the Federal Energy Regulatory Commission methodology in developing rates for the transmission of wholesale power across the TVA system.

While rates vary from system to system since costs are different, TVA's transmission service rates are reasonable when compared with those being offered by other systems of comparable size.

Investigation/Research and Development

583

Comment: *Development of electric vehicles could decrease environmental impacts.*

Comment by: Ann Lamb

Response: TVA supports Chattanooga's electric bus program. TVA has provided funding to the program and is currently providing use of a test track facility for electric vehicles. TVA is also working with the University of Alabama, Huntsville's Electric Vehicle program to identify opportunities to work cooperatively in the future.

TVA plans to continue research and development of electric vehicles as part of its proposed short-term action plan. (See Volume 1, Chapter 10, Figure 10-1.) TVA evaluated three options to promote more widespread use of electric vehicles. TVA will track the development and commercialization of electric vehicle technologies and will promote those technologies as appropriate.

584

Comment: *TVA should show real commitment to electric vehicles in the future, such as the University of Alabama, Huntsville's Electric Vehicle program, and Chattanooga's electric bus program, and get back its electric vehicle test site. Former TVA Chairman David Freeman wanted to have 50,000 electric vehicles in the Tennessee Valley to help balance the power load.*

Comment by: David Bowman (Huntsville News), Michelle Neal (Tennessee Valley Energy Reform Coalition), Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA supports Chattanooga's electric bus program. TVA has provided funding to the program and is currently providing use of a test track facility for electric vehicles. TVA is also working with the University of Alabama, Huntsville's Electric Vehicle program to identify opportunities to work cooperatively in the future.

TVA plans to continue research and development for electric vehicles as part of its proposed short-term action plan. (See Volume 1, Chapter 10, Figure 10-1.) TVA evaluated three options to promote more widespread use of electric vehicles. TVA will track the development and commercialization of electric vehicle technologies and will promote those technologies as appropriate.

585

Comment: *TVA needs to be looking at new technologies to address the greenhouse gas problem including technologies that would help Third World countries such as community-based power plants.*

Comment by: Stan Gloeckner (Sierra Club)

Response: In evaluating various options for power generation, Energy Vision 2020 took into consideration potential greenhouse gas emissions. TVA considered several renewable options (e.g., biomass cofiring, wind energy, landfill methane, coalbed methane, and customer service photovoltaics) which have potential to benefit the greenhouse gas situation. Further work on these options is included in the short-term action plan (see Volume 1, Chapter 10, Figure 10-1).

Some of these technologies could be useful in Third World countries.

586

Comment: *TVA should establish a pilot program for wind resources.*

Comment by: Sandy Loyd, Elizabeth Garber

Response: The Energy Vision 2020 short-term action plan now includes a wind turbine project that will be implemented in two phases. (See Volume 1, Chapter 10, Figure 10-1.) The first phase will identify the available wind resources. In the second phase, a wind turbine will be constructed depending on the outcome of the first phase.

587

Comment: *TVA should monitor energy-efficiency research and development of items such as sulfur lighting.*

Comment by: Hollis Fenn

Response: In addition to the many research and development actions in support of customer service options identified in the short-term action plan, TVA has also listed end-use technologies still under consideration and emerging end-use technologies. Those technologies, which include sulfur lighting, are listed in the end-use technology database in Volume 2, Technical Document 7. TVA will maintain and add to this database by monitoring the technological development and the commercialization of emerging technologies and will include cost-effective new technologies in programs as applicable.

588

Comment: *The short-term action plan calls for extensive research and development programs covering a number of supply-side and customer service options. For TVA to undertake all of these programs, a large expenditure of funds and manpower would be required. Much research and development on power supply resources is underway around the country and world. TVA should take maximum advantage of research and development by the Electric Power Research Institute, science laboratories, other utilities, universities, etc., and thereby avoid much duplication of effort and reduce expenditures. In many cases, TVA could support monetarily the efforts of others rather than undertaking the research and development directly. As in past cases, TVA can provide an important service by cooperating with others by allowing prototype test units to be built on TVA's system.*

Comment by: TVA Retirees Association

Response: TVA takes full advantage of outside research. TVA participates in groups which pursue research and development of new technology, as well as groups which explore improvements to existing technology. For example, TVA is a member of the Electric Power Research Institute.

LOAD FORECAST AND NEED FOR POWER

This section includes comments and responses about:

- the accuracy and range of TVA's load forecasts, including the assumptions and methodology used in forecasting future demands for Energy Vision 2020
- the need for power in the future in the TVA region

Results/Accuracy of TVA's Load Forecast

589

Comment: *TVA should be commended for being "brave" enough to show such a large range in its load forecasts. Most utilities succumb to management's desire for "certainty" and show a very narrow confidence interval. The historical performance of forecasters in the utility industry would indicate that TVA's wider bands are appropriate.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

590

Comment: *Burns & McDonnell's analysis of the load forecast resulted in the conclusion that the median forecast used by TVA was higher than justified by our analysis. However, the range of uncertainties around the median included a sufficiently broad band as to include a forecast considered reasonable for the TVA region.*

Comment by: Tennessee Valley Public Power Association

Response: The medium forecast is the result of TVA's forecast procedure as described in the Load Forecast Summary (see Volume 2, Technical Document 5). TVA agrees with the use of uncertainty analysis to fully evaluate future decisions.

591

Comment: *To test uncertainty, TVA produces both a high and low economic forecast. The high forecast predicts annual growth of 4.5 percent for the 1993 to 2015 time period, while the low forecast predicts 1.2 percent annual growth.*
Burns & McDonnell/XENERGY's conclusions are as follows:

- *TVA follows thorough and reasonable procedures for estimating economic growth*
- *TVA's middle forecast is consistent with the growth patterns seen over the past 25 years*
- *TVA's high and low forecast probably create a wider bound than is necessary*

Comment by: Tennessee Valley Public Power Association

Response: TVA produces both a high and low economic forecast to account for uncertainty. TVA's purpose in producing these high and low forecasts is to establish the upper and lower bounds, respectively, of a range for which the probability of future economic growth being outside of that range is 10 percent. Because of the large number of factors affecting the economy and the degree of uncertainty associated with these factors, this is

a wide range. The range for the regional forecast should be expected to be wider than the range for the national forecast because of additional uncertainty due to the poorer quality of available historical economic data at the subnational as opposed to the national level and the fact that the national forecast is a main driver of the regional forecast (and thus uncertainty associated with the national forecast is being added to that of the regional forecast).

How wide the probability range of the forecasts should be is defined by how they are used. These forecasts are used by TVA as part of the uncertainty analysis for the load forecast. In this analysis, probabilities are associated with these upper and lower bounds defined by the high and low economic forecasts, as well as for other factors affecting the load forecast. Through the uncertainty analysis, desired probability ranges (with greater or less uncertainty associated with them) can then be derived for the load forecast.

592

Comment: *How do these economic growth rates compare with history? During the high growth period of 1967 to 1973, the Tennessee Valley grew at an annual rate of 4.6 percent, roughly equal to the current high forecast for 1993 to 2015. While this level of growth occurred for a six-year period (1967 to 1973), there is no evidence that it could be sustained for the full 22 years of the forecast horizon. In addition, there is no evidence that the Tennessee Valley has ever grown at a rate of 1.9 percent faster than the country as a whole for that significant a period of time. Therefore, the high forecast of 4.5 percent is perhaps too high, but certainly serves as a useful upper bound.*

Comment by: Tennessee Valley Public Power Association

Response: The high forecast serves as the upper bound to the range of probable forecasts and is used in uncertainty analyses.

593

Comment: *The low forecast of 1.2 percent annual growth is clearly below any that has occurred in the three recent historical periods. Again, the low forecast may be too low, but it at least serves as a useful lower bound.*

Comment by: Tennessee Valley Public Power Association

Response: The low forecast serves as the lower bound to the range of probable forecasts and is used in uncertainty analyses.

594

Comment: *TVA's load forecast appears too high. Even the medium load growth projection is based on optimistic assumptions about regional economic growth. We think the low or medium low forecasts are much more likely to occur. Therefore, TVA should plan for a lower growth rate with the flexibility to respond to upward growth only if necessary.`*

Comment by: Sharon Fidler (League of Women Voters)

Response: TVA recognizes that there is a great deal of uncertainty in forecasting future loads or sales. TVA uses a range of forecasts to capture this uncertainty. (See Volume 1, Chapter 6.)

TVA also agrees that we should plan for the low growth rate and provide flexibility to respond to higher growth. This flexibility to respond to uncertain load growth is a cor-

nerstone of the short-term action plan (see Volume 1, Chapter 10). In the short-term action plan, future electric load will largely be met with flexible internal and external supply-side options (see Volume 1, Chapter 7). If load growth is as expected, then TVA can implement these options; if load growth is low, then it will not be necessary for TVA to implement these options.

Assumptions/Variables Used in TVA's Load Forecast

595

Comment: *The 1993 through 2015 forecast also shows significant increases in heat pump saturations at the expense of resistance heating and window air conditioning. These assumptions seem reasonable. In addition, TVA incorporates reasonable assumptions for efficiency improvements based in part on the requirements of the Energy Policy Act of 1992.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

596

Comment: *The bounds on TVA's expected forecast are relatively wide and, as such, should incorporate all reasonable growth scenarios. The expected forecast, however, seems to be biased high by relying on increased gas prices to drive customers toward electric heat, hot water, and other end uses. TVA also assumes a continuation of the economic advantage that the region has had over the rest of the country.*

Comment by: Tennessee Valley Public Power Association

Response: Independent forecasts were used in preparing the natural gas price forecasts. (See Volume 2, Technical Document 5, Figure T5-9.) The factors that led to TVA's "economic advantage" are expected to continue into the next century (see Volume 2, Technical Document 5, page T5.5). The uncertainties in natural gas prices and economic growth were considered in Volume 2, Technical Document 5, Figures T5-28 and T5-29.

597

Comment: *It seems surprising that air conditioning saturation forecast is only 71 percent for the commercial sector compared to 92 percent for the residential sector. One would normally expect higher air conditioning saturation in commercial facilities such as offices, hospitals, grocery stores, etc.*

Comment by: Tennessee Valley Public Power Association

Response: The commercial sector includes warehouses, loading areas, and other similar work areas that are not ordinarily air conditioned. The data in the commercial sector is measured on a square footage basis, while the residential sector is measured on a unit basis. The percentage of commercial operations that are air conditioned may be higher than the percentage of total square footage that is air conditioned.

598

Comment: *TVA has apparently received gas forecasts from organizations such as DRI/McGraw Hill, the American Gas Association, and the Gas Research Institute. But if gas prices do not rise relative to electric prices, OSHRA predicts a considerably lower commercial forecast could result.*

Comment by: Tennessee Valley Public Power Association

Response: The medium load forecast assumes TVA can maintain its price versus natural gas. (See Volume 2, Technical Document 5, page T5.11.) If TVA cannot maintain this position, it is reasonable to assume some lower load could occur.

The impact of the uncertainty in natural gas prices on TVA's load forecasts is shown in Volume 2, Technical Document 5, Figures T5-28 and T5-29.

599

Comment: *TVA forecasts the industrial sector to grow at 3.3 percent per year from 1993 to 2000 and 1.6 percent annually from 2000 to 2020. This is considerably greater than the historical growth rate of 0.4 percent, which occurred from 1970 to 1993 and the recent annual growth of 0.3 percent from 1990 to 1993.*

It is not clear why TVA is forecasting such high growth for the industrial sector. In fact, TVA's low forecast of 0.4 percent from 1993 to 2000 is roughly equivalent to the actual growth from 1970 to 1993.

Comment by: Tennessee Valley Public Power Association

Response: Total industrial sales include sales by distributors to industry and sales by TVA to directly served customers. The directly served customers tend to be large consumers. Historically the directly served customer class has experienced a decline in sales for the period 1979 to 1994. This is primarily due to declines in two industries, primary metals and chemicals. The distributor portion of manufacturing grew at 2.8 percent for 1979 to 1994 and is expected to continue at a lower 2.2 percent through 2020. This, coupled with a 1.6 percent growth in directly served manufacturing, comprises the 2.0 percent growth in manufacturing sales for 1994 to 2020. (See Volume 2, Technical Document 5, Figure T5-25.)

600

Comment: *There are some additional energy cost savings measures that are already being implemented in the TVA region that are going to have a significant effect on TVA's load in the future and are not a part of this plan of yours.*
Some of them are:

- *Replacement of electric resistance space heating with gas (natural and propane) heat.*
- *Replacement of electric resistance hot water heating with gas (natural and propane) hot water heaters.*
- *Replacement of commercial electric cooking appliances with gas (natural and propane) ones.*

In our own circle of experience we have familiarity with megawatts of such projects being implemented in the last five years.

We feel like the continuing trend to install gas replacements for electric resistance space heating, water heating, and commercial cooking appliances will have a significant

impact on TVA's future load and are concerned that this trend is not considered in this model and that the model will give you incorrect results for the future needs in the region.

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: As part of developing the forecast for energy demand in the future, TVA tracks the fuel shares for gas and electricity for different end uses. The expected fuel share is based on the fuel cost projections, technological advancements and efficiency improvements, and historic trends. Improvements in the efficiency of many electric technologies makes electric use very competitive with gas for many end uses.

601

Comment: *TVA has been a leader in the development and implementation of innovative forecasting techniques. While TVA's modeling efforts are superb and often well above the standard for the utility industry, efforts to supply the models with current region-specific data are lacking, particularly in the commercial and industrial sectors.*

COMMEND, for example, requires data on EUIs (energy intensities in kilowatt-hours per square foot), floorspace, and market share by end use and building type. To date, TVA relies on data from a 1989 mail survey, Electric Power Research Institute southeast regional data, and data supplied by consultants from other utilities. In addition, the marketing and demand-side management group at TVA collected audit data for several years ending in 1989, but participants were self-selected and the data therefore was not used in the forecasting process.

Comment by: Tennessee Valley Public Power Association

Response: TVA has developed region-specific detailed data where a cost-effective method of data collection was available.

602

Comment: *TVA's regional economic simulation model produces the economic forecasts and relies on two major inputs: the DRI national economic forecast and TVA industrial electricity prices. TVA's regional economic simulation model has a high degree of industry detail, and TVA has supplemented the results of the model with detailed essays describing the history and future of each industry in the Tennessee Valley at the two-digit Standard industrial classification level. The process itself seems sound. It suffers the same drawbacks of most forecasts, however, in that it relies on past experience to project the future. The model, for example, continues to show growth rates for the Tennessee Valley considerably in excess of the national average. While this is reasonable given the recent past, it seems clear that such extraordinary growth cannot continue indefinitely.*

Comment by: Tennessee Valley Public Power Association

Response: This is an accurate general description of the TVA economic model used in the forecasting process. The forecasting process uses the historical information available, but the process is not strictly a projection of historical time series growth rates into the future. Model results are supplemented with industry analyses; these are used to explain the region's economic structure and its likely evolution in the future. Current economic conditions are also continually monitored to assess if there is evidence that significant changes to this likely path are occurring.

The forecast calls for growth rates for the Valley through the rest of the decade to be "considerably in excess of the national average." However, this is not due to the projec-

tion of recent historical growth rates, but rather because the conditions that led to those historical rates of growth are likely to continue into the future. For example, as stated in TVA's Economic Outlook report, the relatively new auto and related manufacturing industries in the region have been a prime driver of this growth. Recent evidence shows that the region is likely to remain in an excellent competitive position relative to these industries with several announcements of large investments in these industries to occur over the next few years.

These very fast rates of growth are not likely to continue indefinitely. TVA's regional forecast calls for the Valley's economic growth rate to slow considerably and come much closer to the national average after the end of the decade as the region's newer manufacturing industries mature. Because the Valley is expected to continue to be manufacturing-intensive and this sector tends to be more productive, the Valley is expected to outpace the nation over the long term in the future as it has in history.

603

Comment: *TVA is forecasting annual peak load growth of 2.5 percent for the period 1993 to 2000 with a forecast range of 0.7 to 3.6 percent. This is very close to the forecast of sales (energy) growth, which is forecast to be 0.7 to 4.0 percent with an expected value of 2.7 percent. It is not unexpected that the two forecasts are so close. TVA assumes in large part that the end-use or sector load shapes of today will be the same tomorrow. The only changes in system load shape are when certain sectors grow faster than others.*

Comment by: Tennessee Valley Public Power Association

Response: These are the assumptions in the Energy Vision 2020 forecast.

604

Comment: *TVA's economic projections, which substantially exceed past and national growth, are used to justify spending more money on Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3.*

Comment by: Robert Schreiber (Common Sense)

Response: TVA's load and economic forecasts are not dependent on a particular technology or project. For the period 1985-1994, the TVA region experienced 3.9 percent average annual economic growth as measured by the Gross Regional Product. This compares very favorably to the 2.5 percent average growth in the Gross National Product for the United States. We expect this trend to continue with the TVA region growing 3.5 percent through 2000 and the United States growing at 2.5 percent. This is a reasonable expectation because the region will continue to have strong manufacturing growth (see Volume 2, Document 5, page T5.5), due to good location, low wages, and abundant resources relative to the United States.

Load Forecast Methodology

605

Comment: *In general, TVA's models and methodologies are consistent with those used by many of the largest and most sophisticated utilities in the country. Their use of multiple models and their application of uncertainty analysis is commendable.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

606

Comment: *Over the years, the TVA forecasting system has continued to evolve as newer methods became available. TVA has been an active proponent and supporter of the development of improved models, often serving on Electric Power Research Institute review committees and volunteering as a beta test site for new models. While pushing the frontier forward, TVA has also been prudent about placing full reliance on a new model.*

Comment by: Tennessee Valley Public Power Association

Response: New approaches adopted by TVA using econometric and end-use models and provisions for uncertainty led to better forecasting accuracy. (See Volume 2, Technical Document 5, pages T5.3 to T5.4.) The use of multiple models assists in avoiding blind spots by taking advantage of strengths of different forecasting models. (See Volume 2, Technical Document 5, page T5.8.)

607

Comment: *Much of today's forecasting literature concludes that some improvements in forecast accuracy can be obtained through the use of multiple models. While the reasons for these improvements are uncertain, it seems that the diversity of approaches and assumptions that results from multiple forecasting methods at least intuitively explains the increased accuracy. TVA's forecasting group uses multiple models.*

Comment by: Tennessee Valley Public Power Association

Response: TVA uses multiple models to avoid blind spots associated with one model. (See Volume 2, Technical Document 2, page T5.8.)

608

Comment: *TVA has worked hard at improving its economic forecasting. In 1985, it began a program with universities around the Tennessee Valley to share economic information. These universities review both the regional forecast and the forecasts for their subregions on an annual basis.*

Comment by: Tennessee Valley Public Power Association

Response: This is an accurate statement of this aspect of TVA's economic forecasting process.

609

Comment: *TVA can further improve its approach to forecasting by incorporating additional low-cost forecasting approaches including expert judgment and time series analysis into the process. These methods would add diversity to the current approach, which consists primarily, if not exclusively, of econometric and end-use models. While the current forecasting models should continue to be the primary forecasting tools, other approaches can serve the purpose of broadening the thinking of the planning staff and management.*

Comment by: Tennessee Valley Public Power Association

Response: TVA incorporates expert judgment in the forecast of specific industries, and is considering expanding these efforts into residential and commercial forecasts in the near future.

610

Comment: *The approach to uncertainty used by TVA in load forecasting is very credible and generally a step above what is usually found in the industry. In particular, the method of accounting for interaction is commendable. Despite this extensive look at uncertainty, the method of presenting the forecast as a bell-shaped distribution tends to lead management to plan for the middle result. It may make sense for the forecasting group to present an even number of possible forecasts (e.g., four forecasts) without an assignment of probabilities.*

Comment by: Tennessee Valley Public Power Association

Response: TVA develops a range of load forecasts with probabilities so that additional power supply analyses can also use a probabilistic approach. It should be noted, however, that the sensitivities to the load forecast uncertainty identified in Energy Vision 2020 did not rely on the assignment of these probabilities, and were considered as three independent forecasts. (See Volume 1, Chapter 9, pages 9.27 to 9.28.)

611

Comment: *"Uncertain events" should be introduced into the process. These uncertain events are defined as events which have a low probability of occurrence but a high impact on the future forecast or plan. Often, these events are ignored because forecasters and planners are concentrating on the middle or most likely future. The process of identifying uncertain events is another opportunity for outside involvement, particularly for Tennessee Valley Public Power Association members. A brainstorming exercise involving community leaders and/or Tennessee Valley Public Power Association members to generate possible uncertain events could prove useful to TVA forecasts.*

Comment by: Tennessee Valley Public Power Association

Response: TVA considered many uncertainties when developing Energy Vision 2020. These uncertainties are identified in Volume 2, Technical Document 8, pages T8.20 to T8.45. Some of these uncertainties have what TVA considers a low probability of occurrence, for example, a nuclear moratorium. These uncertainties were developed based on public input, including discussions with the Power Supply Committee of the Tennessee Valley Public Power Association.

612

Comment: *The approach to determining load forecast uncertainties is also very dependent on the selection of the subjective probabilities for the high, medium, and low levels for each variable. There is no statistical basis for the selection of the conditional probabilities showing the relationship between oil prices and electric prices. This is not necessarily bad, but the selection process should be well documented and include a diversity of opinions. In addition, no sensitivity analysis is presented from which to judge whether the selection of these probabilities seriously affects the resulting probability distribution of forecasts.*

Comment by: Tennessee Valley Public Power Association

Response: TVA developed the subjective probabilities by using a diversity of opinions. In the future, TVA expects to develop cost-effective improvements to this process.

613

Comment: *The number of variables considered in determining load forecast uncertainties should be expanded to include non-quantifiable variables related to factors such as technological advances, the regulatory/political environment, changes in management, competitive forces, etc. One method to incorporate a wider array of variables including non-quantifiable variables is called "scenario analysis."*

Scenario analysis can be used in both TVA's forecasting process and integration process, and thereby provide a consistency between these activities. The BASICS methodology developed by Battelle Columbus Division is one method that has been used in the utility industry. Scenario analysis is also a useful technique for involving the distributors and other groups in the process.

Comment by: Tennessee Valley Public Power Association

Response: TVA will certainly consider these types of refinements in the future.

614

Comment: *For the period 2000 to 2020, TVA forecasts 1.9 percent annual growth in peak with a range from 0.0 percent to 3.2 percent. Again, this is very close to the energy forecast which shows 1.7 percent annual growth with a range from -0.3 to 3.2 percent. TVA is not unlike other utilities. In general, it is the industry standard to produce an energy forecast and then to create a peak forecast with similar growth rates. It is very difficult, without an in-depth analysis of expected behavioral, price, and technological changes at the end-use level, to do much else.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

615

Comment: *The review of the TVA load forecast process identified several areas where Burns & McDonnell/XENERGY felt that TVA's process could be enhanced. In general, it is felt that TVA should:*

1. *Conduct interviews with Tennessee Valley Public Power Association members to assess their view of the future and the assumptions used in the forecast. Tennessee Valley Public Power Association members should participate in the identification of key vari-*

ables, the assignment of initial probabilities, and the discussion of interrelationships between variables.

2. *Conduct interviews with large industrial customers to estimate their future consumption.*
3. *Establish a comprehensive system of on-site audits and mail surveys to collect TVA service area-specific data for forecasting and market assessment.*
4. *Enhance the uncertainty analysis by:*
   - *including Tennessee Valley Public Power Association members and outside stakeholders in the development of the subjective probabilities for each uncertainty*
   - *expanding the number of variables considered to include non-quantifiable factors*
   - *introducing low probability, high impact events to the forecast to test their effect*
5. *Incorporate a lower forecast of natural gas prices resulting in lower forecast saturations for electric heating and water heating equipment for the commercial and industrial sectors.*
6. *Consider a lower economic forecast, one more consistent with the national average.*
7. *Compare the historical accuracy of TVA forecasts to other utilities. Also, compare forecast growth rates to other area utilities.*
8. *Improve the analysis of competition and deregulation in the forecast.*
9. *Review the price elasticity assumptions in COMMEND and REEPS to make sure the data are used properly.*
10. *Implement a feedback loop between the forecast and the integrated resource plan, where an adjusted electricity price is fed back into the forecast.*

Comment by: Tennessee Valley Public Power Association

Response: A number of these recommendations have been incorporated in Energy Vision 2020 and the others will be considered in the future as appropriate.

Need for Power

616

Comment: *In TVA's procedure for estimating the region's future power requirements, the medium forecast presents the most likely outcome within a range of variables affecting future power demands. Under this medium forecast, Energy Vision 2020 shows a growth rate of about 2 percent annually, indicating a need for 16,500 megawatts of additional capacity by the year 2020. This means that power supply sources equal to 65 percent of today's system will have to be added by then.*

Comment by: TVA Retirees Association

Response: TVA's generating capacity in 1994 was 25,553 megawatts. With the addition of two nuclear units in 1996, (Browns Ferry Nuclear Plant Unit 3 and Watts Bar Nuclear Plant Unit 1), the total capacity will be about 28,000 megawatts. The indicated need of 16,500 megawatts of additional capacity by the year 2020 is about 60 percent of the total system in 1996.

617

Comment: *TVA has underestimated the need for new generating capacity because it gives too much credit for current generating capabilities.*

- *The need could be 4,000 megawatts greater than 16,000 megawatts because TVA has purchased 3,000 to 4,000 megawatts in order to meet system demands.*
- *Without substantial capital expenses, the reliability of the fossil units may be less than projected.*
- *Availability could be affected depending on how life extension of the 5 nuclear units (Browns Ferry Nuclear Plant Units 2 and 3, Sequoyah Nuclear Plant Units 1 and 2, and Watts Bar Nuclear Plant Unit 1) is treated. I might suggest that the report have a "hold" point around the year 2005 to revisit this issue. You have noted that a pressurized water reactor is a less likely candidate for life extension due to the pressure transients. With respect to Watts Bar Nuclear Plant Unit 1, I am not convinced that life of the plant will be 40 years with respect to the date of issuance. What is the status of the Nuclear Regulatory Commission's ruling on licensing extension, and how will this rule impact TVA?*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division), J. E. Butt

Response: TVA has evaluated the factors listed in this comment that could influence the need for capacity.

First, during peak load periods, it is frequently less expensive to make power purchases in place of running more expensive combustion turbines, or using interruptible contract rights. Adding enough capacity resources to prevent this would be the more costly route and would likely lead to the need to increase electricity rates. The additional capacity of Browns Ferry Nuclear Plant Unit 3 and Watts Bar Nuclear Plant Unit 1, which are planned to be on-line in 1996, will help TVA meet higher peak loads such as occurred in the summer of 1995.

Second, the long-range equivalent availability factor used in Energy Vision 2020 for the fossil units is 85 percent. TVA's fossil units had an equivalent availability factor of 85 percent in 1993. There are ongoing and planned projects for the fossil plants to maintain and improve their reliability and efficiency.

Third, nuclear unit life extension was a possible scenario. This was one of many important planning assumptions which will be reviewed on a regular basis. The Nuclear Regulatory Commission revised 10-CFR-54, which is a rule on license extension, and this rule was issued in 1995. The Nuclear Energy Institute developed guidelines for implementation of the rule. An industry wide demonstration project is planned in early calendar year 1996. TVA's assessment of the revised rule is that it is a workable approach to license renewal. We believe that any process questions will be resolved in time to support preparation of license extension applications for our nuclear units.

618

Comment: *I do not understand how we went from a situation where we had plenty of power to almost a deficit.*

Comment by: Kirk Johnson

Response: In the 1980s and early 1990s, TVA had sufficient power to meet customer needs. During this same period, the demand for electric power continued to grow, but TVA has not added more capacity since 1981. With continued load growth and no new capacity

additions, power deficits would continue to exist without Watts Bar Nuclear Plant Unit 1 and Browns Ferry Nuclear Plant Unit 3.

619

Comment: *Based on last winter and this summer's request to curtail power, TVA is facing a power crisis now. I understand that TVA's margin of capacity is one of the lowest in the nation.*

Comment by: Ed Brooks (Tennessee Southern Railroad)

Response: Browns Ferry Nuclear Plant Unit 3 and Watts Bar Nuclear Plant Unit 1 will help in situations such as those in the summer of 1995 when TVA experienced record high peak loads. This additional capacity will increase our capacity margin to meet power system needs in the next few years.

Some of TVA's larger customers have interruptible power contracts which provide power at a discount. TVA has exercised its rights to interrupt service to these customers based on these contracts. These contracts benefit both TVA and the customer. TVA saves the cost of additional peaking capacity, which would have a low capacity factor.

TVA plans for a reserve margin of 13 percent from 1998 to 2010, which is comparable to other utilities in the United States.

620

Comment: *TVA indicated in the 1994 Southeastern Electric Reliability Council's Coordinated Bulk Power Supply Program OE-411 report that the capacity margin on its system was dropping to the 9 percent level by 2003. The reduction of the capacity margin below the 15 percent level is a general trend being seen by other utilities in the United States.*

Comment by: Tennessee Valley Public Power Association

Response: In the summer of 1994, TVA updated its reliability index, which is used to determine desired reserve margins. The 1995 Southeastern Electric Reliability Council's Coordinated Bulk Power Supply Program OE-411 report shows a capacity reserve of 13 percent for the year 2003. This is after the peak loads have been reduced for expected interruptions of the Economy Surplus Power customers.

621

Comment: *The Energy Vision 2020 evaluation of options is based upon a reserve margin of 15 percent for 1996-1997, 13 percent for 1998-2010, and 12 percent reserve margin thereafter. The report states that this decline in requirements is due to improved availability of generating sources. The addition of smaller size units contemplated by the plan should result in good reliability for these particular units. However, with the existing coal-fired units nearing 70 years of age by the year 2020 (even with improvements), and with an emphasis in the plan on innovative and less mature options, it is difficult to be optimistic that overall availability and reliability of the system will actually be improving over time. New technology usually translates into more testing time and more outage time to make adjustments and corrections. This inevitably will reduce unit availability and require higher reserve margins.*

Comment by: TVA Retirees Association

Response: The decline in forecast reserve margins is largely due to improvements in the existing fossil system and additions of highly reliable new capacity. The Energy Vision 2020 long-term plan includes periodic renovation of the existing fossil generation units. TVA believes that there should be no reason that the units should not be a long-term reliable source of electricity, as long as they are maintained properly. The short-term action plan identifies the addition of capacity which is highly reliable. (See Volume 1, Chapter 10, Figure 10-1.) For example, the option purchase agreements are designed to have 100 percent availability.

622

Comment: *Site-specific National Environmental Policy Act documents tiering off of the present programmatic environmental impact statement must have a documented justification of the need for power. This justification must be supported and approved by any existing state authority such as a public service commission or equivalent. A need for power discussion is particularly important for those proposed power sources with environmental impacts, even if impacts are mitigated.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Any site-specific National Environmental Policy Act documents, which tier off of Energy Vision 2020, will discuss the "need for power" that justifies the particular energy resource option which TVA proposes to implement. The analysis of the need for power in Energy Vision 2020 will largely provide the basis for such a discussion, consistent with the concept of tiering. As a federal utility, TVA power supply planning and energy resource decisions are not subject to review or approval by state public service commissions. Although such commissions' views on proposed TVA actions are welcome, TVA would not request their approval for such actions.

CUSTOMER SERVICE OPTIONS

This section includes comments and responses about:

- the development and characterization of customer service options in Energy Vision 2020
- the merits of beneficial electrification
- the role of education in demand-side management
- the effect of electric rates on energy conservation
- the merits and effect of interruptible rates
- the merits of various end-use renewable energy options
- the importance of promoting energy efficiency, low income energy conservation and energy efficiency programs

General

623

Comment: *I am glad you are considering customer energy efficiency and load management in your plan.*

Comment by: Arthur Smith

Response: Energy efficiency and load management measures can make a significant contribution in meeting the future energy needs of the Tennessee Valley at the lowest economic and environmental cost. Energy efficiency and load management measures accomplish Energy Vision 2020 goals by meeting various customer and load shape objectives including peak clipping, valley filling, load shifting, strategic conservation, and load shape flexibility. The short-term action plan recommends implementation of 650 megawatts of demand-side management by 2002 and up to 2,200 megawatts by 2010.

624

Comment: *TVA has chosen an approach to demand-side management planning that is generally consistent with industry standards. It is a relatively detailed and data intensive approach, and relies on significant internal and outside expertise. (TVA has used 6 different demand-side management consultants, in addition to in-house staff, to either perform or review selected planning tasks.)*

Comment by: Tennessee Valley Public Power Association

Response: TVA used the best available information in the development of customer service options for consideration in Energy Vision 2020. As customer service options are implemented, TVA will monitor and evaluate several program aspects. As better information becomes available, planning estimates will be updated and refined to reflect actual program experience.

625

Comment: *The 50 demand-side management program options developed by TVA are comprehensive in that they cover virtually every customer segment and end use, and offer*

numerous different delivery mechanisms, ranging from direct installation to a mail order catalog program, to real-time pricing.

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

626

Comment: *Demand-side management objectives included lowest rates, lowest costs (total resource cost test), minimize debt, minimize customer inconvenience, enhance customer satisfaction, maximize reliability, and minimize emissions. In essence, these objectives are the same ones used by TVA in the development of Energy Vision 2020.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

627

Comment: *In general, we support your effort to quantify customer service technologies and offer our assistance in so much as is possible in sharpening these inputs so that your overall projections and plans are as much on target as it is possible to be with these type of plans.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: Many of the options included in the Energy Vision 2020 short-term action plan include developing beneficial partnerships with trade allies. Through these partnerships we will gain valuable program experience that will help us refine program offerings and update program planning assumptions.

628

Comment: *TVA should provide technical assistance regarding energy needs to local industry. This can help industry to preserve jobs and ensure low-cost, efficient, environmentally sound supply.*

Comment by: Roger Odom (Lenzinc Fibers Corporation), Bill O'Brien (B. F. Goodrich)

Response: Many of the customer service options identified in the Energy Vision 2020 short-term action plan include assistance to identify opportunities to improve the efficiency of electric end uses. The Commercial and Industrial Energy Services option encourages the application of energy-efficient technologies to meet the financial, environmental, and productivity needs of Valley businesses and industries. This program provides technical assistance, as well as financing and incentives, to assist industry and to ensure low-cost, efficient, and environmentally sound supply and use of electric power.

629

Comment: *TVA should look at the experiences of other utility demand-side management and renewables programs such as Bonneville Power, Ontario Hydro, and Pacific Gas and Electric. TVA should consider bringing in experts to help design and optimize these programs.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition), Dennis Haldeman, Michelle Carratu, Hamp Dobbins, Jr., Walter & Dorothy Stark, Philip & Winfred Thomforde

Response: TVA identified 39 energy efficiency and load management options for consideration in the Energy Vision 2020 planning process. The options targeted the residential, commercial, and industrial sectors and addressed all the major electric end uses. In developing these options, TVA examined the best programs from around the country, including the programs offered by Bonneville Power Administration, Ontario Hydro, and Pacific Gas and Electric. TVA identified the features of the most successful programs and incorporated them into the customer service options developed. TVA developed options to satisfy several evaluation criteria including resource cost, rate impact, and customer value.

TVA also considered a comprehensive list of supply-side options, including several renewable options. The completeness of TVA's list was verified by review of 20 other utility integrated resource plans, as described in Volume 1, Chapter 7, page 7.4. Some of the renewable options considered included biomass, end-use solar photovoltaics, wind, and landfill methane.

630

Comment: *TVA should provide interest-free loans for the purpose of solar water heaters, photovoltaic systems, and energy-efficient appliances including gas clothes dryers, ovens, and ranges.*

Comment by: Linda Cataldo Modica

Response: TVA reviewed a large number of energy efficiency technologies and program concepts to deliver these technologies to customers. These included interest-free loans and other incentives or rebates. The short-term action plan includes implementation of 650 megawatts of demand-side management by the year 2002 and up to 2,200 megawatts by 2010 using a variety of rebates and incentives including financing. In the identified Low Income program option, a number of energy conservation measures would be provided cost-free to low income customers. As part of its short-term action plan, TVA will investigate end-use solar photovoltaics.

Customer service options that would promote fuel switching for certain appliances were also analyzed. This analysis indicated that electricity would be more cost-effective than natural gas, except for water heating.

631

Comment: *A potentially significant drawback to TVA's approach to characterizing its market and demand-side management technology costs and impacts is its heavy reliance on secondary data sources. While building simulation results have been adjusted to match TVA's forecast, these adjustments have either relied on very limited and dated information (the most recent data is the commercial and industrial equipment survey from 1989), or simply used ratio adjustments, with no knowledge of what components were actually inaccurate. Of perhaps greater concern is that no technology or customer data has been weighted to better represent TVA's customer population. For example, secondary data on technology impacts could have been stratified by customer size and building type and weighted to TVA's customers so that overall potential impacts would more closely reflect the demand-side management potential in TVA' s service territory.*

Given that TVA has not actively pursued demand-side management resources since 1988, it is not unusual or surprising that primary customer data is lacking, as it is for many other United States utilities. Given this lack of data, the timing requirements for the

Energy Vision 2020 process, and the potential cost of significant data collection, reliance on secondary data is appropriate. However, it is unclear whether this data has been properly adjusted and weighted to best represent TVA's customer population.

Comment by: Tennessee Valley Public Power Association

Response: In developing TVA's technology costs and impacts for demand-side management programs in Energy Vision 2020, TVA considered three residential building types and ten commercial building types. Separate costs and impacts for each technology were developed for each building type. Using primary data from the TVA regions, the average cost and impact for each technology were weighted based on the estimate of the mix of building types.

632

Comment: *As with its technology assessment, TVA's program development relies heavily on secondary data. TVA has done a commendable job of assessing the demand-side management experience of other utilities and in considering this experience in its own program development. TVA has done little market research, however, to assess how different programs would be received by its own customers, local trade allies, and wholesale distributors. Additional market research (possibly including focus groups, informal group interviews, and phone or mail surveys) could significantly help TVA in assessing the likely response to different program delivery mechanisms and incentive approaches. Assessment of trade ally reactions is particularly critical for some of TVA's proposed programs that rely heavily on trade ally involvement for successful implementation. The impact of demand-side management is highly dependent on the acceptability of the programs to the distributors and their customers. Future demand-side management efforts should include increased data gathering from the distributors and their customers as input to TVA's assumptions.*

Comment by: Tennessee Valley Public Power Association

Response: Detailed implementation plans will be developed for the customer service options in the Energy Vision 2020 recommended short-term action plan. (See Volume 1, Chapter 10, Figure 10-1.) Primary research would be conducted to develop program features that will ensure that program goals are met. Partnerships with power distributors and trade allies are critical to the success of demand-side efforts. Market evaluation will be performed using primary data collection methodologies such as surveys, focus groups, and listening sessions. Data will be collected from power distributors, end-use consumers, and trade allies prior to the actual implementation of any program to assess program delivery mechanisms and market potentials.

633

Comment: *TVA's overall estimates for program option impacts and spending are quite aggressive when viewed as an actual demand-side management plan (2005 cumulative impacts are roughly 10 percent of projected sales and peak demand; this compares quite favorably with the most aggressive utilities in North America). Given the relatively low penetration estimates and fragmented nature of its current program designs, it is likely that TVA's final demand-side management goals will be significantly less than what is potentially achievable in its service territory.*

Comment by: Tennessee Valley Public Power Association

Response: All of the resource options considered in Energy Vision 2020 were assessed based on several evaluation criteria. Those criteria included total resource cost, impact on rates, environmental impacts, and flexibility. Resource strategies were developed using different resource options to satisfy and balance these evaluation criteria. The energy efficiency options included in the short-term action plan compared well against other resource options. Other energy efficiency options, because they had higher levels of uncertainty, cost, or rate impacts, were not viable as part of a future resource strategy.

634

Comment: *TVA has a dismal record of demand-side management in Memphis Light, Gas and Water's service area.*
How will TVA's proposed demand-side management programs be better than previously offered programs?

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: For programs included in the Energy Vision 2020 short-term action plan, TVA will develop implementation plans in partnership with distributors. In those implementation plans, several issues will be addressed. Those issues include TVA and distributor roles in delivering customer service options, impacts of the options on distributors' costs and revenues, and possible incentives to encourage and reward distributor participation in programs. TVA recognizes that the electric marketplace is becoming more competitive. Both distributors and TVA are affected by this. TVA is committed to working with distributors to develop options that enhance distributor and TVA operations and competitiveness. TVA will work with the Tennessee Valley Public Power Association committees and with individual distributors to identify particular needs. This process has already begun.

635

Comment: *The review of the demand-side management process identified the following areas where it was felt TVA could improve the process.*

1. *Establish a comprehensive data collection system that includes on-site audits for the commercial and industrial sector and mail surveys for the residential sector.*
2. *Interview Tennessee Valley Public Power Association members to determine what program designs work and review cost assumptions based on real world experience.*
3. *Pursue approaches with Tennessee Valley Public Power Association that allow recovery of lost revenues and marketing/administrative costs.*
4. *Conduct market research to determine how different programs would be received by customers, local trade allies, and wholesale distributors.*
5. *Review assumptions regarding customer participation, measure penetration, and free-ridership based on experience from other utilities who have successfully implemented similar programs.*
6. *Reassess marketing costs based on a "bundled" approach. Often cost reductions occur as programs are marketed together.*
7. *Evaluate programs from the distribution perspective using the distributors' avoided costs and retail rates.*

Comment by: Tennessee Valley Public Power Association

Response: 1. TVA has had a comprehensive saturation survey since 1979 which regularly collects information about the residential and commercial and industrial sectors. Information is collected about consumers' energy use, residence/building characteristics, and sociodemographics/firmographics. As TVA begins implementation of the customer service options included in Energy Vision 2020, TVA will devise a data collection plan to capture customer information obtained through the programs. TVA will use this information to refine and update future planning assumptions.

2. For all programs included in the Energy Vision 2020 short-term action plan, TVA will develop implementation plans in partnership with distributors. In those implementation plans, several issues will be addressed. Those issues will include detailed program designs and cost assumptions.
3. The implementation plans developed in partnership between TVA and distributors will address the delivery mechanisms for customer service options, impacts of the options on distributors' costs and revenues, and possible incentives to encourage and reward distributor participation in options.
4. Prior to going to market with any demand-side management program, specific market evaluations will be undertaken with end-use consumers, trade allies, and power distributors. Such data gathering is a critical component of any evaluation effort prior to and during program implementation.
5. The experience of other utilities with demand-side management programs has been researched and research will continue to be conducted as TVA implements the customer service options in the Energy Vision 2020 short-term action plan.
6. Options were developed for planning purposes. In the analysis of customer service options, TVA noted that while some technologies may be promoted using similar delivery strategies, there may be significant differences in the costs and impacts of those technologies. In most cases, the cost-effectiveness of the customer service options considered in Energy Vision 2020 was driven by the technology costs and impacts. Decisions to aggregate or disaggregate technologies within options were made to improve the overall cost-effectiveness of the options. In implementation, several options or technologies would be integrated under a single umbrella program. This approach allows TVA to capture lost opportunities and to realize synergies between programs. Administrative costs for options were developed considering more comprehensive program implementation. Care was taken not to overload options with high administrative costs, and to reflect potential scale efficiencies in the option cost estimates.
7. The implementation plans developed in partnership between TVA and distributors will address the impacts of the customer service options on distributors' costs and revenues, using the distributors' avoided costs and retail rates.

636

Comment: *Some of TVA's previous residential conservation programs did not pay for themselves, added to the cost of electricity for all customers, and were a significant financial drain on TVA. Residential energy programs should be funded by residential ratepayers or financed through the private sector or distributors and not add to the cost of electricity of all customers as past residential programs and pilots have been.*

Comment by: Tennessee Valley Industrial Committee

Response: Most of TVA's earlier residential energy conservation programs were initiated during the late 1970s and 1980s in response to the oil crisis. These programs reduced the peak demand for electric power by over 1,000 megawatts. The demand-side programs that have been identified for the residential sector in the short-term action plan have evolved significantly from these early programs. These new programs were identified based on their resource cost, the ability to minimize any rate impact, and their potential to enhance customer value.

The new and expanded Energy Vision 2020 residential programs are designed to work in partnership with the private sector and distributors of TVA power. These programs focus on equipment leasing, maintenance services, catalog and mail order delivery of energy efficient products, and development of the retail infrastructure. By emphasizing education and the customer value created by the residential programs, participants can better understand the full benefits provided to them. These programs allow program beneficiaries to pay more of the cost of the programs thus reducing potential cost increases to non-participants.

637

Comment: *Industrial customers may need to be shielded from residential demand-side management costs through rate design. However, the rate design should consider the benefit to industrial customers of more available power at key times.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: The Energy Vision 2020 residential programs were selected based on their resource cost, the ability to minimize any rate impact, their potential to enhance customer value, and other criteria. The residential options are designed to work in partnership with the private sector and distributors of TVA power. These programs focus on equipment leasing, maintenance services, catalog and mail order delivery of energy-efficient products, and development of the retail infrastructure. By emphasizing education and the customer value created by the residential programs, participants should better understand the benefits provided to them. This allows program beneficiaries to pay more of the program costs, thereby reducing potential rate impacts on other customer classes.

TVA periodically conducts cost-of-service studies to determine the proper allocation of costs for each rate class. The cost-of-service study would consider the availability of power, total energy consumption, load factor, and power factor in determining the optimal pricing strategy. TVA tries to allocate the costs of all resources required to provide reliable electric service, both supply-side and demand-side, in a fair and equitable manner.

638

Comment: *The validity of the entire Energy Vision 2020 process should be seriously questioned due to TVA's lack of consideration on reforming distributor service agreements. Throughout Energy Vision 2020, TVA has assumed a continuation of all existing requirements in its relationship with its distributors. To meet the distributors' future needs for power, TVA would either build generation internally or contract with external suppliers. This assumption is inconsistent with TVA's own "Phase 2" recommendation outlined in the Palmer Bellevue study.*

Contract reform was an integral part of the natural gas industry restructuring process. Pipelines negotiated reduced volumetric takes from producers as the large end

users and local distribution companies contracted for transportation-only services. The pipeline systems that negotiated settlements early and without excessive litigation were the ones with minimum take or pay and transition surcharges.

It is unrealistic for TVA, the nation's largest wholesale supplier, to expect that similar events in the wholesale electric industry are not likely to occur. TVA's vague treatment of this issue as an uncertainty, a probabilistic approach to competitive success, underscores TVA's lack of proactivity in wholesale contract reform. Memphis Light, Gas and Water urges TVA to consider bilateral discussions with its distributors to reform its service agreements.

Why did TVA not consider wholesale contract reform options in its Energy Vision 2020 process along with its other, and potentially more costly, resource options?

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Henry Nickell (Memphis Light, Gas and Water Division)

Response: Energy Vision 2020 is a strategic level document and analysis and specific contracting mechanisms were not evaluated. However, consequences of the actions referenced in this comment have been encompassed by the analyses done for Energy Vision 2020.

In Energy Vision 2020, the changing structure of the electric utility industry on both the supply and demand sides of the market have been considered. On the demand side of the market, TVA's load forecasts recognize the uncertainty in future load growth due to the uncertainty in the future competitive markets. (See Volume 1, Chapter 6, pages 6.4 and 6.5 and Volume 2, Technical Document 5, Load Forecasts.) In Technical Document 5, page T5.20, the future TVA competitive success is recognized as the second most important uncertainty in future load and sales levels. The uncertainty in TVA's sales certainly recognizes the recommendation of the Palmer Bellevue study that at some point in the future the "fence" and the "anti-cherry picking amendment" would not exist, opening the TVA market to wholesale competition. Further considerations in this analysis included the current 10-year cancellation notice contract, the potential for both full and partial requirement contracts, and provisions for stranded investment. The potential for retail open access was only considered qualitatively.

On the supply side of the market, the short-term action plan in Energy Vision 2020 recognizes the need for flexibility in the face of market price and load forecast uncertainty. The recommended supply-side options include both flexible internal and external options. (See Volume 1, Chapter 10, Figure 10-1.) These flexible options are the basis of the short-term action plan.

639

Comment: *TVA should do water conservation through things like "grey-water" systems and cistern systems.*

Comment by: Kathleen O'Donohue

Response: TVA encourages water conservation in conjunction with energy conservation (i.e., low flow shower heads). Presently, TVA has no program to encourage conservation of treated (potable) water by substitution of grey-water or rain water collected in cisterns for non-potable uses such as lawn watering.

640

Comment: *TVA should recruit retirees from other sections of the country to retire in the Valley.*

Comment by: John Sharp, Jr.

Response: Retirees are a recognized important and growing component of the economy. TVA, through its Economic Development Office, works with Valley communities to help them develop their economic development strategy given their particular circumstances.

641

Comment: *I support increased funding for nitrate research at TVA's Muscle Shoals facility.*

Comment by: James Barr

Response: Your comment has been reviewed and noted.

Beneficial Electrification

642

Comment: *TVA and the distributors have been working closely and doing a lot of research and development on beneficial electrification.*

Comment by: Michael Browder (Bristol Tennessee Electric System)

Response: Distributors of TVA power are key to development of beneficial electrification services. TVA also works with the Electric Power Research Institute and other agencies to conduct energy research on new technologies that increase the efficiency and productivity of energy use or reduce environmental impacts associated with energy consumption. In the short-term action plan, TVA identified beneficial electrification opportunities that are most likely to meet these goals.

643

Comment: *We suggest that the 4.7 and 2.5 values that are embedded in the current plan are gross numbers. Why have they not been netted out against the load growth promotion activities proposed by TVA?*

Comment by: Geoffrey Crandall (MSB Energy Associates)

Response: Block 1 of the customer service options is approximately 4.7 percent of the peak demand and 2.5 percent of the annual energy sales in the year 2010. While TVA has prioritized the options in Block 1 because of their low cost and low impact on rates, TVA has also included options from Blocks 2 and 3 in its short-term action plan. Options from Blocks 2 and 3 were included in the short-term action plan to address lost opportunities and to promote market transformation and equity among customers. By including many of the options in Blocks 2 and 3, TVA also builds the capabilities to deliver large-scale demand-side management programs based on future resource needs and costs.

The short-term action plan recommends 650 megawatts of demand-side management by the year 2002 and up to 2,200 megawatts of demand-side management by 2010.

644

Comment: *Why is off-system sales considered a resource and why is it listed as a customer service action in Volume 1, Chapter 10, Figure 10-1?*

Comment by: Eric Hirst (Oak Ridge National Laboratory)

Response: Off-system sales provide an opportunity to use TVA's generating resources when they are not needed to meet TVA customer needs. Off-system sales provide additional revenue to reduce the costs of power to TVA customers. Reductions in the cost of power from off-system sales add customer value; thus, off-system sales were treated as customer service options.

Demand-Side Management

EDUCATION

645

Comment: *TVA needs to go back to its energy education programs for alternative energy sources and conservation.*

Comment by: Sam Denham, Andrew Danzig, Michelle Neal (Tennessee Valley Energy Reform Coalition), Elaine Stancil, Stephen Smith (Tennessee Valley Energy Reform Coalition), Sanford McGee (Cumberland Center for Justice and Peace), Sheilla Cheyenne, Kathleen O'Donohue, Alan Ball

Response: TVA has included several new and expanded customer service options in the Energy Vision 2020 short-term action plan. The customer service options are directed to both residential and commercial and industrial customers of TVA and the power distributors. These options use education and incentives to encourage more efficient use of electricity. The customer service options are expected to provide 650 megawatts of alternative energy resources by 2002 and up to 2,200 megawatts by 2010.

646

Comment: *TVA should provide in the weekly newspaper information including rates, billing procedures, fuel use, reservoir management, etc. This would improve public relations and the public's understanding of TVA's objectives.*

Comment by: L. George Hannye, Bryan Deel, Stephanie Calvert

Response: TVA regularly communicates with the public through several media on different subjects. For example, TVA publishes many brochures and pamphlets that deal with the benefits of electricity, (e.g., *energy right* program). TVA also has an information line that is updated daily (TVA Today) and can be accessed at (615) 751-4000, or (423) 632-4000. This line provides information about TVA events, load demands, and power system output. There is also a 24-hour hotline on lake information [1-800-238-2264 or (423) 632-2264]. In addition, there is an information line on hydro unit discharge schedules that is popular with fishermen [(615) 632-6065].

647

Comment: *The public should be educated about mitigating environmental risks through demand-side management.*

Comment by: Sheila Holbrook-White (Sierra Club, Alabama Chapter), Sharon Fidler (League of Women Voters)

Response: Included in the long-term plan and short-term action plan of Energy Vision 2020 are the Student Self-Audit and Self-Audit programs. A significant feature of these programs is education of the public, including environmental education. TVA has participated with the Electric Power Research Institute in the development of software that compares the environmental emissions of different end-use equipment and differing fuels. Data from this software would be used in the audit programs to educate the public on the environmental impacts of home appliances. For example, heating a 1,500 square foot home with a typical heat pump will create 2,259 pounds of carbon dioxide per year at the generating facility. In comparison, a gas furnace will create 2,647 pounds of carbon dioxide per year, of which 2,042 pounds will be released at the home. Moreover, it is typically easier to control a point source of pollution (a power plant) than to control dispersed emissions (thousands of gas furnaces).

648

Comment: *TVA should also educate the public about "sick building syndrome"—buildings can be built too tight to save energy. Energy conservation can go too far.*

Comment by: Richard Simmers

Response: The American Society of Heating, Refrigerating, and Air Conditioning Engineers, a recognized organization for the development of residential and commercial building standards, has recently updated its recommendations for building ventilation. The new standards recommend higher levels of ventilation because of increased building efficiency, increased occupation, and increased use of office equipment. TVA supports compliance with the American Society of Heating, Refrigerating, and Air Conditioning Engineers standards and has plans to conduct training for architects and engineers on the new standards.

649

Comment: *I am concerned about light pollution which obscures the night sky. We have excessive, unneeded, and inefficient outdoor lighting. Rather than running commercials promoting the waste of energy, TVA should have commercials which educate the public about properly designed and efficient outdoor lighting.*

Comment by: Bruce Gant

Response: Energy Vision 2020 contains programs to encourage energy-efficient outdoor lighting for communities that require additional security and other lighting-related needs. (See Volume 1, Chapter 8.) However, both individual outdoor lighting decisions, and the associated effect on "light pollution" are issues that are best addressed and resolved at the local level.

650

Comment: *TVA needs to use its advertising dollars for commercials and education which explain the benefit that raising rates would have on encouraging energy conservation and reducing TVA's debt. TVA should explain how conservation measures can offset any increase in the rates. This would include measures such as turning off lights, appliances, and heating and cooling systems where unnecessary, and wearing proper clothing, energy-efficient lights, passive solar heating, and weatherization.*

Comment by: Dolores Howard

Response: The purpose of TVA's advertising program is to highlight how competitive TVA's electric rates are compared to other parts of the nation. Another relevant point of consideration is TVA's commitment to holding customer rates steady for another year. Competitive, stable rates allow TVA and its state partners to successfully recruit industry to the Valley, thus creating jobs. This is part of TVA's mission—to foster economic development in the Valley.

As proposed in Energy Vision 2020, TVA's customer service options address activities TVA and distributors would work on cooperatively to advertise and promote energy-efficient measures such as weatherization and audits to identify and install energy-efficiency measures or changes to save energy. (See Volume 1, Chapter 8.)

ENERGY EFFICIENCY

651

Comment: *TVA should have an internal conservation program that links to the federal program to save energy consumption in federal buildings by 20 percent by the year 2000.*

Comment by: Geoffrey Crandall (MSB Energy Associates), Hollis Fenn

Response: TVA has an Internal Energy Management Program. As part of this effort, there is an Energy Conservation Committee to guide and implement energy-efficiency initiatives for TVA facilities. A TVA-wide Internal Energy Management Policy and an Energy Plan have been developed. The 20-year plan targets total energy savings of 660,650 megawatt-hours per year.

652

Comment: *Why has TVA not linked its plan to the Institutional Conservation Program? There is a lot of federal money in this program. There is no mention in the plan for addressing the institutional sector such as schools and hospitals.*

Comment by: Geoffrey Crandall (MSB Energy Associates)

Response: TVA is committed to working with state and local organizations to achieve the greatest benefit from demand-side management programs. The funds under the Federal Institutional Conservation Program are dispersed through the individual State Energy Offices after proper guidelines and requests for funds have been met. However, the current budget proposal for the Federal Institutional Conservation Program is in Congress and a 50 percent reduction from last year has been proposed.

The institutional sector is addressed in Energy Vision 2020 as part of the commercial sector. Many of the energy efficiency and beneficial electrification options, identified for the commercial sector apply equally to the institutional sector. TVA is currently working

with school systems to install and test ground source heat pump systems. These systems show considerable promise in providing efficient and cost-effective heating and cooling for buildings in the institutional sector.

653

Comment: *I commend TVA for participating in the Environmental Protection Agency's Green Lights and Energy Star programs internally. If conservation is good for TVA, why do you not promote conservation with your customers, for example, distributors themselves?*

Comment by: Andrew Danzig, Leslie Shankman-Cohn

Response: TVA has included several customer service options in the short-term action plan to encourage more efficient use of energy. (See Volume 1, Chapter 10, Figure 10-1.) Options were included in the short-term action plan to target all customer segments including residential, commercial, and industrial customers. TVA will encourage both distributors and the customers they serve to participate in the options offered.

As a Green Lights partner, TVA encourages Valley businesses to participate in the Environmental Protection Agency's programs. TVA has sponsored and conducted training inside and outside of TVA to promote Green Lights and to certify new surveyor allies.

654

Comment: *The replacement of incandescent lamps with high pressure sodium lamps in the building interior (the last measure listed in Volume 2, Technical Document 7, LED exit signs and electroluminescent exit signs) would require the color corrected high pressure sodium lamps for aesthetic reasons and that comes in the 50-watt size and larger, not the 35-watt size.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: TVA addressed in Energy Vision 2020 the replacement of incandescent lamps with high pressure sodium lamps for both interior and exterior applications. TVA will investigate and promote the use of higher wattage high pressure sodium lamps in instances where they provide potentially higher value to the customer, (i.e., some indoor applications).

655

Comment: *Tennessee Valley Industrial Committee industries have made investments in energy-efficient equipment and continue to do so. The residential sector does not use electricity as efficiently as TVA's industrial customers.*

Comment by: Tennessee Valley Industrial Committee

Response: TVA recognizes the Tennessee Valley Industrial Committee industries' investments in energy-efficient equipment. TVA sees opportunities for continued improvements in the industrial sector, as well as other customer segments. The Energy Vision 2020 short-term action plan includes customer service options for all end-use customer segments. The customer service options for each segment were developed based on how electricity is used in the segment and the specific customer needs. Most of the energy efficiency options are targeted to the residential and the commercial sectors, acknowledging the greater efficiency potential in those sectors.

656

Comment: *TVA should be assisting small businesses to be more energy efficient.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: The Small Commercial Retrofit program, proposed in Energy Vision 2020, would focus on promoting energy efficiency and renewable technologies that benefit the local business community, TVA, and the customer by reducing costs, improving reliability, and enhancing customer satisfaction and competitiveness. This program would provide participants with an on-site audit where the auditor would install cost-effective lighting, water heating, and weatherization measures. The auditor would also identify and recommend any other applicable cost-effective, energy-efficient opportunities that may exist in the customer's facility. The auditor would refer the customer to other programs offered by TVA and/or power distributors that promote energy efficiency.

Additionally, the Commercial Heating,Ventilation, and Air Conditioning Maintenance program, proposed in Energy Vision 2020, would offer commercial customers maintenance contracts for their heating, ventilation and air conditioning systems. This would cover regular maintenance of the customer's heating, ventilation, and air conditioning equipment by TVA or a contractor. Proper maintenance of the system would result in energy savings and improved performance for the customer.

The Commercial and Industrial Energy Services option included in the short-term action plan includes targeted incentives to help achieve the energy efficiency goals of hard-to-reach small business customers. (See Volume 1, Chapter 10, Figure 10-1.)

657

Comment: *To fulfill its duty, TVA needs to help citizens become energy efficient just so they can pay their bills.*

Comment by: Myles Jakubowski (Sunbeam Household Products)

Response: Energy Vision 2020 includes numerous energy efficiency programs to encourage the adoption of conservation measures. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

The Residential Low Income program is included in both the long-term and short-term plans of Energy Vision 2020. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) This program is designed to help low income customers become more energy efficient by installing weatherization measures free of charge in their homes. Additionally, many of TVA's distributors currently offer a "warm neighbor" program to assist low income customers with their energy payments.

658

Comment: *TVA should make available to its customers energy-efficient lighting devices at a wholesale price.*

Comment by: Hollis Fenn, Catherine Murray (Sierra Club, State of Franklin Group), Sanford McGee (Cumberland Center for Justice and Peace), Carol Kimmons

Response: TVA has identified in its short-term action plan an Energy Efficiency Products Catalog program that would allow customers to purchase smaller, easily installed technologies that are not readily available in the marketplace. The program serves many purposes. First, the catalog will inform Valley consumers of the benefits and applications of

energy-efficient products, including lighting, and offer them the opportunity to purchase these products at a reduced price. The catalog also aims to stimulate the development of the retail infrastructure by increasing the demand for the energy-efficient products. This program will begin in 1996, with full-scale implementation expected to follow in 1997.

659

Comment: *TVA needs a program to retrofit older homes away from electric resistance heat.*

Comment by: Arthur Smith

Response: TVA presently offers a program under which low interest loans are available through participating power distributors for the purchase of heat pumps for existing homes. This program is available to many Valley residents in homes with older electric resistance heating systems, such as baseboard and ceiling heat, which are less energy efficient than current heat pumps.

The percent of Valley homes with electric resistance heating has declined steadily, from 37 percent in 1979 to 24 percent in 1992. During this same period, residences equipped with heat pumps have increased from 8.6 percent to 22.4 percent. The overall electric heating saturation has remained approximately 46 percent.

660

Comment: *TVA and distributors have been working together on demand-side management programs. We find that in the heat pump program, people use one-half to one-third of the power that they previously used under other systems.*

Comment by: Michael Browder (Bristol Tennessee Electric System)

Response: Distributors are a very important part of a successful demand-side management program. For example, the heat pump program has been successful at promoting high efficiency heat pumps and quality installations. The heat pump program is recommended for expansion in the short-term action plan and the long-term plan for Energy Vision 2020.

661

Comment: *Section 113 of the Energy Policy Act, paragraph B, subpart 1 requires a full range of existing and incremental resources be considered. TVA failed to examine the viability of fuel switching or fuel substitution as a demand-side management resource. Vermont, Michigan, and Wisconsin have explicitly quantified the impact of fuel switching in their resource plans. In Michigan they found an energy savings equivalent to a 700-megawatt base-load power plant, by converting water heaters, clothes dryers, and ranges from electricity to gas. Rather, in the form of beneficial electrification, TVA's draft is looking at just the opposite. TVA is looking at load building by switching gas customers to electric.*

Comment by: Geoffrey Crandall (MSB Energy Associates)

Response: Although TVA does not agree that Section 113 of the 1992 Energy Policy Act requires that TVA consider fuel switching as part of the Energy Vision 2020 process, TVA did, in fact, consider the viability of fuel switching, both in the context of an uncertainty and as a demand-side management option. TVA's analyses show that electricity is more economically efficient or equivalent to natural gas with respect to all applications with the exception of water heating.

662

Comment: *TVA should promote use of natural gas for home heating as a more efficient, less polluting source of energy compared to coal-produced electricity.*

Comment by: Catherine Murray (Sierra Club, State of Franklin Group), Benjamin Stewart (Faith Lutheran Church)

Response: TVA has a mix of generating stations including nuclear, coal, and hydro power. Energy Vision 2020 recommends that TVA maintain a portfolio of generation options to meet system needs and environmental concerns. If all of TVA's generation were coal, then natural gas heating would produce less overall pollution. TVA analyzed the emissions for heating a home, given TVA's overall generation mix, with a heat pump compared to a gas furnace. Heating a 1,500 square foot home with a heat pump will create 2,259 pounds of carbon dioxide per year at the generating facility. In comparison, a gas furnace will create 2,647 pounds of carbon dioxide per year, of which 2,042 pounds will be released at the home. Another important environmental consideration is that it was typically easier to control a single point source of pollution (a power plant) than to control dispersed emissions (thousands of gas furnaces).

People choose the fuel they use for space heating for many different reasons. For example, safety, cleanliness of the fuel, convenience, efficiency, and comfort are just a few of the reasons. In many areas of the Tennessee Valley, a high-efficiency heat pump is the most economical heating source for a customer, and customers may not be aware of the technological advances in heat pump efficiencies that have resulted in operating cost reductions.

663

Comment: *It is unclear how some load building efforts will help customers. For example, why should a customer be better off with electric heat than with gas heat and why should a federal agency seek to influence a fuel choice?*

Comment by: Eric Hirst (Oak Ridge National Laboratory), Robert Schreiber (Common Sense)

Response: The beneficial electrification options rely primarily on education, technical assistance, and promotion of high-efficiency options to encourage end-use customers to consider electric technologies.

People choose the fuel they use for cooking, water heating, and space heating for many different reasons. For example, safety, cleanliness of the fuel, convenience, efficiency, and comfort are just a few of the reasons. Additionally, TVA's analyses show that electricity is more economically efficient or equivalent to natural gas for all these applications with the exception of electric water heating. In many areas of the Tennessee Valley, a high-efficiency heat pump is the most economical heating source for a customer. Customers may not be aware of the technological advances in heat pump efficiencies that have resulted in operating cost reductions.

Like off-system sales, the beneficial electrification options provide an opportunity to operate TVA's generating resources optimally and maintain competitive rates for TVA and distributors. The beneficial electrification options also create customer value by promoting technologies with both energy and non-energy benefits for customers.

664

Comment: *TVA should not be promoting use of electricity for applications where natural gas is more efficient, such as electric cooking, electric water heating, and electric heating, and possibly heat pumps. TVA needs to educate customers about this.*

Comment by: Arthur Smith, Steven Walsh

Response: The beneficial electrification options rely primarily on education, technical assistance, and promotion of high-efficiency options to encourage end-use customers to consider electric technologies.

People choose the fuel they use for cooking, water heating, and space heating for many different reasons. For example, safety, cleanliness of the fuel, convenience, efficiency, and comfort are just a few of the reasons. Additionally, TVA's analyses show that electricity is more economically efficient or equivalent to natural gas for all these applications with the exception of electric water heating. In many areas of the Tennessee Valley, a high-efficiency heat pump is the most economical heating source for a customer. Customers may not be aware of the technological advances in heat pump efficiencies that have resulted in operating cost reductions.

Like off-system sales, the beneficial electrification options provide an opportunity to operate TVA's generating resources optimally and maintain competitive rates for TVA and distributors. The beneficial electrification options also create customer value by promoting technologies with both energy and non-energy benefits for customers.

665

Comment: *The Environmental Protection Agency wishes to stress the importance of conservation measures to reduce the need for new power generation and the attendant environmental impacts. The Environmental Protection Agency notes and appreciates the extensive analysis of demand-side management strategies in Energy Vision 2020. However, some other available options do not appear to have been considered in the document. As natural resources continue to fall under the pressures of an expanding population, conservation measures appear to be a viable option for the power industry as a whole.*

The Environmental Protection Agency recommends TVA's exploration and/or inclusion of an analysis of strategic tree planting as a demand-side management strategy to reduce summer cooling costs for residential and commercial buildings. The utilization of trees to affect ambient temperatures around homes and buildings has been documented in "Cooling Our Communities: A Guidebook On Tree Planting and Light-Colored Surfacing." This publication identifies opportunities which are consistent with the demand-side management approach.

Tree planting also contributes to lower urban temperatures as well as to the sequestration of carbon emitted from fossil-fuel plants. This may provide a mechanism for addressing some of the externalities of energy production from such plants. TVA may wish to consider sponsoring tree plantings to sequester carbon dioxide.

The Environmental Protection Agency also suggests consideration of light-colored surfacing as a demand-side management option. This approach involves reducing the amount of solar radiation absorbed by impervious surfaces and reflecting it back into space. This provides lower urban temperatures and reduces the amount of ozone production from photochemical reactions between carbon dioxide, nitrogen oxides, sulfur oxides and solar energy. The light-colored surfacing concept is being considered by the State of California as a method to improve air quality.

If more detailed information is desired, a copy of the Lawrence Berkeley Laboratory Report (LBL-31587) can be obtained from :

GPO Document #055-000-00371-8
Superintendent of Documents
P.O. Box 37194
Pittsburgh, PA 15220-7954
ATTN: New Orders

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA's cost-effective demand-side management measures provide benefits to customers and increase the flexibility of the power system. The Energy Vision 2020 short-term action plan recommends that TVA implement 650 megawatts of demand-side management by 2002. Tree planting for shading and carbon dioxide sequestering is an option that TVA will analyze for individual customers through the Residential Self-Audit and Commercial and Industrial Energy Services options included in the short-term action plan. In addition, TVA analyzed the effect of new carbon dioxide regulations assuming that carbon dioxide allowances would cost $10 per ton or that the equivalent could be spent on such carbon dioxide mitigation activities such as tree planting. TVA also analyzed light colored roofs for commercial buildings. In general, this technology was not cost-effective because of increased energy consumption requirements for heating. TVA recognizes that this is an option that may be cost-effective for individual customers based on their specific operating characteristics. Again, TVA will analyze this technology for individual customers through the Commercial and Industrial Energy Services option.

666

Comment: *TVA should subsidize shade trees and wind breaks in residential areas. This would conserve energy and offset environmental damage caused by current methods of generating electricity.*

Comment by: Retha Ferrell

Response: TVA's cost-effective demand-side management measures provide benefits to customers and increase the flexibility of the power system. The Energy Vision 2020 short-term action plan recommends that TVA implement 650 megawatts of demand-side management by 2002. (See Volume 1, Chapter 10, Figure 10-1.) Tree planting for shading and carbon dioxide sequestering is an option that TVA will analyze for individual customers through the Residential Self-Audit and Commercial and Industrial Energy Services options included in the short-term action plan. Wind breaks also have benefits in certain situations. However, the energy impacts are very site-specific and difficult to quantify.

667

Comment: *TVA should provide free energy audits for all households.*

Comment by: Linda Cataldo Modica

Response: The Residential Self-Audit program and Residential Student-Audit program are included in the short-term action plan. These programs will provide customers an opportunity to perform their own audit. TVA will analyze the audit information and make recommendations for energy savings.

668

Comment: *To encourage conservation, TVA should offer rebates or rate adjustments to those who design more energy-efficient new or remodeled buildings or for the use of more energy-efficient appliances. What effect would this have on the need to build new capacity?*

Comment by: Andrew Danzig, Bruce Wood, Don Scharf (Sierra Club, Middle Tennessee Group), Debra Jackson, Eileen McIlvane (Coalition for Jobs and the Environment)

Response: The short-term action plan recommends that incentives or financing be offered to both residential and commercial customers to design more energy-efficient new or remodeled buildings. These recommendations are contained in the Residential New Homes program and the Commercial and Industrial Energy Services option. It is difficult to forecast the penetration of specific program components like these; however, TVA expects a substantial reduction in load demand as a result of the total demand-side management program identified in the short-term action plan. In total, these are projected to save 650 megawatts of capacity by the year 2002 and up to 2,200 megawatts by 2010.

669

Comment: *I have problems with rewarding the building industry for including energy-efficient options. They seldom do this in a smart manner. Rather, we should educate the end user who will want homes which are more energy-efficient and then builders will build them.*

Comment by: Dolores Howard

Response: As stated in Energy Vision 2020, TVA's residential energy-efficiency options would emphasize the responsibility of the dealer/contractor to provide a quality energy-efficient technology installation. (See Volume 1, Chapter 7.) The Quality Contractor Network provides training for dealers, execution of post-inspection checklists, and awards for maintaining high installation standards. Standards will be established for all program installations to ensure the satisfaction of the consumer and the efficient operation of the system. Inspections during the building process will ensure adherence to program standards. The Self-Audit program included in the Energy Vision 2020 short-term action plan includes educational information to help end-use customers make better decisions regarding energy use.

670

Comment: *A building envelope technology that is making significant penetration in our experience is to replace huge old banks of single pane windows with state of the art "Low E" and insulated glass and "Window Wall" technologies. You might want to expand the table to include this measure category.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: TVA analyzed replacement of standard efficiency windows with high efficiency windows for new buildings. While it was a cost-effective option in new construction, window film used in commercial buildings captures much of the energy and demand savings at a much lower cost. TVA recognizes that many applications of efficient technologies may be cost-effective on a site-specific basis. The Commercial and Industrial Energy Services option will include a process for analyzing these.

671

Comment: *TVA should provide flexible demand-side management options for non-participants.*

Comment by: Sharon Fidler (League of Women Voters)

Response: The customer service options included in the Energy Vision 2020 short-term action plan provide a low-cost resource to meet the demand for electricity, enhance customer value, and have minimal impact on rates. (See Volume 1, Chapter 10, Figure 10-1.) By minimizing the impact on rates, TVA reduces the impact of customer service options on non-participants. In addition, many of the options included in the short-term action plan focus on market transformation. Market transformation efforts make energy-efficient technologies more available in the marketplace for both program participants and non-participants.

672

Comment: *Some kind of tax credits or energy credits should be given to industries and homes and businesses to implement conservation and efficiency programs. I think that would create jobs through weatherization of every structure in the Valley, and it would save electricity.*

Comment by: John Johnson (Earth First)

Response: Energy Vision 2020 includes numerous energy efficiency programs to encourage the adoption of conservation measures. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) The creation of jobs was considered for all final strategies. The analysis included jobs created by both demand-side management programs and supply-side technologies.

673

Comment: *TVA has chosen an unbundled approach to program option development whereby it develops individual program components and screens them independently. This unbundled approach has advantages in that it allows cost-effectiveness testing and ranking of each component and prevents justifying poor options by combining them with other very cost-effective ones. It also has some potential disadvantages, however. It prevents development of comprehensive programs that build on a single point of contact with the customer to capture potential lost opportunities and maximize measure penetration. It also limits capturing synergies between programs. For example, audit programs can be combined with direct installation, rebate, or finance programs so that the audit effectively becomes a marketing and delivery mechanism, rather than a program in itself.*

Comment by: Tennessee Valley Public Power Association

Response: Options were developed for planning purposes. In the analysis of customer service options, TVA noted that while some technologies may be promoted using similar delivery strategies, there may be significant differences in the costs and impacts of those technologies. In most cases, the cost-effectiveness of the customer service options considered in Energy Vision 2020 was driven by the technology costs and impacts. Decisions to aggregate or disaggregate technologies within options were made to improve the overall cost-effectiveness of the options.

In implementation, several options or technologies would be integrated under a single umbrella program, similar to the current Residential Energy Efficiency Program offered by TVA. The Residential Energy Efficiency Program includes a heat pump pro-

gram, new homes program, and a manufactured housing program under one umbrella for the reasons suggested in this comment. When a customer is installing a new heat pump, TVA requires a home to meet certain weatherization standards to ensure optimal equipment selection and performance. This example illustrates the approach that allows TVA to capture lost opportunities and to realize synergies within and between programs. Administrative costs for options were developed considering more comprehensive program implementation. Care was taken not to overload options with high administrative costs, and to reflect potential scale efficiencies in the option cost estimates.

674

Comment: *We agree that further refinement of the first two blocks of demand-side management, which include effective load management and generally accepted low-cost conservation, is needed. This effort should be accomplished in concert with the Tennessee Valley Public Power Association's Energy Services Committee, since success of these programs will depend on distributor acceptance and implementation.*

Comment by: Tennessee Valley Public Power Association

Response: TVA has included in the short-term action plan several options from Blocks 1 and 2 of the customer service options. (See Volume 1, Chapter 10, Figure 10-1.) Some of the options will be implemented full-scale and several of the options will be implemented as flexible demand-side management options. These flexible demand-side management programs provide an opportunity to build the capabilities to deliver large scale demand-side programs. These further afford TVA the opportunity to test alternative delivery strategies to better assess the market potential associated with each. Flexible programs also provide an opportunity to work with the distributors of TVA power to develop partnerships and resolve implementation issues.

For all programs in the Energy Vision 2020 short-term action plan, TVA will develop implementation plans in partnership with distributors to assure greater acceptance. In those implementation plans, several issues will be addressed. Those issues include TVA and distributor roles in delivering customer service options, impacts of the options on distributors' costs and revenues, and possible incentives to encourage and reward distributor participation in options.

675

Comment: *Program customer participation, measure penetration, and free ridership estimates were developed based on the experience of other utilities. In general, these estimates seem low, and the rationale and assumptions used in developing them should be further explored. It is possible that they are based on results from many older programs that had not benefited from the significant lessons learned over the past decade of demand-side management implementation throughout North America, and do not reflect the current state-of-the-art in demand-side management implementation potential.*

Comment by: Tennessee Valley Public Power Association

Response: In developing customer service options, TVA benchmarked against the best programs offered nationally and previous programs offered in the Valley. TVA looked at both prospective participation estimates and participation levels measured from actual program experience. TVA considered the best features of the best programs and estimated the potential penetration combining those program attributes. In addition, TVA

assessed the effectiveness of each delivery mechanism in overcoming the market barriers that exist and prevent adoption of energy efficient technologies.

Considering this, the participation rate and measure penetration rate estimates included in the plan provide a fair basis for assessing the potential impacts of the customer service options. As programs are implemented, TVA will monitor and evaluate several program aspects, including participation rates and measure penetration rates. As better information becomes available, planning estimates will be updated and refined to reflect actual program experience.

676

Comment: *We disagree with the commercial and industrial customer service program market penetration estimates in the plan. For example, we believe that more than 15 percent of the facility owners in the Valley will be interested in insulating the roofs of their buildings.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: There is considerable uncertainty associated with the market penetration of specific demand-side technologies. The penetration estimate of individual energy-efficiency options was based on several factors. Those factors included: option cost-effectiveness, the potential net benefits of an option, the persistence of energy savings over time, technical feasibility; and the current penetration of standard and efficient technologies. The penetration of roof insulation for commercial and industrial customers was limited by the current penetration of roof insulation and technical feasibility. The expected market penetration potential for roof insulation was addressed in two options: the Heating, Ventilation, and Air Conditioning Technology Rebate option and the Measure Financing option. TVA's penetration estimates for these programs range from 15 to 30 percent of the target market, depending on which options are selected.

677

Comment: *The 60 percent specialized chiller and cooling tower penetration figures in your table are for a much more limited population than the rest of the figures and should be clearly footnoted as such. Incidentally, you might want to add large schools to this footnote along with offices and hospitals.*

With cooling towers, we have found that the simple replacement of the 20 year old one with the latest (quite often with a downsizing because the original one was oversized) results in a significant savings in energy usage. We wonder if you might want to include replacement of the cooling tower in this measure category.

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: This is noted at the bottom of the table in Volume 2, Technical Document 7, page T7.44.

TVA recognizes that many unique efficiency opportunities will be cost-effective based on a customer's facility and specific operating characteristics. The Commercial and Industrial Energy Services option will include a process for assessing these.

678

Comment: *In Volume 2, Technical Document 7, page 7.42, we feel that the heading "Annual Eligible Population" on the middle table should be footnoted to show that it is in thousands of square feet and is approximately one-tenth of the total square footage of*

commercial and industrial buildings in the TVA area (approximately the annual percentage confronting replacement of lighting systems each years).

Also, we feel that your percentage assumptions for the "Free Driver Rate" (which we now understand to mean the percentage of those who will implement these technologies but for various reasons (like adversity to bureaucracy and paperwork) choose to avoid participation in the TVA programs) which is showing 0 percent is probably too low. We would like to suggest at least 10 percent and that any lower value would tend to underestimate penetration of these lighting technologies into the marketplace. Similarly for the "Free Rider Rate" which is reflective of the present situation with no TVA programs, the future of 15 percent is too low. We might suggest 25 percent.

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: On page T7.4 of Volume 2, Technical Document 7, the section, Option Descriptions, provides a guide to interpreting the data presented for each of the customer service options.

Both the free driver rate and the free rider rates are based in part on the current penetration of energy efficient technologies in the marketplace. Despite the fact that energy efficient lighting technologies are very cost-effective, they have a very low penetration currently. As programs are implemented, TVA will monitor and evaluate several program aspects, including free driver rates and free rider rates. As better information becomes available, planning estimates will be updated and refined to reflect actual program experience.

679

Comment: *Under LED exit signs and electroluminescent exit signs the market penetration is probably overstated, while the one for fluorescent exit signs is probably understated. Electroluminescent signs are very expensive and the economics on them very poor and LED retrofit kits supply so little light that they can only be used in the thinnest signs. Our experience would indicate values of 20 percent, 5 percent, and 50 percent, respectively.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: The estimate of penetration for each measure was based on the measure's cost-effectiveness, technical feasibility, the persistence of energy savings over time, and the current penetration of the base and efficient technologies. Significant technological advancements have been made with LEDs allowing simple retrofits of existing exit signs. Because of the longer life of LEDs, you get both greater energy savings initially and greater persistence of energy savings over time. The persistence of energy savings from electroluminescent exit signs is even greater than that for LEDs.

As programs are implemented, TVA will monitor and evaluate several program aspects, including measure penetration rates. As better information becomes available, planning estimates will be updated and refined to reflect actual program experience.

680

Comment: *In Volume 2, Technical Document 7, page T7.43 we feel that your "Measure Penetration" value for T-8/electronic ballasts is too high because the figure for reflectors/delamp/electronic ballasts is too low. Our experience is that the two numbers for penetration should be more like 50 percent and 50 percent.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: The estimate of penetration for each measure was based on the measure's cost-effectiveness, technical feasibility, the persistence of energy savings over time, and the current penetration of the base and efficient technologies. While reflectors result in additional energy savings, they have a significantly higher first cost than the T-8/electronic ballasts. In addition, reflectors require a higher level of maintenance. Without proper maintenance, lighting levels deteriorate and energy savings do not persist.

As programs are implemented, we will monitor and evaluate several program aspects, including measure penetration rates. As better information becomes available, planning estimates will be updated and refined to reflect actual program experience.

681

Comment: *We feel that with the new roofing technologies like spray insulation foam roofing, the penetration value for addition of insulation in the roof shown at 15 percent low and should be more like 50 percent.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: The estimate of penetration for each measure was based on the measure's cost-effectiveness, technical feasibility, the persistence of energy savings over time, and the current penetration of the base and efficient technologies.

As programs are implemented, TVA will monitor and evaluate several program aspects, including measure penetration rates. As better information becomes available, planning estimates will be updated and refined to reflect actual program experience. TVA recognizes that many efficiency opportunities will be identified based on the characteristics of a customer's facility and operations, and through development of new technologies and processes. The Commercial and Industrial Energy Services option will include a process for assessing these opportunities.

682

Comment: *To make the document clearer, we feel that you should include building envelopes in HVAC/Building Envelope section's heading in Volume 2, Technical Document 7, page 7.44. Building envelope measures should be a significant percentage of this category.*

Comment by: Wilson Prichett (Tennessee Valley Energy Management Association)

Response: Savings from building envelope measures account for a significant portion of the savings from this option. Program names were selected to suggest the types of measures and incentives that might be available and may not include all possibilities. While heating, ventilation, and air conditioning (HVAC) is usually used to refer to equipment measures it is also suggestive of possible building envelope measures as well. We will change the name of the option in the Technical Document for clarity.

Low Income Programs

683

Comment: *Industrial customers have the capital to make demand-side management investments, but many of us, especially low income customers, do not.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: To assist residential customers, many of the demand-side management programs would offer financing. The Low Income program included in both the long-term and short-term plans of Energy Vision 2020 installs certain weatherization, as well as other practical measures, free of charge for low income customers. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

684

Comment: *TVA's Low Income Weatherization program cannot and should not be a band-aid resulting from the additions of fluorescent lighting and low-flow shower heads.*

Comment by: Martha McGill

Response: TVA is working with community action agencies to implement the Residential Low Income program, which is included in both the long-term and short-term plans of Energy Vision 2020. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) The program provides for quickly surveying a low income residence, installing cost-effective weatherization measures, and providing education about saving energy. Included in the program are compact fluorescent lights, low flow showerheads, as well as pipe insulation, water heater tank wraps, heating, ventilation, and air conditioning maintenance, and attic insulation where cost-effective.

685

Comment: *It seems that now there are local utilities and agencies providing separate weatherization and audit programs. If these were done by one entity the monetary savings could be used to fund low income programs.*

Comment by: Richard Bond, Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA plans to work with the community action agencies and other state and local agencies to leverage existing low income efforts and funding. Working together, we can provide the best service possible to low income customers.

686

Comment: *How will TVA identify who qualifies for its low income consumer program? What income guidelines would be used? Are renters eligible or just homeowners? What measures are included, if any, to urge landlords, both private and Section 8, to implement and utilize energy saving measures?*

Comment by: Naomi Furman Kipp (Legal Services Corporation of Alabama)

Response: TVA is working with community action agencies to develop the detailed implementation plan for the Residential Low Income program which is included in the long-term plan and the short-term action plan of Energy Vision 2020. (See Volume 1, Chapter 9, Figures 9-23 and Chapter 10, Figure 10-1.) As designed, the program would include

renters and homeowners, and target 16 percent of Valley residences as low income. Details concerning eligible customers and renter/landlord interaction will be developed and finalized as part of the detailed implementation plan.

687

Comment: *Do not encourage heat pumps rather than weatherization for low income persons who cannot afford heat pumps.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition)

Response: TVA does not encourage the installation of heat pumps in low income applications when the energy savings would be insufficient to allow the customer to make the payments for a heat pump. The Low Income Weatherization program proposed in Energy Vision 2020 does not provide for the installation of heat pumps. The Low Income program included in both the short-term action plan and the long-term plan provides for simple, cost-effective measures for both the customer and for the power system. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

688

Comment: *A possible answer to the dilemma of providing services to low income customers during deregulation is what is known as a "systems benefit charge." There are various ways to handle this charge under the devise of many names, but whatever the form, it must be both nonbypassable and competitively neutral. So, placing a charge on the use of the distribution system (with distribution defined broadly to include both high and low voltage end-use consumers) answers both concerns. This approach to paying for system benefits is also how utilities' allowable stranded costs should be recovered. In essence, system benefits charges can be implemented relatively quickly and easily. Implementation preserves benefits while giving regulators time to assess what services are effectively produced in a competitive electric market. Removing the risk that restructuring places on these benefits will allow all stakeholders to engage in a more productive dialogue.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: As the electric utility industry is restructured from a regulated monopoly to a more competitive industry, the benefits provided by utility services to low income customers are not likely to be provided by utilities in the future. These services, if continued, will more likely be provided in the same manner as other government-supplied benefits. Even though TVA is entering a more competitive market, TVA has included a flexible demand-side management program in Energy Vision 2020 to assist low income consumers. In addition, many of the concerns expressed regarding low income customers are being addressed by various power distributor programs already in place such as "warm neighbor" programs and work with community action groups.

689

Comment: *If restructuring shifts responsibility for paying costs onto captive customers, the revenues needed should be collected only with state legislative approval.*
In their deliberations over the restructuring of the electric industry, state and federal regulators are urged to adopt the following policies, at a minimum, necessary to protect residential customers on fixed and low incomes:

1. *Affordable Access*
   Any alternative structure must include all of the following:
   A. *Maintain the obligation of utilities and/or other providers to serve as the provider of last resort for vulnerable customers, such as fixed and low income consumers;*
   B. *Enable fixed and low income customers to obtain electricity essential to health and safety;*
   C. *Require utilities and/or other providers to provide affordable service to low or fixed income customers;*
   D. *Provide comprehensive energy conservation and efficiency grant programs. These must improve the efficiency of energy services for fixed and low income customers, address indoor air quality, and make optimum use of the existing network of low income weatherization providers;*
   E. *Provide affordable deposit and deferred payment policies; and*
   F. *Prevent mandatory use of service limits, prepayment cards, or other forms of degraded service.*
2. *Fair Billing and Collection Procedures*
   Any alternative industry structure must ensure freedom from abusive and unfair collection procedures and from unfair disconnect practices. It must:
   A. *Provide adequate notice of proposed termination of service;*
   B. *Provide reasonable payment arrangement options for current and deferred bills;*
   C. *Provide access to customer service representatives who are knowledgeable in the areas of customer assistance, bill assistance, different rate and weatherization programs, energy education, and payment options;*
   D. *Prohibit disconnections that threaten the health and safety of vulnerable customers;*
   E. *Maintain the right to appeal an unfair utility action to an impartial regulator.*
3. *Participation In Setting Public Policy*
   Low and fixed income customers must be able to participate in collaborative or any other form of decision-making relative to electric industry restructuring issues, with funding for full participation.
4. *Environmental Justice*
   Historically, low income and minority communities have been disproportionately harmed by local generation and transmission siting. Any alternative industry structure must avoid adverse environmental and safety impacts on low income and minority communities.
5. *Long-Term Perspective*
   Any alternative industry structure must provide a balanced portfolio of energy resources that are affordable, sustainable, reliable, environmentally and socially responsible, and economically efficient. Such an alternative industry structure must prevent environmental degradation and minimize employment. Long-term goals must not be sacrificed for a short-term perspective which may reduce rates for some customers while increasing bills for fixed and low income customers and exposing them to unacceptable environmental risks.
6. *Fair Allocations of Costs and Benefits*
   A. *The costs resulting from past decisions in the electric industry, especially those that built load and industrial customers' demand, must not be borne by the low-income customer.*
      - *Stranded investments must be borne by providers, industrials, and investors through non-by passable charges.*

- *Stranded costs must be borne by utilities now through rate reductions for all customers without waiting for final resolution of the restructuring issue.*

B. *All customers, including fixed and low income customers, must share in the benefits of a restructured electric industry. Restructuring must not go forward unless bills go down for everyone.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Many of the concerns expressed regarding low income customers are being addressed by various power distributor programs already in place such as "warm neighbor" programs and work with community action groups. The Energy Vision 2020 short-term action plan and the long-term plan also include a low income program to help these consumers conserve energy. (See Volume 1, Chapter 10, Figure 10-1.) The long-term portfolio of options would provide a balance of resources that are affordable, sustainable, reliable, environmentally and socially responsible, and economically efficient. (See Volume 1, Chapter 9, Figure 9-23.) The multi-attribute trade-off method used in the planning process allowed TVA and the public, including the Energy Vision 2020 Review Group, to analyze the trade-offs associated with these objectives and to make informed decisions. The resulting long-term portfolio developed in this process should provide TVA with the knowledge and flexibility to meet the challenges of a changing world and the concerns expressed in this series of resolutions.

690

Comment: *TVA should encourage its distributors to be more conscious of low income issues and promote permanent solutions such as bill averaging and rate discounts.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition), Naomi Furman Kipp (Legal Services Corporation of Alabama)

Response: TVA encourages the distributors of TVA power to be conscious of low income issues and concerns. Currently, many distributors offer "bill averaging" programs and "warm neighbor" programs to assist their low income customers.

691

Comment: *Utility bills should allow individuals to donate money to help fund low income electric bills. This should be TVA-wide and publicized.*

Comment by: Richard Bond

Response: Currently, many distributors of TVA power offer "warm neighbor" programs to assist low income customers with their energy payments. TVA encourages distributors to be conscious of low income issues and concerns. There are also several organizations that would be happy to receive donations from Valley residents to assist low income families.

692

Comment: *TVA should work with its distributors to identify unclaimed customer refunds and overcollections and target these monies toward something like low income weatherization programs. This would not affect rates and has been done in Michigan by the Edison Company.*

Comment by: Geoffrey Crandall (MSB Energy Associates)

Response: Using unclaimed monies for a designated purpose such as weatherization is an interesting idea. The use of unclaimed monies is generally regulated by individual state laws. This idea has been communicated to the distributors of TVA power for their consideration.

693

Comment: *TVA is doing a poor job of protecting the low income residential customer. There was not a low income representative on the Energy Vision 2020 Review Group. TVA should have some low income programs. The low income programs should have free lighting and home insulation for the low income, elderly, and disabled.*

Comment by: Debra Jackson, Elaine Stancil, Peggy Snow, Betty Vincent, Carolyn Novkov, Linda Cataldo Modica, Michelle Neal (Tennessee Valley Energy Reform Coalition), Stephen Smith (Tennessee Valley Energy Reform Coalition), Dennis Henke, Susan Bailey

Response: A low income customer option has been included in the Energy Vision 2020 short-term action plan and long-term plan. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.) Under this program, site visits would be made, and energy-efficient lighting, attic insulation, water heater wraps, pipe insulation, faucet aerators, low-flow shower heads, and caulking would be installed. There would be no cost to recipients. TVA has already initiated discussions with state and local community action agencies to prepare for implementation of the Low Income program. TVA will work in cooperation with the community action agencies and other state and local agencies to identify the needs of this customer group and to deliver the program cost-effectively. In any future stakeholder groups, TVA would certainly consider a low income representative.

Load Management

694

Comment: *Bristol Tennessee Electric System working with TVA already has 6,000 water heaters that can be cut off if there is a shortage. That is an example of an opportunity for saving energy, lessening the need to build new plants.*

Comment by: Michael Browder (Bristol Tennessee Electric System)

Response: Bristol has a very good water heater program. Bristol and other TVA power distributors currently participate in the direct load control of residential water heaters. Residential water heater load management is included in the long-term plan and the short-term action plan.

695

Comment: *Electric water heaters should have switches for cycling.*

Comment by: Retha Ferrell

Response: TVA presently has a radio control system that cycles water heater load to reduce power demand during hours of peak electrical usage. Energy Vision 2020 proposes to

expand participation in the program which is targeted to residential customers with electric water heaters in participating power distributor areas.

696

Comment: *TVA should work more with distributors to reduce peak use and reduce resistance through the wires. Everything should not be controlled from a central location.*

Comment by: Debra Jackson, Nancy Bell

Response: TVA is examining this issue by partnering with power distributors to study distributed generation and storage options to reduce peak system load and losses and increase peak system reliability. Distributed generation and storage consist of power generation facilities located close to energy users. These are normally small-size units (less than 50 megawatts) and may include both generation and energy storage technologies. TVA and distributors are also incorporating direct load control of water heaters and air conditioners to reduce peak demand. This program is recommended to be continued and expanded in Energy Vision 2020.

697

Comment: *As a conservation measure, TVA should establish a plan for 15-minute rotating blackouts for all customers.*

Comment by: John Sharp, Jr.

Response: TVA currently has over 1,700 megawatts of curtailable load through Limited Interruptible Power and Economy Surplus Power rates. TVA's interruptible load was critical this summer in allowing TVA to balance demand for electric power with the available supply during the recent period of high temperatures. TVA plans to pursue additional load management capability in the Energy Vision 2020 short-term action plan through increased residential direct load control, promotion of commercial thermal storage technologies, and a commercial group load curtailment strategy. Instituting 15-minute rotating blackouts for all customers is not considered an appropriate conservation measure. Such blackouts would be disruptive to the economy and critical services.

Rates/Pricing

698

Comment: *TVA's interruptible power rates are effective demand-side management because they offer lower rates to industries, allowing power to be interrupted when system peak approaches system capabilities. As a result, homes, hospitals, and other users could operate air conditioners and cooling systems without fear of power shutdown.*

Comment by: Tennessee Valley Industrial Committee

Response: We agree. TVA has been able to reduce its system power requirements by an estimated 1,780 megawatts by industrial customers' response to interruption notices. This allowed TVA to continue to provide other consumers with firm power supply.

699

Comment: *Interruptible rates and peaking out represent poor utility planning. More energy efficiency and demand-side management would avoid this.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA disagrees. These interruptible rates provide a cost-effective strategy for balancing demand for electric power with the available supply during extreme system peaks. Interruptible rates are an important demand-side management option that helps to avoid the need to construct new generating facilities that would be used only a few hours each year. TVA currently has over 1,700 megawatts of curtailable load through Limited Interruptible Power and Economy Surplus Power rates. The TVA power system is planned to provide a reliable source of power without interruption to customers unless otherwise specified in their contracts.

700

Comment: *TVA should use creative rate designs to modify demand. Why did TVA not evaluate changing its wholesale rates and retail rate structure to provide incentives that would be cost-competitive with other resource alternatives?*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Henry Nickell (Memphis Light, Gas and Water Division), Sharon Fidler (League of Women Voters)

Response: TVA has developed a series of wholesale and retail time-of-day rate options which are designed to shift consumption to off-peak hours when the cost of generating electricity is lower than on peak. Declining block rates were also considered in Energy Vision 2020. A declining block rate charges less for electricity when usage exceeds a certain amount. These rates reflect the lower cost of supplying additional power to existing customers and can be used to encourage new beneficial uses of electricity. (See Volume 1, Chapter 8.)

701

Comment: *While not explicitly addressed in TVA's demand-side management plan, an integral and important issue is the incentives or disincentives for implementing demand-side management faced by TVA's wholesale distributors. TVA recognizes the inherent disincentive for demand-side management created by its wholesale rate structure. Because distributors generally receive a mark-up on each kilowatt-hour sold, energy efficiency, load management, and self-generation all have potential negative impacts on wholesale distributors' balance sheets, and rates, resulting from lost revenue.*

TVA has expressed a willingness to consider proposals for removing the disincentive, and possibly creating incentives, for distributors to pursue demand-side management. This should be investigated as part of the Energy Vision 2020 review process. Approaches could include recovery of all direct expenses for program implementation as well as reimbursement of lost revenue. Another possibility distributors could investigate is shifting the margin they recover on rates to base-load sales, with the result of decoupling net revenues from short-term sales. If the distributors' financial disincentives to demand-side management can be overcome, the significant customer service benefits of demand-side management should provide distributors with a significant incentive to aggressively pursue a demand-side management plan.

Comment by: Tennessee Valley Public Power Association

Response: TVA has included several customer service options in its short-term action plan. (See Volume 1, Chapter 1, Figure 10-1.) These options are designed to improve energy efficiency, help customers manage their demand, and to promote beneficial new uses of electricity. The variety of options allows distributors to choose those options that help them meet their individual load shape objectives.

TVA will develop implementation plans in partnership with distributors for each of the customer service options included in the short-term action plan. In those implementation plans, several issues will be further addressed. Those issues include TVA and distributor roles in delivering customer service options, impacts of the options on distributors' costs and revenues, and possible incentives to encourage and reward distributor participation in programs. TVA will work with the Tennessee Valley Public Power Association committees and with individual distributors. This process has already begun.

702

Comment: *What incentives do distributors have to participate in demand-side management programs given TVA's current end-use billing rate structure?*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: TVA will develop implementation plans in partnership with distributors for the customer service options in the short-term action plan. Those implementation plans will further address several issues. Those issues include: TVA and distributor roles in delivering energy services, the impacts of customer service options on distributor costs and revenue, and possible incentives to encourage and reward distributor participation.

703

Comment: *Discussion of TVA pricing practices is much too sketchy. The links between prices and the resource plan are not specified. I suspect that TVA's pricing is not consistent with its costs. Changing pricing policy would allow TVA to consider acquiring more demand-side management than the anemic amount suggested—equivalent to only 4.7 percent of peak demand and 2.5 percent of annual sales in 2010. Many United States utilities have already exceeded those levels of demand-side management performance. Setting energy prices close to short-term marginal costs would eliminate much of the lost-revenue effect of demand-side management and thereby greatly reduce demand-side management's upward pressure on rates.*

Comment by: Sharon Fidler (League of Women Voters), Eric Hirst (Oak Ridge National Laboratory)

Response: As with many electric systems today, TVA's average costs are higher than either short-run or long-run marginal costs. In the current environment, demand-side management activity may cause revenue erosion. However, the marginal cost of new capacity is so low that basing prices on marginal cost could encourage additional consumption. Following Energy Vision 2020, TVA will conduct a cost-of-service study. There are many more considerations in setting prices than just the impact of demand-side management. TVA will monitor and change its resource plans as pricing policies change.

Block 1 of the customer service options is approximately 4.7 percent of the peak demand and 2.5 percent of the annual energy sales in the year 2010. While TVA has prioritized the options in Block 1 because of their low cost and low impact on rates, TVA has also included options from Blocks 2 and 3 in its short-term action plan. Options from Blocks 2 and 3 were included in the short-term action plan to address lost opportunities

and to promote market transformation and equity among customers. By including many of the options in Blocks 2 and 3, TVA also builds the capabilities to deliver large-scale demand-side management programs based on future resource needs and costs.

The short-term action plan recommends 650 megawatts of demand-side management by the year 2002 and up to 2,200 megawatts of demand-side management by 2010.

704

Comment: *TVA is proposing a declining block rate. This encourages customers to use more which is anti-conservation and an out-of-date approach. We question the legality of such a rate structure that is biased toward large customers and which discriminates against low income and residential customers. All mention of this should be removed from the plan.*

Comment by: Geoffrey Crandall (MSB Energy Associates)

Response: TVA considered a declining block rate in Energy Vision 2020 but did not include it in either the long-term plan or the short-term action plan. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

705

Comment: *Rates should increase with the amount of electricity you use. Those using the lowest amount of electricity should have the lowest rates.*

Comment by: Arthur Webb, Retha Ferrell

Response: The majority of distributors bill residential consumers on flat rates, where all electricity is billed at the same price. A few distributors apply inverted rates that price increased usage at a higher rate. Although consumers may respond to higher prices by using less electricity, this may not be an efficient response, since the higher price could discourage the use of highly energy-efficient appliances like heat pumps.

706

Comment: *An experiment conducted by psychologists at Princeton found that meters in the home reduced electric consumption by 19 percent, which is approximately the nuclear contribution now.*

Having variable rates for low-demand times of the day and week would level out the use of electricity, which would reduce the needed generation capacity of peaks.

Comment by: Fred Wright

Response: An effort was made without success to locate documentation of the Princeton experiment to assist in preparing a response to this comment. It appears from the comment, however, that an experiment at Princeton apparently involved placing “smart meters” in residences. These meters are typically used in conjunction with time-of-use rates and notify the customer which rate period is in effect.

TVA has considered the use of wholesale and retail time-of-use rates in Energy Vision 2020. (See Volume 1, Chapter 7.) Such rates are designed to shift consumption to off-peak hours when the cost of generating electricity is lower than peak times of consumption. To be effective in shifting demand from peak periods to off-peak periods, there must be a significant differential between peak and off-peak rates. TVA’s mix of generating resources results in a lower operating cost difference (and thus a lower rate difference) between peak and off-peak periods than many other utilities experience.

Therefore, TVA's potential for shifting demand for electricity with time-of-use rates is less than for other utilities.

TVA is also working with a distributor to develop a real-time pricing experiment, using state-of-the-art systems.

707

Comment: *There should be a program where people are willing to pay more for energy provided by renewables, environmental options, and energy conservation such as Sacramento Municipal Utility District's photovoltaic program. TVA should provide a green rate.*

Comment by: Claire Cronin, Nancy Bell, Michelle Neal (Tennessee Valley Energy Reform Coalition), Will Kidd (Sunsource Unlimited, Inc.), Edward Smeloff (Sacramento Municipal Utility District), Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: For residential customers, this program concept holds potential if program participation levels are high enough to offset the program's administrative costs. TVA plans to monitor the participation rate for such programs offered by the Sacramento Municipal Utility District and other utilities and further evaluate the option for the Tennessee Valley.

708

Comment: *Some people are willing to pay more for reliability, while others would pay more for greater environmental protection.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA currently has rates in which the price of power is differentiated by degree of interruptability or reliability. TVA intends to monitor and further evaluate the development of rate options where people are paying more for environmentally friendly resource options (green rate programs).

Renewables

709

Comment: *Consider Southern California Edison's Solar Neighborhood Program (photovoltaics).*

Comment by: Kathryn McCoy (Tennessee Energy Education Network), Don Scharf (Sierra Club, Middle Tennessee Group)

Response: We have considered several renewable options in Energy Vision 2020, and have included further research into photovoltaics in the short-term action plan. (See Volume 1, Chapter 10, Figure 10-1.) TVA will monitor the technological development and commercialization of photovoltaics in other areas of the country.

710

Comment: *What are the energy savings of solar water heating and sun rooms?*

Comment by: Philip & Winfred Thomforde

Response: TVA analyzed several options to encourage use of alternative energy sources including solar water heaters and sun rooms. For residential customers, TVA analyzed a solar water heating option where TVA would pay customers a rebate to install solar-assisted water heating equipment. Based on experience within the TVA region and elsewhere, a solar water heater would save 2,500 kilowatt-hours per year. The estimated energy savings for sun rooms would be 1,600 kilowatt-hours per year. Without a back-up heat source, a sunspace could save between 2 and 3 kilowatts per home. However, solar resources are not available at all times, especially in the winter, and a back-up heat source would be needed.

Solar water heaters are analyzed in Volume 2, Technical Document 7. The initial analysis of sun rooms indicated that they were not cost-effective; therefore they were eliminated from detailed analysis.

711

Comment: *Analyze the deployment of solar systems on the roofs of existing residential and commercial buildings. If only half the Valley residents were used, 6,500 megawatts could be produced. Considered Southern California Edison's Solar Neighborhood Program (photovoltaics).*

Comment by: Don Scharf (Sierra Club, Middle Tennessee Group), Kathryn McCoy (Tennessee Energy Education Network), Al Fritsch (Appalachia–Science in the Public Interest)

Response: TVA has considered several renewable options in Energy Vision 2020 and has included further research into photovoltaics in the short-term action plan.

Currently, photovoltaics is not a cost-effective technology for general deployment. Photovoltaics may be an effective technology in the Tennessee Valley when deployed as a distributed resource. TVA has experimented with roof-mounted and integral roof photovoltaic systems, the quality of the connection needed (direct current conversion to alternating current), and the safety issues related to having photovoltaics connected to the system (which cannot easily be turned off). These experiments indicated that roof-mounted photovoltaics were not cost-effective. TVA will continue to evaluate this technology, especially as a solution for remote applications. TVA will monitor the technological development and commercialization of photovoltaics in other areas of the country.

In Energy Vision 2020, TVA analyzed several options where TVA would pay customers a rebate to install solar-assisted water heating equipment. Solar water heaters are analyzed in Volume 2, Technical Document 7.

712

Comment: *TVA should play a role in developing the market for efficient home energy systems off the grid. This is an alternative to adding carbon dioxide from burning coal. That is environmental leadership.*

Comment by: Don Scharf (Sierra Club, Middle Tennessee Group), John Johnson (Earth First)

Response: TVA is partnering with some distributors to study distributed generation, which would include the evaluation of off-grid systems.

713

Comment: *Do not let people with photovoltaics sell their power to the grid.*

Comment by: Kirk Johnson

Response: Photovoltaic systems, if connected to the grid, would have to comply with safety and power quality requirements that would be specified in a contract to purchase the power. These contract specifications would avoid undesirable connections to the system that might reduce the effective operation of the power system.

714

Comment: *Promote clotheslines, a solar technology, instead of dryers.*

Comment by: Ann Lamb

Response: TVA included a Residential Self-Audit program in the Energy Vision 2020 short-term action plan. This program will assist customers by estimating the energy consumption for all major appliances, including dryers. Customers will be able to determine the energy savings available to them from use of clotheslines rather than dryers. Any customer may choose to take advantage of this very low-cost energy saving opportunity.

715

Comment: *TVA should assist in setting up a regional workshop conference on alternative energy in Chattanooga.*

Comment by: Sanford McGee (Cumberland Center for Justice and Peace)

Response: TVA sponsored a conference on energy efficiency in Chattanooga in 1993 and would consider sponsoring another in the future. Education and training are important aspects of the short-term action plan included in Energy Vision 2020.

SUPPLY-SIDE OPTIONS

This section includes comments and responses about:

- the identification and characterization of supply-side options in Energy Vision 2020, including coal-fired, gas-fired, and hydroelectric resource options
- the merits of nuclear generation options
- the Kenetech wind farm project
- the merits of large photovoltaic and wind stations
- the effect of various options on global climate change or the greenhouse effect
- the merits of purchased power options, including the purchase of call options
- smaller-scale distributed generation options

General

716

Comment: *In general, Burns & McDonnell/XENERGY conclude that TVA's treatment of its available power supply options was very thorough. The breadth of alternatives considered by TVA in Energy Vision 2020 was probably larger than that of most, if not all, integrated resource plans developed to date by electric utilities. For available power supply options, TVA has considered emerging technologies, mature technologies, central-station generation, distributed generation, renewable resources, independent power producers, and others. It appears TVA has not omitted from consideration any significant supply-side options.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

717

Comment: *In general, the supply-side options considered in the strategies by TVA were diverse and included many existing and developing technologies.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

718

Comment: *TVA has included a thorough mix of both traditional and non-traditional supply-side alternatives in Energy Vision 2020. By evaluating non-traditional alternatives, TVA must contend with technologies in different stages of commercial development. For Energy Vision 2020, TVA stipulated that a new technology option must be sufficiently well developed that credible estimates are available for the date of commercial availability, cost, and performance of the option.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

719

Comment: *TVA did not screen the options to a smaller number. The main reason given for this was that TVA used different measurement methods to evaluate the performance of each supply-side option under different criteria. Because the "best" plan changed based on the measurement and criteria used to rank the supply-side options, TVA did not want to eliminate certain options from future consideration. TVA felt it could not eliminate any of the supply-side options under consideration because of the multiple criteria used to rank the options.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

720

Comment: *It will be very difficult to adequately assimilate all of the information that TVA developed in its analysis of options.*

Comment by: Tennessee Valley Public Power Association

Response: Integrated resource planning is complicated and utilizes a large amount of data. Energy Vision 2020 tried to make this as simple and understandable as possible.

721

Comment: *In general, Burns & McDonnell/XENERGY agrees with the approach TVA has taken in developing its resource capital cost and operating cost assumptions. TVA has identified an unusually large number of supply-side alternatives for consideration in Energy Vision 2020. With this large number of alternatives, it would be extremely difficult to develop detailed cost information on each alternative. Accordingly, TVA is relying to a large extent on information contained in the Electric Power Research Institute's Technical Assessment Guide. The Technical Assessment Guide is widely used by electric utility planners for resource information in the absence of a more detailed set of assumptions or cost data.*

Where more detailed information was available, TVA used that information instead of the Technical Assessment Guide information. This is a preferred practice, but care must be taken to ensure that all assumptions are developed on a consistent basis.

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

722

Comment: *It appears TVA has attempted to go beyond the regions specified in the Electric Power Research Institute's Technical Assessment Guide for estimating capital costs. TVA has indicated that, where site-specific capital cost estimates were necessary, a site location at milepost 160 on the Tennessee River was used. For the purposes of evaluating supply-side options in a long-term planning study such as Energy Vision 2020, this capital cost estimating technique is acceptable. However, assuming all new generation (with certain site-specific exceptions such as repowering at Bellefonte Nuclear Plant) is located at milepost 160 does not allow TVA to capture the associated transmission system impacts of actual potential unit sites. Certain portions of the TVA system could benefit more than oth-*

ers from having generation locally sited. Before final decisions are made to proceed with the construction of any new resources, TVA will need to assess site-specific system impacts.

Comment by: Tennessee Valley Public Power Association

Response: We generally agree with this assessment. However, the short-term action plan recommends siting new generating facilities in the western part of the system because of transmission benefits. (See Volume 1, Chapter 10, pages 10.4 to 10.5.)

723

Comment: *There should be units located on the west end of the system to aid in reducing losses and supporting the transmission system. These units should be located as close to load centers as practical.*

Comment by: Tennessee Valley Public Power Association

Response: The short-term action plan recommends that new generating facilities be sited in the western part of the system because of transmission benefits. (See Volume 1, Chapter 10, pages 10.4 to 10.5.)

724

Comment: *One option that TVA should consider is reducing its outage and capital project planning costs by using small, highly efficient firms on an as needed or lump sum basis in lieu of permanent staff or full time contract personnel.*

Comment by: Paul Amon (Amon Consulting)

Response: TVA makes appropriate use of outside contractors when it is more efficient and cost-effective to do so.

Coal

725

Comment: *Clean coal technologies mitigate environmental impacts and improve operational efficiencies. This fuels economic growth and satisfies environmental concerns. The Department of Energy's Clean Coal Technology Program is demonstrating that these technologies can meet current and projected stringent environmental standards. (See DOE "Clean Coal Technology Demonstration Program: Program Update 1994" April 1995, pages 1-10.)*

Comment by: William Bowker (Kentucky Coal Marketing and Export Council), Jan Jones (Tennessee River Valley Association), J. Richard Hommrich (Volunteer Barge & Transport, Inc.)

Response: Clean coal technologies, many of which are being developed in the Department of Energy's Clean Coal Technology Program, have been evaluated in Energy Vision 2020. (See Volume 1, Chapter 7.)

726

Comment: *All potential options for increased use of coal from Valley states should be carefully explored because of the economic importance of coal in this region.*

Comment by: William Bowker (Kentucky Coal Marketing and Export Council)

Response: TVA continuously explores the potential for utilizing economically priced coal mined in the TVA region. This approach has three positive impacts:

1. TVA obtains low-priced fuel for electrical operation.
2. Transportation costs are reduced.
3. Economic development of the TVA region is fostered.

Preference to regional coals is given when prices are equal to coals from other states. However, other coals are purchased when they are less costly on a delivered basis to TVA's plants.

727

Comment: *As a provider of barge service, Volunteer Barge and Transport, Inc. believes that the public is best served by utilizing low-cost water service for delivery of coal to the plants to provide low-cost electricity for the Tennessee Valley economy.*

Comment by: J. Richard Hommrich (Volunteer Barge & Transport, Inc.)

Response: Barge transportation has always been an important element of TVA's coal transportation.

Natural Gas

728

Comment: *Quick-start gas units could provide both generation and transmission benefits.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

Hydroelectric

729

Comment: *While the reduction in the planned hydro unit outage rate due to upgrades should also reduce maintenance costs, it was not clear whether or not sufficient water storage exists to operate the units the additional hours provided by the improved availability.*

Comment by: Tennessee Valley Public Power Association

Response: The hydro modernization program has the following objectives:
1. improve the efficiency of the hydro units,
2. increase their output, and
3. reduce maintenance costs and improve availability.

The improvement in efficiency will result in more energy being extracted from a given amount of streamflow without changing water storage capability. The availability improvements from the modernization program will similarly help in utilization of river resources by reducing the amount of water that needs to be spilled rather than passed through a hydro unit due to unit outage.

730

Comment: *The information available on proposed new hydroelectric plants, the addition of new units to existing plants, and new pumped-storage plants is minimal. The cost estimates are based on preliminary studies conducted 10 to 25 years ago. More definitive and current studies will have to be conducted by TVA before decisions are made on the options.*

Comment by: Tennessee Valley Public Power Association

Response: Much of the cost data for new hydro unit improvements and pumped-storage plants are from studies that are dated. However, for Energy Vision 2020, TVA also compared TVA's estimates to those of the Electric Power Research Institute's Technical Assessment Guide. These estimates were judged to be adequate. However, we are currently in the process of updating TVA's studies. Before these resources are put in place, more detailed studies will be performed to ensure we have an accurate picture of project economics and impacts.

731

Comment: *The environmental and possible flooding problems that could result from adding units at Raccoon Mountain could be difficult to resolve. Considerable additional flow would be released from the units which could flood out the next downstream hydro project under some conditions.*

Comment by: Tennessee Valley Public Power Association

Response: Currently, generation from TVA's Raccoon Mountain Pumped-Storage Project is limited under serious flooding conditions. During a preliminary analysis of the hydraulic impacts of an expansion of Raccoon Mountain Pumped-Storage Project, TVA examined the historical frequency of actual limitations on Raccoon Mountain Pumped-Storage Project generation due to serious flooding conditions. With the current plant capacity, generation would be limited an average of less than 1 percent of the time during a given year. Therefore, TVA concluded that the generation constraints for the proposed expansion due to wet hydrology would probably not be serious and should not preclude further consideration of this project.

Nuclear

732

Comment: *Browns Ferry Nuclear Plant Unit 1 should never restart because the cost of bringing it back to service would not justify the benefits. TVA should begin writing it off.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition), Beth Wallace, Bruce Wood, J. E. Butt, Sharon Force

Response: Energy Vision 2020 recommends that TVA not, by itself, recover Browns Ferry Nuclear Plant Unit 1 as a nuclear unit. Instead, TVA will keep open alternatives that would meet the goals and objectives of Energy Vision 2020 including minimizing rates, increasing flexibility, minimizing costs, and limiting debt.

733

Comment: *Watts Bar Nuclear Plant Unit 2 should be completed as a nuclear unit. Its value as anything else is limited because of the use of common systems and areas.*

Comment by: J. E. Butt

Response: In December 1994, the TVA Board decided that TVA would not, by itself, complete Watts Bar Nuclear Plant Unit 2 as a nuclear unit. Instead, TVA will keep open alternatives that would meet the goals and objectives of Energy Vision 2020 including minimizing rates, increasing flexibility, minimizing costs, and limiting debt. Alternatives include completing Watts Bar Nuclear Plant Unit 2 as a nuclear unit with partners, converting it to another technology, or replacing the capacity. Knowledge gained from the Bellefonte Nuclear Plant conversion study and future information on nuclear performance and costs are among factors that will be carefully considered as alternatives are evaluated, and eventually the most cost-effective long-term use for Watts Bar Nuclear Plant Unit 2 will be determined.

734

Comment: *I propose that TVA negotiate with the Department of Energy to burn excess weapons material and produce tritium using Watts Bar Nuclear Plant units.*

Therefore, my recommendation is to complete Watts Bar Nuclear Plant Unit 2 equivalent to Watts Bar Nuclear Plant Unit 1 so it can burn mixed oxide fuel. The Watts Bar Nuclear Plant has trained staff to operate Unit 2 with minimal additional support.

Also, TVA should work with the Department of Energy to consider finishing the Bellefonte Nuclear Plant units. If completed, TVA would have a substantial amount of nuclear generation after 2020 to approximately 2040. A greater vision!

Comment by: Whiting Delk

Response: In December 1994, TVA decided it would not, by itself, complete Bellefonte Nuclear Plant Units 1 and 2 and Watts Bar Unit 2, as nuclear units.

TVA is keeping open alternatives for the uncompleted nuclear units that would meet the goals and objectives of Energy Vision 2020 including minimizing rates, increasing flexibility, minimizing costs, and limiting debt. Alternatives include converting them to another technology or replacing the capacity. TVA will continue to be receptive should outside entities propose an acceptable financial arrangement to complete these units as nuclear facilities.

735

Comment: *I object to TVA's proposed use of diluted weapons-grade material in powering nuclear plants. Please remove this from Energy Vision 2020.*

Comment by: Myles Jakubowski (Sunbeam Household Products)

Response: As explained in the section on Uranium Procurement in Volume 2, Technical Document 1, page T1.117 a substantial reduction in the quantity of nuclear warheads in the world is expected. Highly enriched uranium from nuclear warheads will be diluted to low enriched levels, allowing it to be used in commercial nuclear plants.

736

Comment: *Corrosion of steam generator tubes has been the single biggest problem affecting Westinghouse pressure water reactors. TVA is assuming that steam generators will have to be replaced at all four of its Westinghouse pressure water reactors (Sequoyah Nuclear Plant Units 1 and 2 and Watts Bar Nuclear Plant Units 1 and 2), and it allowed for this in the Energy Vision 2020. These assumptions are reasonable.*

Comment by: Tennessee Valley Public Power Association

Response: Corrosion of steam generator tubes has been the single biggest problem affecting Westinghouse pressurized water reactors. Steam generator replacement was included in Energy Vision 2020 and will continue to be evaluated for cost-effectiveness.

737

Comment: *During the 1970s and 1980s, industry-wide operating and maintenance costs rose much more quickly than inflation. These increases were driven almost entirely by the responses to continually changing Nuclear Regulatory Commission requirements.*
Over the last four to six years, both TVA's nuclear operating and maintenance costs and industry-average costs have been essentially constant (in real terms). This stabilization of operating and maintenance costs is primarily the result of:

- *A substantial decrease in the rate at which the Nuclear Regulatory Commission has imposed new operating requirements.*
- *Significant efforts by most utilities to improve the efficiency with which they meet existing requirements.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

738

Comment: *Capital expenditures reflecting total investment in plant facilities for each resource option included allowed capitalized overheads. However, TVA did not include capitalized overheads in the costs associated with the nuclear resource options. TVA did not believe that this made a difference in the results of its evaluations of nuclear resources.*

Comment by: Tennessee Valley Public Power Association

Response: TVA included capitalized overheads in the costs associated with the nuclear resource options in every strategy.

739

Comment: *Cost comparisons do not reflect the billions of dollars of subsidies provided for the development of nuclear power, nor do they include future costs of waste disposal and plant decommissioning.*

Comment by: Andrew Danzig

Response: The TVA power program receives no congressional appropriations, and there was no direct subsidy to TVA for its nuclear power program. All costs of completing and operating TVA nuclear units, including the costs for waste disposal and decommissioning are included in the Energy Vision 2020 analysis.

740

Comment: *In Energy Vision 2020, why did TVA not explore contracting with utilities that have an above average performance record of operating nuclear plants to manage its nuclear operating risks?*

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: As a result of technical and operational problems and regulatory concerns, TVA shut down its operating units in 1985 and conducted an extensive review of its nuclear program. TVA determined that the primary cause of the problem was a lack of a sufficient number of experienced nuclear managers who could provide leadership and proper direction for TVA's nuclear activities. In response, TVA restructured its organization and assigned responsibility for all nuclear power activities to a single organization based in large part on a new management team. TVA also developed a Nuclear Performance Plan to provide a comprehensive recovery plan.

As discussed in the section on Nuclear Generation in the chapter on Existing Power System (see Volume 1, Chapter 4), TVA's nuclear performance has improved considerably over the last few years due to the leadership and direction of the new management team. TVA obtains contract assistance for work performed by crafts that are not part of the TVA work force and work requiring particular knowledge or expertise that TVA employees do not have.

741

Comment: *The accumulated costs associated with canceled TVA nuclear units totaled approximately $4.2 billion and were written off sporadically over the period 1981 through 1990. Approximately $3.0 billion of this amount was written off against non-operating income and was, therefore, not recovered in TVA's rates.*

Another $0.8 billion was charged to expense and, thus, flowed through TVA's utility service revenues. The remaining amount of $0.4 million was reclassified as Plant Held for Future Use. This amount represented the estimated cost of land, improvements, and buildings at the Hartsville site which was determined to have potential for other generation use by TVA. TVA has not identified publicly any plans for putting this investment to use. There was no indication that this site was considered for any of the resource strategies in Energy Vision 2020. However, when a decision is reached as to the disposition of these assets there could be significant implications on TVA's rates.

Comment by: Tennessee Valley Public Power Association

Response: The Hartsville site is being held in inventory as a possible site for future generation. The use of this site will be reviewed periodically.

742

Comment: *I have a concern about the waste disposal issue. My position on this subject is that if it is a problem TVA creates in the region, TVA should solve that problem in the region. Shipping the waste long distances to someone else's backyard is not a responsible course of action.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: TVA's plans for dealing with nuclear waste are discussed in the section on Nuclear Waste in Volume 2, Technical Document 1, page T1.122. TVA manages its wastes safely and in accordance with all applicable laws and regulations.

Renewable

743

Comment: *TVA should consider in its research and development additional renewable or green energy sources such as:*

- *Solar and wind technologies in real applications, not experimental stations*
- *Biomass, including hot water heaters that use a compost pile as a source of heat*
- *Electrolysis in making hydrogen as motor vehicle fuel or other fuel*
- *Using waste heat from its generating plants*
- *Geothermal*
- *Ocean energy*
- *Advanced air conditioning without freon.*

Comment by: Andrew Danzig, Walter Stenberg, Retha Ferrell, Beth Wallace, Carolyn Novkov, Sandy Loyd, David Bordenkircher, Michelle Carratu, Jim Snell, Mike Eastman, Elizabeth Garber

Response: Energy Vision 2020 includes additional research and development into several renewable technologies. This includes solar, wind, biomass, and waste heat from TVA generating plants. This research and development is reflected in the short-term action plan. (See Volume 1, Chapter 10, Figure 10-1.) TVA continues to assess most new technologies such as electrolysis and advanced air conditioning without freon. There are some generation technologies such as geothermal and ocean energy which are not important for the TVA region.

744

Comment: *TVA should install hydrogen bat generators down the side of Brindlee Mountain.*

Comment by: Mark Richardson

Response: We have no information about "hydrogen bat generators" and cannot respond specifically to this idea at this time without more information from the commenter. In general, however, we note that TVA uses numerous means to stay abreast of new technologies and evaluate their possible use by TVA. We are confident that if this concept has

potential benefit in utility applications, it will later be identified and given appropriate consideration by TVA.

745

Comment: *TVA's past experience with photovoltaics needs to be closely considered.*

Comment by: John Wood

Response: The short-term action plan includes a research and development study of specific end-use applications of solar photovoltaics. Past TVA experience will be considered as part of this study.

746

Comment: *TVA should consider more solar and wind options in its plan over the next 25 years. For example, in Minnesota wind will be produced for 3 cents per kilowatt-hour levelized over 30 years. Sacramento Municipal Utility District is producing solar power for $4.71 per watt, and it is reasonable to assume that it will decrease to $2 to $3 per watt by 2000. We anticipate that wind costs are going to go down. In contrast, fossil fuel prices will go up.*

Comment by: Will Kidd (Sunsource Unlimited, Inc.), Barbara Soliday, Stephen Smith (Tennessee Valley Energy Reform Coalition), Catherine Murray (Sierra Club, State of Franklin Group), Arthur Smith, Dolores Howard

Response: The available wind and solar energy, and thus the feasibility of using these energy sources, varies greatly throughout the country. The available wind in Minnesota is considerably greater than in the TVA region. The available sunshine in the Sacramento Municipal Utility District region is also considerably greater than in the TVA region. Thus, the economics which apply in those locations do not apply to the TVA region. Energy Vision 2020 evaluated wind and solar options for bulk power generation based on the available wind and sunshine in the TVA region, and found that their potential for that purpose in this region is rather limited.

TVA considered two options to encourage the use of customer-owned photovoltaics by providing technical assistance and incentives. The potential for use of photovoltaics was analyzed at both the current cost level and at a cost of $3 per watt, as photovoltaic prices are predicted to drop in the near future. Because of technology costs and limited availability of solar resources, TVA found that use of photovoltaics was limited to highly specialized or remote applications.

In Energy Vision 2020, the short-term action plan includes research and development of several renewable technologies including wind, biomass, landfill methane, and end-use solar photovoltaics. (See Volume 1, Chapter 10, Figure 10-1.)

747

Comment: *Why did TVA reject an offer from Kenetech Windpower who proposed to build a 400-megawatt wind plant in West Virginia for less than 4.5 cents per kilowatt-hour and would have reduced emissions significantly?*

Comment by: Danielle Droitsch, Stephen Smith (Tennessee Valley Energy Reform Coalition), Michelle Neal (Tennessee Valley Energy Reform Coalition), Powell & Sharon Foster, John Johnson (Earth First), Clark Buchner (Sierra Club, Tennessee Chapter), Sandy Loyd, Alan Jones (Tennessee Environmental Council), Howard Switzer (Sun/Earth Tempered Organic Architecture)

Response: From a cost perspective, TVA has other options available to produce or acquire electricity at costs below 4.5 cents per kilowatt-hour. The cost of alternative options ranges from 2.5 to 3.5 cents per kilowatt-hour. TVA's current average cost of generation is only 4.2 cents per kilowatt-hour.

The Energy Vision 2020 short-term action plan includes a wind turbine project in the TVA region. This project will be developed in two phases. The first phase will investigate wind resources in the TVA area. The second phase will build a wind turbine depending on the results of the first phase.

748

Comment: *TVA experience has shown the power service area does not have an adequate and dependable, year-round wind resource. I hope that TVA is cautious and does not make needless expenditures to gather the same experiences in the future. Technology has improved but not enough to overcome the limitations of geography.*

Comment by: John Wood

Response: The wind resource investigation included in the short-term action plan will include a review of TVA's past experience and data in order to avoid such repetition.

749

Comment: *Where are the wind resources? If they are not accessible in the TVA service region, do not use them. Wind farms are different to look at, but not necessarily aesthetic.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: The location and aesthetic effects of potential wind energy sites are discussed in Volume 2, Technical Document 2, page 2.46. As indicated, the TVA region does have limited wind resources. One area with potential for wind energy use is on the Cumberland escarpment in northeast Tennessee. Another is in southwest Virginia near Johnson City.

750

Comment: *Biomass should also be considered as a feedstock for chemical production.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: The short-term action plan has been revised to include the investigation of a biomass refinery project which would produce both chemicals and a boiler fuel which would be used to produce electricity.

751

Comment: *TVA has refused to enter the waste-to-energy field. Every city, town, and county in the region is having to address their solid waste management problems, but the most obvious solution (waste-to-energy) is denied to them because TVA is not willing to involve itself in the firestorm that siting and permitting a waste-to-energy plant will produce. An example is the fact that TVA has let a decent fluidized bed unit sit idle for years at Paducah, Kentucky. At least two attempts to evaluate the site for waste-to-energy have not produced reasonable cost estimates. It is hard to believe that when you start with the land, building, feed equipment, boiler, and air pollution control system in hand that you cannot make that work, even if you do have to replace the controls, modify the boiler, and*

add a generator. This site should serve as a regional solid waste combustion unit serving that corner of the system and possibly as a waste tire combustion center taking tires shipped by barge.

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: As noted in this comment, disposal of solid waste is a significant problem in some areas of the country and is becoming more costly. Waste-to-energy plants are one option which local governments may use to address this problem. For example, Nashville operates such a facility. TVA recognizes the potential benefits of such plants to the region. The proposed long-term action plan in Energy Vision 2020 identifies refuse-derived fuel as a future option. (See Volume 1, Chapter 9, Figure 9-23.)

752

Comment: *On average the cost per kilowatt-hour for burning garbage is twice that of nuclear plants and garbage-generated energy is unpredictable. It is worthless to TVA, does not displace coal or gas, yet under Public Utilities Regulatory Policy Act, TVA is forced to buy such energy from the Nashville Thermal Plant. Recycling and composting of the fuel for Nashville Thermal would save more energy than the plant.*

Comment by: John van der Harst

Response: TVA purchases power under the Public Utilities Regulatory Policy Act at published prices. These prices are based on TVA's avoided costs. TVA purchases power from qualified facilities, including the Nashville Thermal Plant, at these standard rates.

753

Comment: *TVA should consider harvesting undesirable tree species for fuel. This will improve forest stands and provide another cash crop to timberland owners.*

Comment by: C. L. McKinney (Creret, Inc.)

Response: TVA has analyzed wood, primarily waste wood (such as sawdust) as a fuel supplement. The short-term action plan (see Volume 1, Chapter 10, Figure 10-1) calls for performing cost-effective biomass cofiring. The short-term action plan also recommends further research into other biomass uses, such as short rotation woody crops. TVA does not contemplate using whole trees as a fuel source.

754

Comment: *I am opposed to biomass. It is too expensive to dry it out. The people that generate the most bark, chips, and sawdust already have wood-fired boilers.*

Comment by: Kirk Johnson

Response: Waste wood used as biomass fuel does not ordinarily have to be dried. The heat content is enough to evaporate the moisture and still provide useful energy to a boiler. If the delivered cost of biomass fuel is quite low, the useful energy can still be economical.

755

Comment: *From looking at Volume 1, Chapter 3, Figure 3-15, it does not appear that TVA purchases a lot of fuel inside the service region. TVA should try to purchase as much fuel as possible from inside the region. Cofiring wood with coal will help this situation, but TVA should be doing this at every coal-fired plant. The wood is available and, in some cases, TVA can go higher than 5 percent heat input.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: TVA purchases coal from the most economical sources. The referenced figure identifies the location of TVA's 1994 coal suppliers by county.

It is expected that most if not all of the wood used in cofiring at TVA plants will be from inside the TVA service region. The wood waste cost is a strong function of the transportation distance, so it is likely that the area supplying wood waste to a plant utilizing biomass cofiring will be limited to a 50- to 75-mile radius about the plant. Based on wood resource assessments completed for the TVA region, there may be enough wood waste at favorable prices to support wood cofiring at up to 10 percent for some of TVA's units. For other units, cofiring will be limited to substantially less. Decisions regarding the amounts of wood waste that will ultimately be cofired at various plants will be based on more rigorous, plant-specific evaluations of the cost and availability of wood waste.

756

Comment: *Where are the coalbed methane resources? If they are not accessible in the TVA service region, do not use them.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: The methane concentration varies widely among coal seams. In the TVA region, the coal seams most promising for methane use include eastern Tennessee, northern Alabama and Mississippi, and eastern and western Kentucky.

757

Comment: *In addition to the biomass-to-energy options, you may want to consider recycled plastics as an energy source as reported in Energeia, v6(4), 1995 from the University of Kentucky, Center for Applied Energy Research.*

Comment by: Andrew Danzig

Response: TVA did not specifically evaluate the use of recycled plastic as an energy source. However, the long-term plan identifies refuse-derived fuel as a future resource option. (See Volume 1, Chapter 9, Figure 9-23.) Plastics typically contribute significantly to the energy value of the solid waste stream. However, the recycling of plastics for non-energy uses is becoming more prevalent and plastics are increasingly being removed from the solid waste stream.

Environmental

758

Comment: *TVA coal-fired plants should have efficient scrubbers.*

Comment by: Richard Simmers

Response: Energy Vision 2020 considered several options for mitigating sulfur dioxide emissions. These included efficient scrubbers, switching to low-sulfur fuels, and repowering of coal-fired units. (See Volume 1, Chapter 7, pages 7.9 to 7.10.) TVA has already installed scrubbers on six of its units. The efficiency of these scrubbers at the six units varies from 86 to 95 percent, with the two most efficient scrubbers also being the most recent scrubber installation, TVA's Cumberland Fossil Plant.

759

Comment: *Wind power should be considered as a Clean Air Act Phase II control strategy.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Wind power has been included in Energy Vision 2020 as a Clean Air Act Phase II control strategy in the form of off-site repowering. On-site repowering of existing fossil plants has not been considered due to the space constraints typically associated with large wind powered plants. Off-site consideration of wind is included in Strategy T. (See Volume 2, Technical Document 2, Figure T2-1.) As such, wind power received the same consideration for displacement of future energy and capacity supply as other supply-side options included in Energy Vision 2020.

760

Comment: *TVA's right-of-way maintenance should not include tree cutting or use of herbicides.*

Comment by: Catherine Murray (Sierra Club, State of Franklin Group)

Response: Power lines, like highways and other public infrastructure, must be kept clear of trees and vegetation. A single tree coming into contact with a large high-voltage transmission line could cause thousands of people to lose electricity in their homes, businesses, schools, and hospitals. In addition, power lines felled by trees are extremely dangerous to anyone in the vicinity. TVA therefore selectively cuts trees near the edge of rights-of-way that could endanger transmission lines.

TVA tries to eliminate herbicide use to areas where mechanical cleaning is not feasible. All herbicides used by TVA are registered by the Environmental Protection Agency for this specific use. They are strictly applied according to Environmental Protection Agency methods by licensed applicators at the lowest volumes necessary. TVA also attempts to notify residents when herbicides will be applied.

761

Comment: *TVA should permit chip mills, provided clear cutting is mitigated somehow.*

Comment by: Sandy Loyd

Response: TVA does not have regulatory control over or responsibility over chip mills. It does not "permit" chip mills. It does respond to requests for TVA property upon which chip mills would be located and to requests for approval of water use facilities associated

with chip mills. In accordance with these responsibilities and the National Environmental Policy Act, TVA appropriately considers the potential effects of clear cutting and the merits of mitigating adverse effects.

762

Comment: *TVA should immediately halt all logging on Land Between The Lakes and avoid removing forest cover on all TVA property.*

This forest cover is necessary to act as a carbon sink to offset the maximum amounts of carbon dioxide pumped into the atmosphere by TVA and industry in this region. I think that doing this, and utilizing Land Between The Lakes and areas around the reservoirs as a carbon sink will be an offset for an inevitable carbon tax. It will also show an example in preservation of biological diversity for this region.

Comment by: John Johnson (Earth First)

Response: TVA recently released a final environmental impact statement on natural resource management at its Land Between The Lakes. This evaluated the potential consequences of forest management, including timber harvesting, effects on biodiversity, and greenhouse gas emissions.

TVA recognizes the potential of forestry and other carbon sequestration projects for offsetting a portion of the carbon emissions from fossil fuel power plants. In fact, TVA is participating with about 50 other electric utilities in the Utility Forest Carbon Management Program. This program identifies and funds cost-effective forestry and related carbon sequestration projects. TVA has contributed $150,000 to this program and is committed for an additional $75,000 in 1996. TVA also plans to hold discussions with state forestry agencies to identify other cost-effective carbon sequestration opportunities in the Tennessee Valley in which TVA could participate.

763

Comment: *TVA should set up carbon sink incentives for landowners in the Tennessee Valley to offset TVA's carbon emissions.*

Comment by: Dennis Haldeman

Response: TVA recognizes the potential of forestry and other carbon sequestration projects for offsetting a portion of the carbon emissions from fossil fuel power plants. In fact, TVA is participating with about 50 other electric utilities in the Utility Forest Carbon Management Program. This program identifies and funds cost-effective forestry and related carbon sequestration projects. TVA has contributed $150,000 to this program and is committed for an additional $75,000 in 1996. TVA also plans to hold discussions with state forestry agencies to identify other cost-effective carbon sequestration opportunities in the Tennessee Valley in which TVA could participate.

764

Comment: *TVA is the nation's largest emitter of carbon dioxide, the primary greenhouse gas implicated in global climate change. TVA has failed to develop a plan to meet commitments to return carbon dioxide emission levels to 1990 levels. Renewables could aid in this commitment.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA is participating in the Administration's Climate Challenge Program. It has committed to reduce its generation of greenhouse gas emissions by approximately 22 million tons by the year 2000. This is one of the strongest commitments made by any of the electric utilities participating in this program. These reductions are expected to be achieved through a number of ways, including improvements in energy efficiencies and the use of renewables (e.g., biomass cofiring). Energy Vision 2020 takes this into account, and the long-term plan considers other renewable and energy efficiency programs which could further reduce projected greenhouse gas emissions. (See Volume 1, Chapter 9, Figure 9-23.) Energy Vision 2020 evaluated two minimum carbon dioxide strategies. One of these strategies (Strategy B) would maintain average carbon dioxide emissions from 1996 through 2020 at approximately 100 million tons or just slightly greater than TVA's emissions in 1994. However, this strategy, although reducing carbon dioxide emissions, led to higher costs and higher short-term electric rates. (See Volume 1, Chapter 9.)

Peaking/Storage

765

Comment: *After a cursory review of TVA's assumptions, Burns & McDonnell generally agrees with the data accumulated for the supply-side options. However, one option not included in the list of possibilities is conversion of the existing combustion turbines to combined cycle operation.*

Comment by: Tennessee Valley Public Power Association

Response: TVA's existing combustion turbine fleet is more than 20 years old. TVA did a preliminary screening on repowering these combustion turbines compared to new combined cycle units. The new units were determined to be less expensive on a life-cycle cost basis. Thus, we did not include repowering the old combustion turbines in the options for Energy Vision 2020.

766

Comment: *Combustion turbines will experience a gradual degradation in net heat rate and net output as they age. This can be corrected by rebuilding the combustion turbines every three years. These degradations can be on the order of 2.5 to 3.0 percent of the original values. It does not appear that the heat rate and output values cited in Energy Vision 2020 include the effect of these deratings.*

Comment by: Tennessee Valley Public Power Association

Response: TVA recognized early in the process of preparing data for input to Energy Vision 2020 that the large number of alternatives to be analyzed would preclude inclusion of details on annual variations in performance. In the case of combustion turbines, there is a cycle over a period of three years or so over which there is some variation in performance. The forecast of operation and maintenance costs and capital additions and improvements included sufficient funds to maintain the performance of the combustion turbines.

767

Comment: *Duplicate Raccoon Mountain on top of Brindlee Mountain in the Morgan City area.*

Comment by: Mark Richardson

Response: The initial investigations of sites available where pumped-storage could be considered a viable option included some 160 sites. These sites had to meet the initial screening criterion of providing a minimum of 700 feet vertical separation between a possible upper and lower reservoir. The Brindlee Mountain location did not meet the criteria since it provides only 450 feet of vertical separation.

768

Comment: *Energy Vision 2020 should discuss the proposed private pumped-storage project and any other such proposed power projects. It is unclear, for example, how a large power source that is planned for the Tennessee Valley could operate in the Valley without selling power to TVA. If TVA must or ultimately elects to purchase power from the proposed hydro, such purchase would be inconsistent with Energy Vision 2020, which indicates that no new hydro facilities are planned (see Volume 1, Chapter 9, page 9.25 and Volume 2, Technical Document 2, page T2.45).*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: The review and approval of both the Federal Energy Regulatory Commission and TVA must be obtained before the two privately-proposed pumped-storage facilities in the Sequatchie Valley can proceed. It is contemplated at this time that such review will be in the form of an environmental impact statement. TVA may or may not purchase power from these facilities if they are ultimately built and operated. If TVA does not purchase power from the facilities for use on its system, such power could be wheeled to other utility systems outside the TVA region. The referenced pages correctly state that TVA is not planning new hydroelectric plants in its Energy Vision 2020 strategies. This does not preclude other public or private entities from proposing such plants. The TVA purchase of power from such plants would not be inconsistent with the referenced statements or Energy Vision 2020, which purposefully incorporates flexibility in future energy resource option decision-making. As appropriate and consistent with the National Environmental Policy Act, TVA would tier from Energy Vision 2020 to any resource option, whether proposed by TVA or others.

Independent Power Production/Purchased Power

769

Comment: *TVA should purchase and sell power off-system economically.*

Comment by: Larry Smith (Mid-South Peace and Justice Center)

Response: TVA will continue to use sales and purchases of electricity to and from other utilities when it is economical to do so. (See Interchanges with Neighboring Utilities section of Volume 2, Technical Document 3, page T3.9.)

770

Comment: *The TVA system does not have the excess interconnection capacity to import a substantial amount of the distributors' load.*

Comment by: Tennessee Valley Public Power Association

Response: Although TVA has established a high level of interconnected transmission capacity with neighboring utilities (greater than 25,000 megavolt amperes), the capability to import blocks of power into the TVA system from neighboring regions is limited by transmission "bottlenecks." These limitations occur at import levels that are low relative to TVA's total distributor load at peak times.

771

Comment: *TVA should consider private industry generating power to sell to TVA. Private industry can generate power cheaper than the government.*

Comment by: C. L. McKinney (Creret, Inc.)

Response: TVA considers the purchase of power from private industry. TVA continually receives proposals from private industry and evaluates the proposals to determine if they are viable supply options. TVA currently purchases excess energy from 11 dispersed power customers throughout the Tennessee Valley.

The purchase of power from private industry was addressed in Energy Vision 2020. (See Volume 1, Chapter 7, pages 7.5 to 7.8.)

772

Comment: *I support the proposed Phillips Lignite Project in Choctaw County as a way to help the residents of the county. I care about whatever TVA can do to help us with economic development.*

Comment by: Don Threadgill

Response: A lignite-fired plant was considered in Energy Vision 2020. (See Volume 2, Technical Document 6, Figure T6.1.) TVA is continuing to work with the developers of the referenced lignite project to further study the viability of the project.

773

Comment: *TVA is considering external sources of power provided by independent power producers. TVA's distributors are municipalities and cooperatives that carry tax exempt status. The cost of capital for a distributor is less than that of an independent power producer. If distributors were to build generation facilities which could be used during periods when TVA would otherwise purchase external sources of power, savings equal to the difference in the after-tax rate of return could occur.*

Why did TVA not look at allowing distributors the opportunity to construct generation instead of investor-owned independent power producers?

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: In Energy Vision 2020, hundreds of supply- and demand-side options were considered including conventional supply-side options; purchases from other utilities, independent power producers, and power marketers; and distributed generation. (See

Volume 1, Chapters 7 and 8.) In addition, TVA solicited options through extensive public participation efforts, including distributors of TVA power.

In Energy Vision 2020, the specific contracting mechanisms for the development of projects or technologies were not considered. TVA's current contracts with its customers are full-requirements contracts and do not allow distributor-owned generation.

774

Comment: *TVA should be doing a better job of working with the wood products industry to encourage development of financially solid businesses that can reliably cogenerate. TVA should adopt policies that encourage this industry by either taking their wood waste for its cofiring program at a respectable price or helping them set up cogeneration systems that have high reliability and paying up to TVA's average system cost of production (not avoided costs) for power produced beyond their needs. This could be done by a formula that takes size, demonstrated reliability, and environmental responsibility into consideration. I do not think TVA should deal with dedicated independent power producers, other than waste-to-energy, beyond the requirements of the Public Utilities Regulatory Policy Act or wheel their power out of the region.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: TVA is currently cofiring wood waste at its Allen Steam Plant and will begin cofiring wood waste at its Colbert Steam Plant within the next several months. These are test burns which will help verify the viability of this fuel. TVA is also working with several wood product industries that are installing cogeneration systems and want to sell power to TVA. Energy Vision 2020's recommended short-term action plan contains cost-effective biomass as an option. (See Volume 1, Chapter 10, Figure 10-1.)

Under the Public Utilities Regulatory Policy Act, TVA is required to buy power from qualified facilities at its avoided cost. In addition, if a qualified facility wants to sell their power outside the region, TVA has a price to wheel the power out of the region.

Bids/Option Purchase Agreements

775

Comment: *TVA may be paying excessive premiums for its call options. There are several factors which affect the price of an option: strike price, underlying market price, price volatility, time to expiration, and interest rates. Volatility and time to expiration usually have the greatest impact on option prices. Price volatility can be affected by the ability of market participants to enter into and exit out of a contractual agreement without paying significant transaction costs. Currently, bulk power is traded in a spot market by a limited number of buyers and sellers. As the Federal Energy Regulatory Commission opens transmission access, the number of market participants should increase. Added liquidity could help to lower premiums on option prices. Also, since the value of a "long" call option decreases with time, the longer TVA waits to enter into an option, the lower the premium.*

What are the prices of the call and put options quoted to TVA?

What are the implied volatilities of the call and put options quoted to TVA?

Comment by: Henry Nickell (Memphis Light, Gas and Water Division)

Response: TVA has taken every measure reasonable to ensure that premiums paid for call options are as low as possible. While volatility and time to maturity are significant factors impacting the value of an option, TVA has found from direct experience that another important factor is the difference between the exercise or strike prices of the call option and expected future spot prices. It is only true that the value of a call option (both long and short) diminishes with time if prices remain at the same level as when the call option was purchased or if prices decline. The value of a call option will increase in accordance with increases in the price of the underlying asset, in this case the price of electricity. Thus, if TVA were to wait to buy call options and prices were to increase, then the price of the call option would be higher. Of course, the converse is true if prices were to decline. TVA has evaluated the likelihood of both price increases and decreases and is taking a balanced approach by relying on a combination of resource alternatives to satisfy future supply requirements to include forward contracts, internal alternatives, spot market purchases, and call options.

In TVA's "Request for Proposal for Option Purchase Agreements," TVA stated that the information contained in all proposals would be kept strictly confidential. For this reason and for reasons of competitive position, TVA cannot release this information. Similarly, revealing the implied volatilities of the call and put options quoted to TVA would violate the confidentiality of the information from TVA's "Request for Proposal for Option Purchase Agreements."

Distributed Generation

776

Comment: *The report needs to provide more information on the use and economics of gas turbines as dispersed generation. Gas turbines have about one-sixth the capital cost per kilowatt-hour of coal plants and one-twentieth of nuclear plants.*

Comment by: John van der Harst

Response: While gas turbines have low capital cost, that advantage tends to be offset by much higher fuel costs than for coal and nuclear plants. Many of the supply-side options are based on gas turbines. Among these were a small cogeneration plant (see Volume 2, Technical Document 6, Figure 6-1, option 1.1.2.4) and a small combined cycle plant (option 1.1.2.5). In addition, Energy Vision 2020 considered small gas turbines for cogeneration and self-generation among the customer service options (see Volume 2, Technical Document, pages T7.70 to T7.72 and T7.114). TVA is also conducting a study to evaluate the potential cost and benefits of distributed generation alternatives.

777

Comment: *TVA should be encouraging distributed generation through the use of things like fuel cells, which are smaller production units that distributors could control. This is going to be a necessary component in the era of increased competition.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: TVA is currently conducting an investigation of possible distributed generation applications and is working to develop better generating technologies (such as fuel cells)

for these applications. The short-term action plan (see Volume 1, Chapter 10, Figure 10-1) includes further research and development on distributed generation, including fuel cell technologies.

778

Comment: *I believe a 20- to 50-megawatt waste wood-fired unit in the Tupelo area might be appropriate to consider. There are fairly large quantities of waste wood in northeast Mississippi. TVA is considering cofiring wood with coal at Allen and Colbert Steam Plants. The rule of thumb on wood fuel is that transport beyond 50 miles is not usually economical. Therefore, a wood-fired unit located somewhere just below Tupelo could be supported and not interfere with TVA's cofiring strategy.*

Comment by: David Stephenson (Southeastern Regional Biomass Energy Program)

Response: Electricity from wood-fired plants has historically been expensive in most locations, although more reasonable costs have been reported recently. The short-term action plan includes cofiring of wood waste in existing coal-fired power plants. Cofiring achieves the same low fuel costs and emissions benefits that would result from wood-fired plants, without the capital cost of a new plant. (See Volume 1, Chapter 10, Figure 10-1.)

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This section includes comments and responses about:

- various aspects of the environmental quality of the TVA region
- the effect of coal combustion on air quality related problems, including acid rain, visibility, adverse effects in the Great Smoky Mountains National Park, forest health impacts, and global climate change
- water quality in TVA reservoirs and the TVA region
- socioeconomic conditions
- the treatment of environmental consequences in Energy Vision 2020, including the impact of radioactive wastes

Affected Environment

AIR RESOURCES

General

779

Comment: *Since the passage of the Clean Air Act in 1970, we are using 81 percent more coal, but emissions are down a total of 26 percent.*

Comment by: Barbara Altizer (Virginia Coal Council)

Response: TVA is not aware of the basis for the 81 percent figure in the comment. Through the addition of scrubbers and fuel switches to medium and low sulfur coal between 1976 and 1990, TVA has been able to significantly reduce sulfur dioxide emissions. By 1994, TVA's sulfur dioxide emissions were reduced from that in 1976 by about 54 percent, while at the same time in 1994, approximately 5 percent more coal was consumed than in 1976. By 2005, TVA's sulfur dioxide emissions are projected to be only 20 percent of their 1976 level. Nitrogen oxides emissions are just now beginning to be reduced under Phase 1 of the 1990 Clean Air Act Amendments, but TVA anticipates reductions in system-wide nitrogen oxides emissions by the year 2000 of 40 to 50 percent for roughly the same amount of coal consumed in 1994.

780

Comment: *TVA and other regional utilities are causing air pollution problems in the Great Smoky Mountains National Park. They have regional haze problems with visibility as much as 60 to 70 percent below what it should be. In the summer months, visibility is down to 10 miles when it should be as much as 60 to 100 miles. That is being traced back to sulfates from coal-fired plants. There are also ground-level ozone problems damaging trees, and they are considering posting the park for ozone hazards to visitors because they are exceeding the 120 parts per billion ozone standard. Much of that is due to nitrogen oxides emissions from coal-fired plants. There are also fine particulate and mercury emissions from coal-burning. Demand-side management and energy efficiency would lessen these impacts.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: Electric utilities including TVA, as well as industry and other sources, contribute to the air emissions causing visibility degradation in the Southeast such as regional haze. One important pollutant contributing to visibility degradations is sulfur dioxide, which forms sulfate particulate. TVA has reduced sulfur dioxide emissions by more than 50 percent since 1976. An 80 percent reduction will be accomplished when TVA finishes implementing control strategies to comply with the 1990 Clean Air Act Amendments. TVA also expects to reduce nitrogen oxides emissions, which can contribute to ozone formation by about 50 percent.

Energy Vision 2020 addresses visibility impairment and TVA's contribution to this and other air quality problems. (See Volume 2, Technical Document 1, pages T1.65 and T1.91.)

781

Comment: *While you correctly discuss the effect of power plant emissions on visibility reduction (see Volume 2, Technical Document 1, pages T1.63 to T1.66), you have ignored one more impact of air pollution on tree growth rates: reduced photosynthetically active radiation. According to Aber and Federer (1992), deciduous and evergreen trees in the eastern United States have growth rates controlled by three primary factors outside of soil nutrient levels: soil water, ambient temperature, and photosynthetically active radiation. Since there is generally plenty of soil moisture in the eastern United States, soil moisture is not generally the limiting factor here, except during periods of drought. They have done a careful study in a number of forests in the eastern United States, measuring these three parameters as well as tree growth rates. They found that for a 10 percent reduction in photosynthetically active radiation, deciduous trees experienced a 4.4 (±2.9) percent reduction in growth, while for evergreen trees, the value was 7.0 (±2.4) percent. Grant (manuscript in preparation) has taken their results along with aerosol loadings in the eastern United States and estimated that deciduous trees would have growth rates reduced by 3.8 (±2.9) percent, while evergreen trees would see a 6.7 (±2.7) percent reduction. While this is a small effect, it is both measurable and consistent with the general growth rate declines noted for the region.*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: The hypotheses here regarding the impact of power plant emissions on photosynthetically active radiation are very interesting. We have never heard the issue raised before. Given that the ideas have not been published to date nor have any experimental data, we look with interest toward future research in this area.

782

Comment: *You cannot cite an Environmental Protection Agency document. My copy of the Citation of the Environmental Protection Agency's 1995 draft ozone criteria document states clearly on the cover and on each page: "Do not quote or cite." Did you get a different version than I did? The problem with citing draft documents is that the conclusions can change. In addition, they do not yet have the approval of the agency. One way around the citing prohibition is to develop arguments in your document based on the underlying literature quoted in the Environmental Protection Agency document. (See Volume 2, Technical Document 1, Figure T1.54, page T1.84.)*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: You are correct in noting that the Ozone Criteria document (Environmental Protection Agency 1995) is a document "in review" and it would be inappropriate to cite preliminary conclusions from the draft document. However, as a compilation of the current literature, the draft Environmental Protection Agency document is a more appropriate source. The citation of this document was used to provide the most current information available in Energy Vision 2020.

783

Comment: *The article, McLaughlin et al., 1995, is not included in the citation listing, (see Volume 2, Technical Document 1, page T1.150).*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: The text has been changed appropriately.

784

Comment: *"Nitrogen oxides emissions have been weighted three times greater for their impact to crop and forest productivity than sulfur dioxide emissions."*

While this statement in Volume 2, Technical Document 1, page T1.90, may be qualitatively correct at some regional emission/deposition rates, it is not clear that it is quantitatively correct. For example, sulfates in clouds are more important for affecting the cold hardness of red spruce than are nitrates (Sheppard 1994). Also, sulfur can only reduce soil pH to about 4.2, while nitrogen can reduce it below 4.2 (Shultz 1989). A better justification of the 75:25 ratio should be provided, along with an estimate of its range and uncertainty.

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: A three-to-one ratio for weighting nitrogen oxides emissions compared to sulfur dioxide emissions was decided because sulfur dioxide is a component of acid deposition, while nitrogen oxides is a component for both acid deposition and ozone. Currently, ozone is considered to be the most significant air pollutant in the southeastern United States.

Acid Deposition/Rain

785

Comment: *A measure of forest sustainability is mortality rates. Recent mortality rate trends have been up, which is not good for sustainability.*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: Forest growth statistics take into account tree mortality information. TVA agrees that mortality rate information is very important for measuring forest sustainability. However, information on stand age, species composition, insect infestation, disease outbreaks, and other factors must also be included before determining if rates are abnormal and whether cause-effect relationships can be implicated.

786

Comment: *The National Acid Precipitation Assessment Program 1991 concluded that the vast majority of forests in eastern North America are not in decline, although atmospheric deposition may be implicated in the premature mortality of high elevation red spruce in the Northeast. Evidence of red spruce decline and pollution involvement in the southern Appalachians is less substantial.*

First, the National Acid Precipitation Assessment Program 1991 was written under political direction, often with blatant disregard to the underlying scientific findings (Loucks, 1992). Thus, reliance on the findings of the National Acid Precipitation Assessment Program on this or any other matter is strongly suspect.

Second, the effects of air pollution, including acid deposition and ozone, have been fairly well documented for red spruce in the southern Appalachian Mountains, e.g., Eager and Adams (1992).

Third, many other trees are also in decline due to the effects of air pollution, (e.g., oaks). If we look at the growth rates of oaks in Arkansas, North Carolina, and Tennessee, using tree rings as the indicator, we see from the data published by Starkey et al. (1987) that there was an increase in growth rates in the 1930s and 1940s, followed by declines below the pre-1930s growth rates in the 1980s. My interpretation is that acid deposition is responsible for both the increases in the 1930s and 1940s and the subsequent decline. Acid precipitation does two things to increase the nutrient availability to trees at first: it provides mineralized nitrogen (in agreement with a statement in Volume 2, Technical Document 1, page T1.77) and it releases exchangeable divalent base cations (calcium, potassium, magnesium) into the soil solution. After awhile, however, increasing soil acidity reduces the calcium-to-aluminum ratio to below about 1, where the trees are more likely to take in the toxic aluminum rather than the beneficial base cations, and there are other effects on soil fauna and flora which reduce the availability of soil nutrients and the ability of the trees to assimilate them; hence, the period of decline. A good overview is found in Sverdrup and Warfvinge (1993).

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: Many of the results of the National Acidic Precipitation Assessment Program fell short of being conclusive, but rather indicated various “trends” or “correlations” in the data, such as the gradient studies reported in Loucks (1992). As Dr. Loucks points out, such studies “were not designed to show causality by themselves.” Whenever data are inconclusive, there will always be controversy in the interpretation of results.

With regard to whether the forests of eastern North America are truly in “widespread decline,” this issue certainly receives some support from certain studies, but overall has not been clearly demonstrated. Even Dr. Loucks (1992) states that, “analysis of the historic periodic “declines,” observed in several forest species regularly over centuries, is such that the present pattern of tree death cannot yet be distinguished from past patterns.”

As to whether acid deposition is the cause of any “declines,” evidence to date is circumstantial or of limited geographical or temporal extent, with the exception of red spruce. The existence of a correlation does not, of course, prove causation, but is simply grounds for generating hypotheses. Individuals may impose their own interpretations on the results, but the forest scientific community awaits more evidence that any of these “declines” have been caused by acid deposition.

With regard to the role of acid deposition in altering nutrient cycles and other ecosystem functions, the section of Energy Vision 2020, Volume 2 on “Acid Deposition-Forests” thoroughly describes the types of perturbations that acid deposition is currently affecting

(see Volume 2, Technical Document 1, pages T1.76 to T1.80). This discussion includes impacts on the base cation cycling, on nitrogen cycling, and on the availability of soil nutrients. The interaction of calcium and aluminum are also addressed on page T1.77.

787

Comment: *The National Acid Precipitation Assessment Program did not find a regional decline of southern pines.*

That should not be used to imply that there is no decline in southern pines, since the National Acid Precipitation Assessment Program was politically directed. Anderson et al. (1988) did find the effects of air pollution on eastern white pine in the southern Appalachian Mountains, with symptomatic trees having 49 percent less mean volume than healthy trees.

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: Decline is a specific term used in plant pathology (Manion 1981) and can be evaluated at a tree, community, or regional level. The National Acidic Precipitation Assessment Program did not find a regional decline of southern pines. Eastern white pine is not considered a southern pine species.

788

Comment: *My general opinion is that the draft plan/environmental impact statement greatly understates the effects of power plant emissions on the vitality of forests. Whether this is a deliberate attempt to mislead the public and decision-makers or done out of lack of knowledge is not clear. However, since TVA has a large forest research unit, it is hard to imagine that its staff is unaware of the large body of literature examining the multitude of effects of ozone and acid precipitation on trees, as well as the reports of extensive impacts on the forests of the eastern United States which can be related to air pollution.*

There are several recent reports of declines in forest vitality in the eastern United States. A popular account is given in Charles Little's The Dying of Trees. It discusses Camel's Hump, Vermont, Mt. Mitchell in North Carolina, and Lucy's Woods in West Virginia in the eastern United States, all of which are severely impacted by air pollution. Another account can be found in the periodic United States Forest Service Forest Inventory Analysis Reports for the southeastern states, where both standing tree stock and mortality rates can be found. Since 1960, mortality rates for red oak have doubled, those for white oak have tripled, those for hickory have quadrupled, and for all hardwoods, the rate is more than double. It is highly likely that air pollution has played an important role. More recently, it has been realized that the Allegheny Mountains forests are suffering severe dieback due to acid precipitation. While this finding has not yet received publicity, Phil Wargo with the United States Forest Service in Connecticut (203-230-4312) can provide information on it. The fact that there are several cases in the eastern United States that are experiencing forest decline due to air pollution belies the so-called findings of the National Acid Precipitation Assessment Program, which were politically, rather than scientifically, motivated (e.g., Loucks 1992).

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: TVA disagrees that Energy Vision 2020 understates the possible effects of power plant emissions on the vitality of forests. Changes in forest health in specific southern areas such as Mt. Mitchell and Lucy's Wood have not been directly linked to air pollution (Eagar and Adams 1992). Instead, a multiple stressor complex that includes exotic

insects, disease, degradative land use practices, atmospheric deposition, and other factors have been implicated. Mortality calculated for United States Forest Service Forest Inventory Analysis documents is not a rate function. Instead, mortality is defined as the volume of sound wood in trees that have died of natural causes (United Service Forest Service 1988). Furthermore, there are no direct and indirect linkages made in those documents between mortality and air pollution.

In a telephone conversation with Dr. Phil Wargo on October 26, 1995, he confirmed that his research indicates that forests, in and near the Allegheny National Forest, are declining. While his work has not been published in the peer-reviewed literature, he stated that insect defoliation, drought, disease, outdated practices, and low soil nutrition were the primary causes of decline. Soil nutrition levels may be indirectly linked to atmospheric deposition, but Dr. Wargo did not have data to substantiate that hypothesis.

789

Comment: *There is a pervasive forest health decline occurring in the area from airborne deposition, assaults from acid rain, and increasingly noticed, being known as nitrogen saturation, primarily from utility companies and from pulp mills.*

Comment by: Dennis Haldeman

Response: The assertion that “there is pervasive forest health decline… [in hardwoods]” is counter to the National Acidic Precipitation Assessment Program report to Congress (National Acidic Precipitation Assessment Program, Report 16, 1990). This document is a summary of over ten years of work on forest health. A multitude of studies are cited in this document. The conclusions of the National Acidic Precipitation Assessment Program report do not indicate that there is “pervasive decline.”

The assertion that “airborne deposition” is leading to nitrogen saturation is unfounded. The nitrogen saturation hypothesis is simply that: a hypothesis that as yet is untested. The Scandinavian countries and parts of Europe are attempting to define what may constitute critical loads that may subsequently result in nitrogen saturation. Little research has been done in the United States concerning nitrogen saturation, but several studies have suggested that high elevation forests may be susceptible to nitrogen saturation. These observations come from reports of high soil nitrogen levels in spruce fir forests in the eastern United States; however, a wide range of possibilities exist as to why these specific sites may exhibit high nitrogen levels, including greater mineralization rates and decreased nitrogen uptake. Overwhelmingly, the scientific literature supports what forest scientists have known for decades, that forests are nitrogen-limited and respond positively to nitrogen additions.

790

Comment: *Data from Mt. Mitchell should have been added to Volume 2, Technical Document 1, Figure T1-35. Such data are available in Aneja and Li (1991). Values averaging above 60 parts per billion by volume are common.*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: The temporal ozone pattern observed at Mount Mitchell is very similar in shape to the flat pattern observed at Cove Mountain and numerous other high elevation sites. The greatest differences are in the magnitude of concentrations. We chose not to include data from other sites in the interest of keeping the figure uncluttered and easily understandable for persons not familiar with the subject.

791

Comment: *Assuming 24 to 48 hours for summertime sulfate formation and transport, sources 400 to 800 kilometers away are likely contributing to sulfate deposition in the Tennessee Valley. Aerosols are removed from the atmosphere by dry deposition or rainout in clouds. The lifetime of aerosols is often stated to be 7 days, not 1 to 2 days. Thus, the impact region for emissions from TVA should be much larger than 400 to 800 kilometers, which would include the Great Smoky Mountains National Park and beyond.*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: It is true that the total impact region for sulfate derived from TVA emissions extends farther downwind than 400 to 800 kilometers. The distance cited in Energy Vision 2020 and the cited travel time of 24 to 48 hours represent the range over which the TVA contribution to sulfate deposition would be greatest. As downwind distance increases, the relative contribution of TVA emissions to the total atmospheric loading of sulfate decreases. Thus, at seven days, the relative contribution of TVA emissions of total downwind sulfate deposition is minute. TVA impacts on acid deposition and visibility are expected to be greatest within 800 kilometers downwind, which can include the Great Smoky Mountains National Park, where sulfur dioxide dry deposition is at a maximum (sulfur dioxide dry deposition velocities being much greater than those of sulfate). Sulfate, especially under stagnant transport conditions, can accumulate and contribute to periods of severe visibility degradation. In addition, stagnation can lead to especially concentrated washout of sulfate in summertime thunderstorms.

792

Comment: *Why were data from the Great Smoky Mountains National Park not included in Volume 2, Technical Document 1, Figure T1-40, page T1.62.*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: Data points in Volume 2, Technical Document 1, Figure T1-40 were selected to represent the range of geographic variability at low elevations. Selected data points also had to represent long periods of record, which were not available for Great Smoky Mountains National Park at low elevations (see Volume 2, Technical Document 1, page T1.62).

793

Comment: *With carbon dioxide present in the atmosphere at 330 parts per million, the acidity of rain due to the presence of carbonic acid is 5.6. At current carbon dioxide levels of 355 parts per million, the pH is still near 5.6. Where does the figure of 5.2 come from?*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: The "natural" pH of rain water is affected by things other than carbon dioxide. Volcanic emissions, forest fires, sea spray, and biogenic emissions inject various quantities of sulfur dioxide, other sulfur compounds, chlorides (including hydrochloric acid), nitrogen oxides, and organic acids into the atmosphere. When combined, these substances account for an average "natural" pH value that is slightly less than 5.6. A National Research Council report (1983) gives a lower end of the range for "natural" pH of 4.9. The estimate of 5.2 falls within this range.

794

Comment: *Calcium is an essential plant nutrient. Magnesium is also essential for photosynthesis and potassium is essential for regulating osmotic pressure. Normally, forest soil scientists discuss the (calcium + potassium + magnesium)/aluminum ratio, with a considerable body of data showing that when this ratio drops below about 1, tree growth rates begin their decline. What is needed is a soils condition survey of the eastern United States that would measure divalent base cation concentrations in soil solutions for the various upper soil layers (O, A, E) and use them with a model to estimate the present and future condition of the soils in the region in relation to effects on tree vitality. Volume 2, Technical Document 1, Figure T1.83 is inadequate since only aluminum and calcium are used, it is for only one site, and nothing is stated about the effects on tree growth for the various molar ratios presented. If, as is sometimes done, calcium is used as shorthand for calcium + potassium + magnesium, then all values above a ratio of 1 are generally not good for trees.*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: We recognize that magnesium and potassium are important soil nutrients. In fact, the potential for aluminum to interfere with the uptake of magnesium is pointed out at the bottom of column one, page T1.77 in Volume 2, Technical Document 1.
It is more common to discuss the calcium/aluminum ratio, although the (calcium + magnesium + potassium)/aluminum ratio is sometimes used. Early work in this area (Foy et al 1969, Lund 1970, Rost-Siebert 1983, and Hutterman and Ulrich 1984) focused on the calcium/aluminum ratio. The topic has recently been reviewed at length by Cronan and Griga 1995; (see this paper for above references).

We agree that the long-term soils condition survey for the eastern United States is badly needed. Because of the effort to reduce federal funding, finding financial support for such a survey is unfortunately very difficult. The Forest Health Monitoring Program, within which TVA is an active participant, has such a soil survey as one of its goals. Volume 2, Technical Document 1, Figure T1-52, was intended simply as an illustration of how aluminum/calcium ratios would shift under different emission scenarios, not as a definitive representation of all sites in the eastern United States. The use of aluminum/calcium ratios is adequate in TVA's opinion. (See review article by Cronan and Griga [1995]). We agree that aluminum/calcium ratios above 1 are generally not good for trees, though species vary greatly in their tolerances of low calcium/high aluminum.

Global Climate Change

795

Comment: *TVA's participation in the Climate Challenge program should not be driven by political reasons. Rather, participation should be based on a clear understanding of the advantages and disadvantages of participation. Unless limits on greenhouse gas emissions become mandatory, TVA could increase its costs over its competitors' by pursuing reductions in greenhouse gas emissions. Some proponents of greenhouse gas limitations may feel that TVA should set an example for the rest of the industry to follow in making greenhouse gas reductions, even at the expense of higher overall costs. The Tennessee Valley Public Power Association members, on the other hand, may not be willing to accept higher costs for the sake of voluntarily reducing greenhouse gas emissions.*

Comment by: Tennessee Valley Public Power Association

Response: As stated in the Climate Challenge Memorandum of Understanding, one of the principles upon which the program is based is that the actions utility participants take "will be cost-effective and will take into consideration impacts on rate payers and share holders and the competitive situations of the utilities with regard to costs and rates." Within the utility industry, there are many technically and economically sound activities that a utility can implement as part of its normal business practices that also reduce greenhouse gas emissions. Most of the actions included in TVA's Climate Challenge commitment have been evaluated as cost-effective actions independent of their impact on greenhouse gas emissions. For example, TVA has included in its commitment heat rate improvements at fossil fuel units, the hydro modernization program, restarting Browns Ferry Nuclear Plant Units 2 and 3, completion of Watts Bar Nuclear Plant Unit 1, biomass cofiring, certain demand-side management programs, and transmission system efficiency improvements. The biomass cofiring, hydro modernization, and the demand-side management programs are also included in the Energy Vision 2020 short-term action plan. The actions included in TVA's Climate Challenge commitment will not negatively impact rates.

TVA is committed to Climate Challenge and wants to do everything possible to make it a successful program. While the scientific evidence relating human produced greenhouse gas emissions to global warming is considered inconclusive by some, many think it is prudent to take cost-effective action to reduce greenhouse gas emissions and not wait until scientific evidence is more conclusive.

796

Comment: *TVA is directly responsible for the greenhouse effect. TVA is number one in the United States and if you take China out of the loop, probably the world in producing carbon dioxide.*

Comment by: Bryan Deel, Bruce Wood, Sharon Force, John Noel

Response: The United States accounts for about 23 percent of the world's greenhouse gas emissions. Electric utilities account for about 35 percent of the United States greenhouse gas emissions. TVA emits about 4 percent of the United States electric utility greenhouse gas emissions. Therefore, TVA contributes about 0.3 percent of the world's total greenhouse gas emissions. The contribution of nuclear and hydro power to the TVA generation mix helps keep greenhouse gas emissions lower than they would otherwise be.

797

Comment: *In Volume 2, Technical Document 1, page T1.70, the statement that nuclear emits no carbon dioxide is wrong. Calculate the coal used for powering uranium enrichment plants and the carbon dioxide and other emissions produced. In 1990 an estimated 10.7 million tons were burned to enrich uranium. This resulted in 661,000 tons of sulfur dioxide and 195,000 tons of nitrogen oxides. It is estimated that 3 percent of all sulfur dioxide emitted in the United States is associated with enriching uranium. It is estimated that the enrichment process consumes 25 percent of the electricity produced by nuclear power plants. Even after Phase I of the Clean Air Act, a nuclear power plant will still cause about as much acid rain as a new coal-fired plant with scrubbers on an emissions-per-kilowatt-hour basis. Uranium enrichment produces approximately 22 million tons of carbon dioxide annually.*

Comment by: Al Fritsch (Appalachia–Science in the Public Interest)

Response: The generation that supports uranium enrichment would produce some amounts of various pollutants. The statement in Volume 2, Technical Document 1, page T1.70 was intended to apply only to the direct emission of carbon dioxide from nuclear plants.

TVA estimates that less than 5 percent of the total electrical output from a commercial nuclear power plant would be required for nuclear fuel enrichment processes. These figures are based on currently available gaseous diffusion enrichment technology. The more modern centrifuge and laser-based enrichment technologies would reduce the enrichment energy requirement significantly.

The emissions from a coal-fired plant would, accordingly, be more than 20 times the emissions resulting from enriching fuel for a nuclear power plant where the energy source for enrichment is a coal-fired plant. The situation improves when a portion of the energy is supplied by a nuclear plant.

WATER RESOURCES

798

Comment: *Volume 1, Chapter 3, Figures 3-13 and 3-14 and Volume 2, Technical Document 1, Figures T1-64 and T1-65 provide useful information regarding the principal water quality concerns and waterbody use impairments in TVA reservoirs and watersheds. Was the determination of use impairments conducted by TVA or was this information taken from the state 305(b) reports or other sources? If use impairments were determined by TVA, Energy Vision 2020 should include a brief description of the process used in evaluating use impairments. This description should include a discussion of the data sources (e.g., TVA, states, U.S. Geological Service) and criteria used in the evaluation (e.g., state water quality standards).*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA has conducted comprehensive aquatic monitoring throughout the Tennessee Valley since 1990. The two primary objectives of this effort are to evaluate the ecological health of major streams and reservoirs ("vital signs monitoring") and to examine how well these water resources meet the goals of the Clean Water Act ("use suitability monitoring"). The water quality concern and use impairment information depicted in Figures 3-13 and 3-14 were derived by TVA primarily using data and analyses generated through this program. Data from other TVA monitoring activities were also used, including TVA's Aquatic Plant Management and Reservoir Releases Improvement Programs. The basis used to make judgments about conditions were state water quality standards and fish consumption advisories issued by the states. Most of this information and data are captured in TVA's annual River Pulse reports. The text has been revised for clarification.

799

Comment: *Energy Vision 2020 states that TVA monitoring has shown no "significant negative effects" from heated discharges. How is "significant negative effects" defined in the context of Energy Vision 2020? (See Volume 1, Chapter 3, page 3.21, Surface Water, TVA Heat Releases.)*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: In the context of Energy Vision 2020, "significant negative effects" means demonstrable damage to established water uses or aquatic ecological integrity. The text has been revised for clarification.

800

Comment: *Energy Vision 2020 states that nonpoint sources "contribute as much as five times more dissolved oxygen-consuming wastes than point sources." (See Volume 2, Technical Document 1, page T1.96, Rainfall and Runoff Pollutants.) Is this intended as a general statement or is it specific to the TVA region? Also, is this statement intended to apply to average conditions or is it specific to rain events? Finally, while the constituents of power plant wastewater may not contain loading of oxygen-demanding materials equal to nonpoint sources, reservoir releases may contribute significantly to the in-stream dissolved oxygen deficit. Has an analysis been conducted comparing the impact on the instream dissolved oxygen deficit from low dissolved oxygen reservoir releases with the dissolved oxygen deficit contributed by nonpoint sources?*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: The statement that nonpoint sources contribute as much as five times more dissolved oxygen-consuming wastes as point sources is intended as a general statement that applies to the TVA region. However, this statement is generally accurate nationwide, based on studies by the Environmental Protection Agency and others, such as the Environmental Protection Agency's 1983 report, Nationwide Urban Runoff Program. Nonpoint sources of pollutants have typically been associated with rainfall events, either directly from surface runoff or from delayed groundwater discharge to streams. TVA has not conducted a comparative analysis of the relative dissolved oxygen deficit contributions for nonpoint sources, point sources, or natural sources on specific reservoirs.

801

Comment: *Because of historical energy policies, TVA's reservoirs are eutrophic. TVA does not follow Environmental Protection Agency standards for classifying the condition of its lakes.*

Comment by: Dennis Haldeman

Response: Based on monitoring data from 1994, TVA classified conditions for aquatic life as "good" in six and "fair" in three of the nine mainstream Tennessee River reservoirs. There are a variety of factors unrelated to trophic status that influence the ecological health rating of these reservoirs.

In 1983, TVA developed two tropic state indices: one for mainstream "run-of-the-river" reservoirs on the Tennessee River, and one for storage reservoirs on tributaries to the Tennessee River. These new indices were developed because the tropic state indices used at the time to evaluate natural lakes—such as the one used by the Environmental Protection Agency—were judged to be inappropriate for evaluating reservoirs. The characteristics and behavior of reservoirs are significantly different from natural lakes in terms of both (1) the concentrations of nutrients associated with excessive productivity and (2) the extent to which excessive productivity changes the water quality parameters that scientists monitor. The TVA trophic state indices allow much more accurate prediction of the response of reservoirs to nutrient addition.

802

Comment: *The Nashville District United States Army Corps of Engineers operates nine multipurpose reservoirs which incorporate hydroelectric production facilities on the Cumberland River and tributaries. Approximately half the power production from eight of these projects is marketed through the Southeastern Power Administration to TVA. We do not anticipate any significant changes in these power resources. We have, however, completed a hydropower optimization feasibility study at Lake Cumberland which focused on uprating the existing six units at Wolf Creek Powerhouse for peaking operation. On the middle Cumberland River our reservoir regulation integrates the need for adequate cooling water at TVA's Gallatin and Cumberland City Fossil Plants on Old Hickory Lake and Lake Barkley, respectively. In addition, we have performed a preliminary analysis of pumpback at Laurel Lake on the Upper Cumberland River.*

Comment by: Bradley Hoot (Department of the Army)

Response: Appropriate text changes have been made to Volume 2, Technical Document 1, Comprehensive Affected Environment, to incorporate a discussion of your studies on the Cumberland River hydroelectric system.

803

Comment: *Regarding the navigability of the Cumberland River (see Volume 2, Technical Document 1, page T1.101), the Cumberland River is considered navigable to its origin, the confluence of Clover Fork and Poor Fork at Mile 694.2. The limits of commercial navigation (maintained 9-foot channel) are at Mile 381.0, at Celina, Tennessee.*

Comment by: Bradley Hoot (Department of the Army)

Response: The appropriate changes have been made to the text.

804

Comment: *In Volume 2, Technical Document 1, page T1.102, in paragraph 4, column 1, it states the tailwaters of Lake Cumberland, Dale Hollow, Center Hill, and Laurel Lakes "provide good to excellent trout (Salvalinus namaycush) fisheries." The species (Salvalinus namaycush) is the lake trout which, since 1977, has been stocked in Dale Hollow Lake and to a lesser extent in the Obed River below Dale Hollow Dam. The rainbow trout (Oncorhynchus mykiss) and the brown trout (Salmo trutta) are routinely stocked in large numbers in the referenced tailwaters by the State of Tennessee and Commonwealth of Kentucky. These two species are the focus of the popular fisheries in these tailwaters.*

Comment by: Bradley Hoot (Department of the Army)

Response: The appropriate text changes have been made.

LAND RESOURCES

805

Comment: *Watts Bar Nuclear Plant's evacuation plan should be included in Energy Vision 2020.*

Comment by: Mandy Tiesler, Jean Cheney, Jamie Pizzirusso

Response: The evacuation route and plan for evacuation for Watts Bar Nuclear Power Plant are found in the "State of Tennessee Multi Jurisdictional Emergency Plan." Copies are located at TVA emergency centers, local county emergency centers, and the Tennessee Emergency Center in Nashville.

Each year TVA provides information, including maps and evacuation routes, to residents within a 10-mile radius of each nuclear plant. For Watts Bar Nuclear Plant, the information is mailed each November.

806

Comment: *Children continue to be exposed to low-level radiation which is cumulative, working up through the food chain.*

Comment by: Jean Cheney

Response: Together, natural and man-made radiation expose the average American to about 360 millirem a year. Nuclear energy is only one—and among the least—of the many sources of radiation. People are exposed to radiation from radon in the air; from radioactive potassium in our food and water; from uranium, radium, and thorium in the earth's crust; and from cosmic rays and the sun. Natural background radiation accounts for almost 85 percent of the average total annual exposure.

Nuclear energy exposes even the people living nearest the plants to under 0.1 millirem a year. The radiation exposure from Three Mile Island caused an average exposure of 1.5 millirem to people within 50 miles of the plant. This is a small fraction of what most of us receive each year from naturally occurring radioactive materials in soil, rocks, air, food, and water.

TVA has a responsibility to safety first. The plants are designed, built, and operated to high standards and adhere to strict regulations to ensure the health and safety of the public and TVA employees.

FUEL

807

Comment: *The coal industry is subject to heavy environmental regulations and has come a long way.*

Comment by: Barbara Altizer (Virginia Coal Council)

Response: The environmental impacts of coal mining have been greatly reduced through compliance with the Surface Mining Reclamation and Control Act and through industry initiatives.

SOCIOECONOMIC RESOURCES

808

Comment: *Bad financial decisions are responsible for worker layoffs and reductions, and not environmental requirements.*

Comment by: Retha Ferrell

Response: Worker layoffs and reductions are typically a response to changing markets and an entity's particular competitive position within its markets, and are usually not the

result of any single condition. Many factors can add to costs and deteriorate competitive positions. To the extent that environmental regulations add to cost, this also changes the market and the competitive position of entities. Environmental regulation may decrease the demand for one product (e.g., high-sulfur coal) and increase the demand for another (e.g., clean coal technology). Jobs may thus be created in one industry while being lost in another. However, unemployment is likely to occur due to displaced workers not having the needed skills for other available jobs.

809

Comment: *There are great economic benefits to the region of Kentucky that produces coal provided to TVA.*

- *In 1994 Kentucky supplied 28 million tons of the 39.1 million tons of the coal delivered to TVA.*
- *This provided 4,300 mining jobs earning $168 million annually. (These jobs average more in earnings, than any other industrial sector.)*
- *This resulted in a multiplier effect of 17,000 jobs.*
- *This produced $29 million in severance taxes.*
- *Total tax revenues from associated economic activity are approximately $87 million.*
- *In total, this creates about $1.4 billion in annual output of goods and services.*
- *Other coal deliveries to TVA from Tennessee and Virginia produced 370 mining jobs.*

Comment by: William Bowker (Kentucky Coal Marketing and Export Council)

Response: There are economic development benefits associated with coal production as a result of TVA purchases. In Energy Vision 2020, the economic development effects due to all final strategies, including those effects resulting from mining activity in the TVA region generated by energy options requiring coal purchases, have been analyzed.

810

Comment: *Low-cost, reliable electricity has been and continues to be the prime driver of economic growth in the region and benefits everyone.*

Comment by: Jan Jones (Tennessee River Valley Association), J. Richard Hommrich (Volunteer Barge & Transport, Inc.), William Bowker (Kentucky Coal Marketing and Export Council)

Response: In the economics literature, as well as in TVA studies, the cost of electricity has been found to be a significant factor in economic development. Economic development effects due to electricity prices were analyzed as part of each strategy in Energy Vision 2020.

811

Comment: *The economies of Tennessee, half of Alabama, and a third of Mississippi are carrying TVA's $28 billion debt, and these states finished low in every economic indicator. This represents the fundamentally corrupt nature of TVA.*

Comment by: Bruce Wood

Response: TVA's power service area incorporates significant portions of Alabama, Kentucky, and Mississippi, and almost all of Tennessee, as well as much smaller pieces of three other states. These four states together compose the East South Central region of the country, which by some measures of economic well-being, such as per capita income levels, ranks

at the bottom of the regions of the United States. Tennessee has the best ranking of the four states, and even it only ranks thirty-third in terms of per capita income levels.

However, these measures are more a reflection of where these states have started from economically. In times of economic growth, these states have performed much better than other states. All four states are in the top ten in terms of per capita income growth in the 1990s. They also rank in the middle in terms of levels of gross state production, reflective of their high manufacturing capacity, which has propelled their strong economic growth. In order to improve their rankings in terms of economic welfare, continued economic growth is necessary. Reliable, low-cost electricity has been a contributor to the states' economic growth. This will continue to be the case in the future, and TVA must plan to meet the growing needs of the states.

812

Comment: *In the past TVA was hung up about the socioeconomic benefits of large projects and this influenced them not to cancel projects when they were not needed.*

Comment by: Kirk Johnson

Response: As a regional resource development agency, one of TVA's responsibilities is to foster the economic development of the TVA region. It therefore views socioeconomic benefits as very important. Energy Vision 2020 demonstrates this. Economic development was one of a number of criteria that TVA used to evaluate possible energy resource strategies. Other criteria included costs, rates, environmental impacts, debt, reliability, risk management, and equity among customers. All of these evaluation criteria were consistently applied using the multi-attribute trade-off method, and the Energy Vision 2020 final strategies performed well on all criteria.

813

Comment: *The TVA region's economic condition is worse than depicted in Energy Vision 2020. People are underemployed or sub-employed.*

Comment by: Charles Sanford (Sanford & Associates)

Response: In its analyses of the Valley economy, TVA uses standard economic statistics and definitions from the U.S. Departments of Commerce and Labor. These statistics are the same as those used for the United States as a whole and for other parts of the country and for which there are long time series available. The historical unemployment data that TVA uses is from the United States Department of Labor. The Department has acknowledged that these data do not reflect underemployment, and in this way fails to fully capture the prevailing labor market conditions. Regardless, these statistics do fully represent relative conditions between the Valley, the United States, and other areas of the country, as well as changes in conditions over time. It is these attributes that are important to the Energy Vision 2020 economic analyses where comparisons between strategies are being made.

Environmental Consequences

GENERAL

814

Comment: *The Environmental Protection Agency rates the draft Energy Vision 2020 an "EC-2" (Environmental Concerns; more information requested). Specifically, we are concerned about potential impacts because of the uncertainty of predicting the energy sources and their attendant impacts for the next 25 years. However, we can appreciate the difficulty in making such predictions on a programmatic scale and generally agree with the TVA approach to upgrade existing sources, conservation, and to add some new sources in the short term, and to consider new alternatives such as renewables for the long term. This could even be considered for the addition of a new unit to a conventional power plant, such as at Shawnee. The information provided in the draft Energy Vision 2020 is considerable, although some additional information is requested above. This includes consideration of the human health risk of indirect exposure from energy generation sources in your analysis and the upstream/downstream impacts associated with proposed modifications of existing hydroelectric units. Although site-specific National Environmental Policy Act documents would address some of these issues, some additional information on these issues would already be appropriate in the final Energy Vision 2020.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA's goal is to provide an effective energy resources planning process with the environment as an integral consideration. The uncertainties of the electric utility industry do indeed make projections of impacts difficult. This is why flexibility was determined to be key to TVA's future success.

TVA has responded to each specific comment by the United States Environmental Protection Agency. The index to this volume provides a numbered list of these comments and their page location.

815

Comment: *Never before has such a comprehensive balancing of natural and human resources been undertaken in determining energy production options for this or any other large region of our country. With a commitment to provide full compliance with environmental laws (and beyond where possible), we can expect our region's natural resource heritage to be ensured.*

Comment by: TVA Retirees Association

Response: It was TVA's intent to develop a comprehensive plan.

816

Comment: *The agency has performed an impressive multi-parameter environmental assessment that evaluates all environmental impacts of alternative strategies against a base or reference "no-action" alternative. The impacts considered are land, water, and air, as well as socioeconomic. The analytical approach used involved trade-off considerations which allowed the public to set value criteria for judging impacts and benefits. This allowed TVA to select mitigative strategies that resulted in the highest environmental benefit considering financial, rate, economics, and other criteria. It would appear that this*

ensures higher environmental performance in the future compared to "base case" considerations. This approach is thoroughly discussed in Volume 2, Technical Document 2 and the environmental controls associated with each strategy are presented in Figure T2-1. These considerations have been, of necessity, broad in nature. However, the agency commits to further detailed evaluation as well as mitigation of impacts whenever specific resource options are utilized. Meeting all environmental protection laws while reviewing environmental commitments under the public review of the National Environmental Policy Act is certain to minimize future environmental costs.

Comment by: TVA Retirees Association

Response: It was TVA's intent to conduct a broad, yet comprehensive environmental review.

817

Comment: *TVA's multi-parameter environmental assessment that evaluates all environmental impacts of alternative strategies is a comprehensive balancing of natural and human resources.*

Comment by: TVA Retirees Association

Response: The intent of using the multi-attribute trade-off analysis method, as pointed out, was to allow trade-offs between each of numerous quantitative environmental evaluation criteria (parameters) and each of several other evaluation criteria to be examined across all strategies. Importantly, additional environmental factors not quantified for multi-attribute trade-off analyses were evaluated qualitatively.

818

Comment: *TVA's treatment of environmental issues in Energy Vision 2020 appears to be very thorough.*

Comment by: Tennessee Valley Public Power Association

Response: Your comment has been reviewed and noted.

819

Comment: *The draft Energy Vision 2020 provides a comprehensive coverage of the multi-state affected environment and potential environmental effects of the Energy Vision 2020 strategies.*

Comment by: Bradley Hoot (Department of the Army)

Response: Your comment has been reviewed and noted.

820

Comment: *The Virginia Department of Environmental Quality anticipates no significant environmental impacts for the Commonwealth of Virginia from the projects proposed in Energy Vision 2020. We have no objections to the proposed plan and support TVA's use of integrated resource planning as a useful management tool for future long-term energy supply planning efforts.*

Comment by: Tom Griffin (Commonwealth of Virginia)

Response: Your comment has been reviewed and noted.

821

Comment: *The project document includes lengthy discussions of the planning process and objectives but does not provide project-specific information on impacts of the various management alternatives considered. While the North Carolina Wildlife Resources Commission recognizes that the intent of the document is to outline an overall strategy for energy production and resource management in the Tennessee Valley, the scale of the analysis does not allow us to assess impacts to North Carolina's fish and wildlife resources resulting from project alternatives.*

Comment by: Chrys Baggett (North Carolina State Clearinghouse)

Response: As site-specific actions are proposed, environmental reviews will be conducted and coordinated with the State of North Carolina agencies as appropriate. These reviews will ensure that potential impacts to fish and wildlife resources are adequately assessed.

822

Comment: *As a programmatic environmental impact statement, we understand that at this time environmental impacts can in general only be qualified (and not quantified) and can be compared by alternative. However, future substantive TVA federal actions (e.g., construction and operation of a new power plant) would likely require site-specific National Environmental Policy Act documentation in which impacts are both qualified and quantified (e.g., potential conversion of the Bellefonte Nuclear Plant and construction of a new power plant unit at Shawnee Fossil Plant).*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Site-specific environmental reviews according to the National Environmental Policy Act will be conducted as appropriate for future actions.

823

Comment: *Human health concerns need to be considered in any site-specific National Environmental Policy Act documents for any proposed energy projects such as new power plants. At a minimum, such an analysis would need to include a screening for emitted hazardous chemicals and comparisons against any existing "standards," or the equivalent. If no "standards" exist, some appropriate screening should still be provided. Because of the association of mercury with fossil-fuel power plants, mercury should be emphasized in such screening studies. Depositional modeling should be conducted for all metals exceeding its "standard" or for which there is reason for concern (we would encourage such analysis for mercury even if levels are predicted to be below a given "standard"). If one or more chemicals exceeds its "standard" or there is reason for concern, the human risk for direct exposure impacts (inhalation) of power plant air emissions should be determined. Additionally, indirect human impacts such as ingestion of food (crops, cattle) grown in areas affected by the deposition of power plant emissions is strongly encouraged since it has been shown that the indirect exposure risk is greater for many substances than for direct exposure.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: The programmatic environmental impact statement for Energy Vision 2020 is not intended to address site-specific evaluations. Subsequent project-specific reviews will address human health concerns and will use appropriate standards to benchmark evaluations.

824

Comment: *The Environmental Protection Agency notes that human health was considered in the Energy Vision 2020 evaluation, specifically, through air emission inhalation and water ingestion. Given the importance of assessing indirect exposure risks, we recommend that TVA also strongly consider inclusion of indirect exposure risks to human health in their Energy Vision 2020 analyses.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: The important indirect pathway to human health risk for the purpose of Energy Vision 2020 was addressed—the ingestion of contaminated fish. (See Volume 2, Technical Document 1, page T1.105.) Ingestion was one of the impact area indices for water quality. The impacts of airborne mercury and other toxic metals were considered in weighting for the human health-ingestion index. The pathway of most potential impact on human health for airborne mercury is considered to be through eating fish in which the metal has accumulated. Other indirect pathways for airborne toxic metals, such as through cattle grazing, were not included in either the air quality or water quality indices. Their relative contribution to the weighting of the indices would have been less than that of fish ingestion.

Subsequent environmental reviews will address indirect health impacts and pathways as appropriate.

825

Comment: *The short-term action plan, developed from the long-term action plan, exhibits several environmentally friendly options. These include the potential conversion of the Bellefonte Nuclear Plant to an integrated gasification combined cycle demonstration technology; biomass cofiring; power purchasing; modernization of hydro facilities; and engineering and siting work on coproduction, combined cycle, and other facilities. In general, these efforts need not significantly impact the environment if properly pursued.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Your comment has been reviewed and noted.

826

Comment: *For fossil-fuel plants, new fuel sources such as coalbed and landfill methane would be beneficial to promote recycling as well as a reduction in greenhouse gases in the atmosphere, while use of biomass as a cofiring fuel would utilize domestic resources.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: These fuel sources are included in the Energy Vision 2020 long-term plan and short-term action plan. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

827

Comment: *Considering the long term (30-50 years) of the required Federal Energy Regulatory Commission's license for hydros, a re-evaluation of the environmental impacts with appropriate mitigation should be conducted at relicensing.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA hydroelectric facilities and dams are not licensed or approved by the Federal Energy Regulatory Commission. These TVA facilities are not subject to relicensing. As appropriate and consistent with the National Environmental Policy Act, proposed TVA actions at or involving its hydroelectric facilities and dams consider potential environmental impacts and ways of mitigating impacts.

828

Comment: *I think that the draft environmental impact statement needs to fully assess the long-term off-site and cumulative and synergistic effects of the TVA power system and all human industrial activities in the Tennessee Valley Authority service area.*

Examples include pollution in the Tennessee River. One of the cumulative impacts is batch releases from the nuclear plants with all the releases from DuPont and the other industries that see fit to utilize the Tennessee River as their toilet.

Comment by: John Johnson (Earth First), Dennis Haldeman

Response: Energy Vision 2020 addresses potential cumulative environmental effects by first assessing the condition of the existing environment. Second, the cumulative environmental consequences of all proposed supply-side and demand-side options were then addressed on a quantitative or a qualitative basis.

Wastewater discharges from TVA facilities (as well as industry) are permitted under the National Pollution Discharge Elimination System as administered by the states. These permits are designed to protect, preserve, or restore the water uses identified by state stream classifications.

829

Comment: *TVA's plan fails to consider reasonably foreseeable impacts caused by increasing demand, which is in violation of the National Environmental Policy Act.*

Comment by: Dennis Haldeman

Response: Energy Vision 2020 considers reasonably foreseeable effects (impacts) as required by the National Environmental Policy Act. Examples illustrating this include the following:

Reasonably foreseeable impacts due to air emissions and wastewater discharges were evaluated using air and water quality impact environmental indices (See Volume 2, Technical Document 2, Environmental Consequences.)

Air quality effects include those related to the formation of secondary air pollutants, the changes to TVA's contribution to the regional inventory of such pollutants, and the pollutant's fate in the environment. These secondary pollutants include sulfate and nitrate particulate and ozone. Potential indirect effects from these pollutants are the effects of acid deposition and ozone exposure to natural and man-made resources.

Water quality effects addressed by the water quality indices include changes in food chain biomagnification in fish of toxic metals discharged from coal-fired (including air deposition) and nuclear power plants, and reservoir sediment releases. Also, indirect water quality impacts from changes in coal procurement and the related coal mining were considered.

The air and water quality indices for alternative energy strategies showed improvement in comparison to the reference strategy. (See Volume 2, Technical Document 2, Figures T2-14 and T2-27.)

Land resource impacts were also addressed as appropriate in the plan. This included land use conversion due to changes in coal mining resulting from TVA's coal procurements.

Economic development effects stemming directly from TVA actions (i.e., job creation from power plant construction and operation, and from demand-side management) were evaluated for all energy strategies. The indirect or multiplier effects of the payroll from these job creations on the local economy were quantified. The indirect effect of the procurement of goods and services (i.e., power plant fuel, replacement parts, and equipment) were also evaluated. Additionally, the more subtle but important indirect effect of TVA's future cost of electricity on economic development was quantified for each strategy.

830

Comment: *New epidemiological research findings by the Centers for Disease Control and various other domestic and foreign sources over the next 25 years, as well as new corresponding regulations and/or policies promulgated by the Occupational Safety and Health Administration, the Environmental Protection Agency, the Department of Energy, the Department of Defense, the Federal Highway Administration, and others will likely influence TVA's selection of resource options within its portfolio and its approach to minimizing human health risk. In this regard, we encourage TVA to develop, implement, and keep current a policy based on such research and regulations.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: The uncertainties of future environmental regulations and environmental and health problems identified in the future are among the reasons that TVA identified flexibility in energy resource planning as critical to the Energy Vision 2020 plan. Various TVA staff regularly monitor and review health and environmental developments. TVA also relies on sister federal agencies, such as the Environmental Protection Agency, the Centers for Disease Control, and Department of Energy, to help it keep abreast of such developments.

831

Comment: *Not all the criticisms of the plan I have read about from the environmental community seem valid. One suggestion is to beef it up with more "sustainable development" language. To my knowledge the term was not used.*

The plan's main goal was well-stated, (i.e., "going beyond simply providing low-cost power by considering economic development and the environment as part of TVA's mandate to be a leader in total resource development"). This is the essence of sustainable development—the linking of economic development and the environment. In effect, TVA is a sustainable development agency.

Comment by: Tom Forsythe

Response: TVA received several comments concerning sustainable energy policy. Responses to these comments address omission of the term "sustainable" in TVA's discussion.

832

Comment: *TVA has demonetized the environmental cost of the power operations and stopped externalizing them and making us, the public, and the biological diversity of this Valley pay for that.*

Comment by: John Johnson (Earth First)

Response: Environmental control costs based on current regulatory programs were internalized and thereby considered in power operations costs. Although not monetized, a full range of environmental externalities were assessed in the multi-attribute trade-off analyses. These analyses ensured that environmental externalities were assessed on the same basis as other evaluation criteria. As a result, the final strategies and the preferred alternative, a portfolio of options, mitigate potential environmental impacts. (See Volume 1, Chapter 9.)

833

Comment: *The choice of call options is a good decision because it provides flexibility. However, option purchase agreements need to be evaluated on their environmental impacts. If they are independent power producers, they should be held to a high environmental standard because they may be less regulated than TVA.*

Comment by: Stephen Smith (Tennessee Valley Energy Reform Coalition)

Response: The flexibility afforded TVA by using call options to meet future load growth is one of the primary reasons for their use.

Proposals have been evaluated relative to their potential environmental impacts in Energy Vision 2020 and will be further evaluated prior to the decision to accept a proposal. All of these energy suppliers will have to meet federal, state, and local requirements which are formulated to protect the environment.

834

Comment: *As we move into the twenty-first century, an emphasis on sustainable development—continued economic growth and development balanced with protecting the environment—will influence United States energy policy. As related to energy issues, a sustainable energy supply envisions and requires the following attributes:*

- *A fuel source which is dependable, reliable, and stable for the foreseeable future*
- *Related development, production, transport, generation, and waste disposal facilities that are safe, reliable, and long lasting*
- *Compatibility with maintaining the natural environment in a healthy condition*

Comment by: Linda Church Ciocci (National Hydropower Association)

Response: TVA has developed an energy plan that balances several evaluation criteria including controlling cost, managing debt, increasing economic development, maintaining competitive rates, mitigating risk, improving system reliability, and minimizing environmental impacts.

AIR RESOURCES

835

Comment: *Site-specific National Environmental Policy Act documents subsequently resulting from the programmatic environmental impact statement should incorporate demand-side management and other conservation methods as appropriate. Documents for power sources involving fuel combustion should include an analysis of greenhouse gas emissions for the fuel mix proposed. We recommend that the 1992 National Environmental Policy Act manual for "Climate Change and Environmental Assessment: Technical Manual for*

Environmental Protection Agency's Programs and the National Environmental Policy Act" (March 1991; revised June 1992) be used as guidance for such analyses.

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: As appropriate, future TVA actions will consider the benefits of demand-side management and conservation, and potential effects on greenhouse gas emissions. Energy Vision 2020 already addresses these subjects in considerable detail, and we intend to tier from this programmatic review to subsequent project-specific reviews.

836

Comment: *As TVA is aware, state permits must be secured from the appropriate states concerning acid rain and Prevention of Significant Deterioration/New Source Review permits if/when specific projects involving air impacts are proposed for construction and operation.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA will, of course, comply with these requirements.

837

Comment: *Improved TVA fossil plant efficiency will reduce environmental impacts and fuel costs.*

Comment by: Linda Cataldo Modica, Ann Lamb

Response: Energy Vision 2020 contains a number of proposed actions that would improve fossil plant efficiency, including the possible repowering of units. TVA is also taking steps to improve plant efficiencies as part of its response to the Climate Challenge Program. (See Volume 2, Technical Document 2, Environmental Consequences.)

One example of a possible repowering or conversion technology evaluated in Energy Vision 2020 is integrated coal gasification combined cycle. Integrated coal gasification combined cycle is the cleanest, most fuel-efficient way currently available to utilize coal to produce electricity. Integrated coal gasification combined cycle's emission rates for sulfur dioxide, nitrogen oxides, and carbon dioxide are sufficiently low for it to be considered as a Clean Coal Technology by the Department of Energy. Integrated coal gasification combined cycle is typically able to achieve sulfur dioxide removal rates of 99 percent or better, resulting in emission rates of 0.03 pounds of sulfur dioxide emitted per million Btu of coal fired. Utilization of advanced combustion turbine technology results in nitrogen oxides emission rates on the order of 0.03 pounds of nitrogen oxides emitted per million Btu of coal fired. These emission rates are significantly lower than that achievable by more conventional coal-fired power plants. In addition, integrated gasification combined cycle plants are more efficient than their conventional counterparts. The higher efficiency results in less fuel consumption and consequently lower emission rates of carbon dioxide, as well as sulfur dioxide and nitrogen oxides.

838

Comment: *I am concerned about air pollution problems, including those in the Great Smoky Mountains, caused by TVA's existing coal-fired plants. The plan does not adequately address these problems.*

Comment by: William Emmott, Luther Gulick, A. B. Evans, Catherine Murray (Sierra Club, State of Franklin Group), Jo Anne Clark, M. Nathan Perry, Chris Gulick, Faith Young, Myles Jakubowski (Sunbeam Household Products), Ann & Mike

Sanders, Ruth Peeples, Walter & Dorothy Stark, Mary Anne Terry, Susana Harwood, Shirley Schaaf, Dottie Hodges, Karl Grotke, Ray Williams, Stephen Smith (Tennessee Valley Energy Reform Coalition), John Harwood, Linda LaForest (Tennessee Citizens for Wilderness Planning), Anne Redwine, John Johnson (Earth First), Bruce Wood, Sharon Force, Hamp Dobbins, Jr., Rodney Webb, M. Case, Salo, Sahara, Karah Bates, Tohert, Garry Shores, K. Varnum, Kathy Priore, Kim Grube, Amy Perry, Hermann, L. M. Johnson, Sr., Lynn Leach (Alabama Environmental Council), F. W. Munson, C. Strain, N. E. Whitfield, Deborah Cuva, Ben & Winn Welch, R. & G. Ludwig, Karen Lovell, Marion Zachiel, Yvonne Seperich, Robert Peeples, John Schwarz, Jr., Mary Schwarz, Isahl Hemm, Sharron Eckert, Stephen Stedman, C. T. Brewster, Katherine Osborn

Response: TVA is also concerned about air pollution and has long led research efforts in controlling air pollution from coal-fired power plants. In response to the requirements of the Clean Air Act, TVA has substantially reduced its emissions since 1976. Particulate emissions have been reduced by 90 percent. Sulfur dioxide emissions were reduced by 50 percent from 1976 through 1990 and are expected to be reduced a total of 80 percent when TVA completes the actions being taken to comply with the 1990 Clean Air Act Amendments. Nitrogen oxides emissions are also expected to be reduced by about 50 percent in response to the 1990 amendments. Other actions are being taken to reduce TVA's use and release of chlorine compounds. These emission reductions help ameliorate a number of pollution problems: ozone (smog), acid rain, visibility impairment, and depletion of stratospheric ozone (the ozone hole).

These actions are described in Energy Vision 2020. (See the Air Pollutants section of Volume 2, Technical Document 1 for discussion of trends in emissions of sulfur dioxide and nitrogen oxides.) For estimated TVA contributions to pollutant loading in the Valley, the following are discussed in Volume 2, Technical Document 1: tropospheric ozone (see pages T1.52 to T1.53), sulfate and nitrate deposition (acid rain) in the Great Smoky Mountains National Park (see page T1.62), and sulfate particle loading (visibility) in the Great Smoky Mountains National Park (see page T1.65).

TVA projects that the strategies in Energy Vision 2020 compared to TVA's 1995 emission levels would reduce sulfur dioxide by up to 57 percent, and nitrogen oxides by up to 16 percent. Greenhouse gas emissions are expected to increase but would be up to 13 percent less than the reference strategy and would be less on a per kilowatt-hour basis compared to the present system. This occurs despite a projected increase in coal combustion on the TVA system of up to 35 percent more than current combustion rates.

839

Comment: *Utilities across the nation are responsible for 72 percent of sulfur dioxide, 33 percent of nitrogen oxides, 36 percent of carbon monoxide, 33 percent of particulate matter, and 25 percent of mercury. This needs to be looked at.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition)

Response: Energy Vision 2020 examined the potential effect of various energy resource options and strategies on emissions. (See Volume 1, Chapter 9 and Volume 2, Technical Document 2.)

840

Comment: *TVA's contributions to visibility in the Smokies may not be as small as they think it is. At some point in the near future, modeling of nitrogen oxides and sulfur dioxide emissions needs to be done.*

Comment by: Arthur Smith

Response: TVA, the Electric Power Research Institute, and other southeastern utilities are addressing the Great Smoky Mountains visibility issue at this time through a jointly funded research effort in partnership with the National Park Service. Data are currently lacking that are necessary to adequately model sulfur dioxide and nitrogen oxides emissions affecting the Great Smokies. Although not quantified through detailed ambient air quality modeling, the analyses done for Energy Vision 2020 conclude that TVA's typical contribution to visibility problems in the Smokies are likely to be relatively small because of prevailing meteorological conditions, the location of TVA coal-fired plants, and because the production of visibility-impairing sulfates from emitted sulfur dioxide is slow. TVA nitrogen oxides emissions contribute only insignificantly to visibility impairment. The ongoing research effort will help to improve the understanding of this issue.

Energy Vision 2020 recognizes the benefits of locating any additional generating capacity in the western part of the TVA system, farther from the Great Smoky Mountains. (See Volume 1, Chapter 10, page 10.4 to 10.5.)

841

Comment: *In Volume 2, Technical Document 1, page T1.33 and in Volume 1, Chapter 3, page 3.13, a 40 percent drop from 500,000 tons per year to 305,000 tons per year is shown to occur between 1998 and 2000. In Volume 2, Technical Document 2, page T2.23, the yearly nitrogen oxides emissions for a number of strategies is shown. The average post-2000 emission rate is about 425,000 tons per year, with only one strategy showing 385,000 tons per year. The figure in Volume 2, Technical Document 2, page T2.27 shows only about a 20 percent drop in nitrogen oxides emissions per unit of energy generated. Now the optimistic figure has the footnote that the reductions of 40 percent will occur if TVA complies with the 1990 Clean Air Act Amendments. From the discussion accompanying the figures in Volume 2, Technical Document 2, pages T2.23 and T2.27, it is clear that TVA does not intend to comply with the 1990 Clean Air Act Amendments regarding emissions of nitrogen oxides. I recommend that at a minimum, the text accompanying the figures in Volume 2, Technical Document 1, page T1.33 and in Volume 1, Chapter 3, page 3.13 be modified to show that TVA will not, in fact, achieve such reductions. I would prefer that the figure be changed to show expected reductions, rather than mandated reductions that will not be realized.*

Comment by: William Grant (Sierra Club, Virginia Chapter)

Response: TVA will certainly comply with all requirements of the 1990 Clean Air Act Amendments, including nitrogen oxides reduction requirements. However, the Environmental Protection Agency has not established the nitrogen oxides removal limits for Phase II Group 1 (wall and tangential fired) boilers and for Group 2 (cyclone, cell burners, etc.) boilers. These limits are expected to be finalized by January 1, 1997. TVA's treatment of the uncertainty related to these future limits is the cause of the apparent inconsistency discussed in the comment.

In Volume 1, Chapter 3, and Volume 2, Technical Document 1, TVA described the affected environment in which Energy Vision 2020 decisions are being made. TVA attempted to project the actual level of nitrogen oxides emissions for the reference case (which assumes full compliance with all Clean Air Act requirements) for comparison with historical emissions. In order to make this a meaningful comparison, we used our best judgment of what the Environmental Protection Agency would establish as the limits in 1997 and included these limits in our projections (further assuming these reductions would be required by 2000). Volume 1, Chapter 3, Figure 3-9, and Volume 2, Technical

Document 1, Figure T1-26, show emission projections that include these anticipated reductions of approximately 40 percent.

In the calculations made to compare the performance of alternative energy strategies, the focus is on differences between the strategies and the absolute emissions level is less important. For these calculations, we did not attempt to quantify the additional emissions reductions that will be required as a result of the 1997 Environmental Protection Agency rulemakings. Therefore, the emissions portrayed in Volume 2, Technical Document 2, Figures T2-18 and T2-22 are not identical to those given in the earlier figures.

842

Comment: *There are health impacts associated with coal gasification, which has been proposed for Bellefonte, as well as with coal-fired plant emissions.*

Comment by: Bruce Wood, C. L. McKinney (Creret, Inc.)

Response: Coal gasification, such as that used in the integrated gasification combined cycle technology, generally has low emissions. This is why it is viewed as a clean coal technology. Any emissions from use of this technology would have to meet a number of environmental requirements that are formulated to protect public health and welfare.

843

Comment: *TVA's world-class scientists and economists should be mandated to eliminate TVA's emissions of carbon and sulfur.*

Comment by: Linda Cataldo Modica

Response: It would be very economically costly to eliminate all carbon and sulfur emissions from the TVA system and would be an extremely difficult task. This could be done in two ways: (1) replacement of all existing TVA fossil plants and combustion turbines with non-emitting technologies (nuclear, hydro, or renewables) and/or (2) removal of all carbon dioxide and sulfur dioxide gases from TVA's existing coal plants and combustion turbines. TVA has considered such options in the past and found that both of these options are extremely capital cost-intensive and uneconomical. TVA reduced sulfur dioxide emissions 50 percent between 1976 and 1990 by adding scrubbers and switching fuels to medium and low sulfur coal. Sulfur dioxide emissions will be reduced to about 20 percent of the 1976 level by the addition of the recently installed Cumberland Fossil Plant scrubbers, one or more future scrubbers, and fuel switches by approximately 2005. Upon completion of these activities, TVA will have significantly reduced its sulfur dioxide emissions. As explained in Volume 2, Technical Document 2, Environmental Consequences, TVA has committed in the Climate Challenge Program to manage its potential carbon dioxide emissions in order to achieve a 22.7 million ton reduction compared to the reference case.

More could conceivably be done to reduce TVA's sulfur dioxide and carbon dioxide emissions, but TVA has to strike a balance between various objectives including controlling cost, managing debt, increasing economic development, maintaining competitive rates, mitigating risk, improving system reliability, and monitoring environmental impacts. Many of TVA's customers have indicated that electricity rates are their major and foremost concern, and we expect rates to become increasingly important as competition increases. Consequently, TVA is continuously looking for ways to enhance the environment in a cost-effective manner.

844

Comment: *We believe that global warming is a serious threat to humanity, and TVA's resource portfolio shows substantial increases in carbon dioxide emissions. Additional information should be provided about greenhouse gas emissions including TVA's participation in the Department of Energy Climate Challenge Program.*

Comment by: John Johnson (Earth First), Nancy Bell, Eric Hirst (Oak Ridge National Laboratory), Linda LaForest (Tennessee Citizens for Wilderness Planning)

Response: There remains considerable uncertainty regarding the possible effect of carbon dioxide and other emissions on global climate. However, at the Earth Summit in Rio de Janeiro, Brazil in June 1992, the United States and over 150 other nations signed the United Nations Framework Convention on Climate Change, establishing the objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous man-made interference with the climate system. In October 1993, the President announced the Climate Change Action Plan, which has the goal of returning United States greenhouse gas emissions to 1990 levels by the year 2000. As part of this action plan, the United States Department of Energy initiated the Climate Challenge, which is a voluntary program to manage United States electric utility greenhouse gases through reduction, avoidance, or sequestering of greenhouse gases.

On April 20, 1994, the Climate Challenge Memorandum of Understanding was signed by the Department of Energy, four utility organizations, and TVA. Subsequently, 104 individual Climate Challenge Participation Accords have been signed with the Department of Energy that represent 487 utilities including TVA. The efforts taken by TVA and the other 450 plus Climate Challenge participants will mitigate possible negative effects utility emissions may have on global climate in a more cost-effective manner than other control measures such as emissions regulations or carbon taxes. TVA is committed to a 22.7 million ton reduction in carbon dioxide by the year 2000 in the Climate Challenge Participation Accord. These reductions are projected from TVA's 1987 to 1990 baseline emissions and the emissions projected by a year 2000 modified reference case. Primarily, TVA greenhouse gas reductions by the year 2000 come from increased use of nuclear power, biomass cofiring, demand-side management programs, fossil-fuel power plant efficiency improvements, transmission system improvements, and hydroelectric power plant modernization.

Although actual carbon dioxide emissions increase under all strategies (see Volume 2, Technical Document 2, Figure T2-20), the rates of increase have been mitigated by Climate Challenge actions and are also less than increases under the Energy Vision 2020 reference strategy. Additionally, the carbon dioxide emitted per unit of electric energy produced would be 10 to 15 percent lower than TVA's present power system (see Volume 2, Technical Document 2, Figure T2-24) by the year 2005. This increase in efficiency throughout the planning period is due to: (1) increased production of nuclear power, (2) hydroelectric power plant modernization, (3) addition of more efficient fossil-fired plants, (4) increased use of renewables, and, (5) in some strategies, the repowering of existing coal-fired plants with more efficient energy conversion systems. The final document has been changed to provide this information.

The possibility of future carbon dioxide regulation was also evaluated in Energy Vision 2020 as an uncertainty. It was assumed for purposes of this uncertainty that there would be a cap on carbon dioxide emissions beginning in the year 2000 at 1990 levels. Any carbon dioxide emissions above this cap could be purchased at $10 per ton of carbon dioxide and any emissions below the cap could be sold for the same price. Because of this cap, there would be a direct reduction of carbon dioxide emissions of 2 million to

3 million tons per year on the TVA system. Also, long-term costs were increased sufficiently to reduce emissions to 1990 levels assuming a cost of $10 per ton of carbon dioxide. The cost of this emission reduction averaged $257 million per year for TVA.

845

Comment: *Why do carbon dioxide emissions increase each year from 1996 through 2004 then decline in 2005 and increase from 2005 to 2020?*

Comment by: Eric Hirst (Oak Ridge National Laboratory)

Response: Referring to Volume 2, Technical Document 2, Figures T2-2 and T2-20, increases in equivalent carbon dioxide emissions are due to the addition of fossil-fired supply-side options at various times. Decreases are due to implementing supply-side options with equivalent carbon dioxide reductions at various times. These options include coalbed methane recovery, landfill methane recovery, and biomass.

846

Comment: *According to the Environmental Protection Agency's fourth Annual Green Lights Report, energy-efficient lighting would prevent carbon dioxide emissions equivalent to those of 43 million cars.*

Comment by: Michelle Neal (Tennessee Valley Energy Reform Coalition)

Response: One of the actions that TVA is taking to conserve electricity is participation in the Green Lights Program. In fact, TVA is a charter federal partner in the program. Program participants are required to survey all of their facilities to determine where and what type of more efficient lighting would be cost-effective. A goal of the program is to ultimately implement (by 2005) all of the lighting replacements for which there would be at least a 10-year economic payback.

TVA is proposing to take additional actions to improve its efficiencies and to conserve energy in the short- and long-term plans of Energy Vision 2020. (See Volume 1, Chapter 9, Figure 9-23 and Chapter 10, Figure 10-1.)

847

Comment: *Motor vehicle emissions cause air pollution in the Great Smoky Mountains. Maybe TVA should be promoting electric cars. Electric vehicles are not zero-emission vehicles. The plants that produce electricity also produce pollution.*

Comment by: Al Fritsch (Appalachia–Science in the Public Interest), Barbara Altizer (Virginia Coal Council)

Response: TVA has included electric transportation research in the short-term action plan. (See Volume 1, Chapter 10, Figure 10-1 and Volume 2, Technical Document 7, page 7.93.) This would include electric buses and vans for commercial, industrial, and municipal customers and electric cars for residential customers in selected areas. While the option is generally perceived as a means of reducing emissions and improving the environment, the environmental advantages and disadvantages of the program will be considered in evaluating the research and pilot program data. For example, the potential for increased point source emissions from power plants to accommodate the increased electrical demand would be determined because this could offset the reductions from use of electric vehicles. In addition, if this option is pursued, the spatial and temporal shifts in emissions (such as reducing ground-level volatile organic compounds emissions from vehicles in ozone nonat-

tainment areas and increasing emissions of nitrogen oxides from large point sources in other areas) and resultant impacts on the environment would be examined.

848

Comment: *TVA should reduce sulfur dioxide, nitrogen oxides, and carbon dioxide emissions, using wood and agricultural waste, but not garbage or whole logs.*

Comment by: John Johnson (Earth First)

Response: In the short-term action plan of Energy Vision 2020, TVA proposes to cofire wood waste biomass with coal. (See Volume 1, Chapter 10, Figure 10-1.) This option provides greenhouse gas reductions. Other steps are being taken to achieve large reductions in sulfur dioxide and nitrogen oxides emissions to meet requirements of the 1990 Clean Air Act Amendments. In its investigation of refuse-derived fuel and biomass projects, TVA will evaluate potential environmental impacts.

849

Comment: *Air indices were developed to help characterize how TVA power system operations in combination with other alternative energy strategies might affect air quality. The development of indices was innovative in that it allowed assignment of relative importance to each air emission based on TVA's contribution in affecting overall human health and the environment in general. The weighting methodology is detailed in Volume 2, Technical Document 1, Comprehensive Affected Environment. Due to uncertainty in scientific understanding of how TVA emissions contribute to overall pollutant exposures and how changes in exposure result in changes in impacts, the indices were primarily developed to express differences in relative importance of the impacts themselves. The weightings are provided in Volume 2, Technical Document 1, Figure T1-57. The indices reflected the following impact areas:*

1. *Human health*
2. *Visibility impairment*
3. *Forests and crops*
4. *Material damage*
5. *Greenhouse gas (potential impacts)*

The approach had the advantage of giving greatest importance in the analysis of strategies to those emissions of greatest concern for causing impacts. In all strategies, the indices after analysis reflected improvement over the "base case." It was significant that all strategies also improve on the index for greenhouse gases compared to the reference strategy. Actual emissions were also estimated for each alternative strategy. Reductions were found for all options as reflected in Volume 2, Technical Document 2, Figures T2-15 and T2-16. Air quality impacts have been sharply minimized by decisions to comply with Phase II of the Clean Air Act as well as control options associated with carbon dioxide reduction. TVA's commitment to the United States Department of Energy Climate Challenge will further enhance this protection. Given TVA's modeling capability, the selection of specific options can be expected to satisfy these commitments when those details are known.

Comment by: TVA Retirees Association

Response: TVA developed the air indices to be responsive to the air emissions and impacts of concern.

WATER RESOURCES

850

Comment: *While we agree that the idea of upgrading of hydro units is generally a good one, and that hydros (as opposed to fossil-fuel power plants) do not produce significant water pollution or require National Pollutant Discharge Elimination System permits, they can produce substantive reservoir and downstream impacts. It is unclear, for example, if the minimum flows of the upgraded hydros would increase, decrease, or stay the same. In general, instream studies should be conducted for these hydros in coordination with the United States Fish and Wildlife Service to determine appropriate flows for the given habitat and fishery (Instream Flow Incremental Method studies), and with the state/Environmental Protection Agency to determine minimum flows for assimilative capacities (National Pollutant Discharge Elimination System permitting).*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: In 1991, TVA conducted a comprehensive review of its Tennessee River and reservoir system operation. As a result of that review, TVA decided, among other things, to improve dam tailwater conditions by maintaining minimum flows below 16 dams and to aerate releases below 16 dams to increase dissolved oxygen. This initiative was approved prior to the Energy Vision 2020 process and is being undertaken without regard to whether or not a hydro modernization project is planned at a particular hydro plant, although the choice of aeration technique may be influenced by plans for upgrading. Where such projects are planned, minimum flows will not be significantly changed. The minimum flows established at each hydro plant were based on Wetted Perimeter studies. Instream Flow Incremental Method studies have been done by TVA at some, but not all, TVA hydro plants.

The effects of this initiative were accounted for in Energy Vision 2020.

851

Comment: *Groundwater would need to be considered in site-specific documents for power generation sources such as power plants that involve the use of groundwater for make-up water for cooling towers or cooling reservoir water, or for on-site potable water and sanitation. Seepage from cooling reservoirs into groundwater systems would also need to be modeled and monitored to ensure consistency with any state groundwater quality standards. Alternatives to groundwater use should also be considered and may be particularly important at certain sites where groundwater quantity is a concern.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA will consider groundwater resources and their protection in future site-specific environmental reviews, as appropriate.

852

Comment: *The following comment is based on projected project impacts described in Volume 2, Technical Document 2, Environmental Consequences. It is based on our concerns regarding impacts to fish and wildlife resources from reservoir operations and land use on TVA projects in North Carolina.*

The project document mentions recent TVA efforts to improve dissolved oxygen levels in reservoir releases. The North Carolina Wildlife Resources Commission continues to participate in evaluation of efforts to improve water quality in TVA project tailwaters. We are

also committed to active, watershed-level management of land and water uses that affect water quality and recreational activities on TVA project reservoirs. Comparative discussion of water quality impacts from the various alternatives does not appear to address the effects of different demands on hydropower operations. Impacts on quality of dam releases and reservoir retention times would have relevance for North Carolina waters and should be discussed.

North Carolina Wildlife Resources Commission is concerned regarding impacts of project operations on river flow rates and reservoir levels. Magnitude and timing of reservoir releases may have significant effects on fishery resources, both within reservoirs and in tailrace areas. Habitat availability in both areas is directly impacted by flow rates, with impacts to fisheries ranging from reduced reproductive success to loss of species in severally impacted areas. The document should place greater emphasis on the effects of each long-term operations strategy on hydropower demand, tailrace flow variability, and reservoir water level fluctuation. No comparison of strategies based on water quantity issues is given, and recommendations on preferred strategies are not possible.

Comment by: Chrys Baggett (North Carolina State Clearinghouse)

Response: The existing minimum flow rates below each TVA hydro plant were established as part of TVA's 1991 Lake Improvement Plan and will be met for the upgraded plants. Overall water flow and discharge patterns will change after hydro modernization projects are implemented at individual dams. The appropriate level of site-specific environmental review will be undertaken for each individual project at the appropriate time, including effects on hydro power demand, tailrace variability and reservoir water level fluctuation.

Hydro modernization involves upgrading the efficiency of existing units and no new units would be added. Existing dissolved oxygen and minimum flow targets will be maintained. Modernization projects are planned at 88 of the 109 TVA hydro units including most of those in North Carolina. Such projects will eventually be implemented at all hydro units.

853

Comment: *Indices were developed for water resources impacts. Three water quality impacts were considered: (1) human health impacts by ingestion, (2) impacts on water supply and waste assimilation, and (3) direct impacts on fish, aquatic life, and diversity. In Volume 2, Technical Document 2, a comprehensive discussion of potential and existing pollution and related issues and impacts is provided. In Volume 2, Technical Document 2, Figure T2-27, the indices for each strategy and impact area are provided. In general, there are no significant changes in water quality expected for any of the strategies. For those strategies where coal-fired production increases from existing plants, the impacts are seen to increase slightly.*

A complete discussion of impacts is provided, but the only significant change in water quality occurs where existing coal-burning plants continue to be utilized. Similarly, strategies that increase the use of coal increase projected water impacts, but it is expected that the changes will be small under new regulations.

Since no strategies involve new hydroelectric facilities, no further water resource impacts should result from damming of rivers. The strategy of increasing efficiency of hydroelectric facilities is environmentally beneficial. Like air emissions, new, more efficient coal-fired facilities are expected to reduce thermal and other releases below the reference case.

Comment by: TVA Retirees Association

Response: Your comment has been reviewed and noted.

LAND RESOURCES

854

Comment: *All land-based impacts are expected to be minimal based on the evaluation of existing and future sites. The commitment to avoid impacts or mitigate actions taken will preserve or enhance the natural resource base as energy resource decisions are made for the future.*

Comment by: TVA Retirees Association

Response: Your comment has been reviewed and noted.

855

Comment: *It is difficult to assess impacts of operations alternatives on land use on North Carolina TVA projects. In general, we are concerned regarding habitat loss from construction of new facilities and transmission lines. Specific impacts of projects on land resources will depend on final construction designs and cannot be assessed at the scale involved in the existing document. We anticipate that any future production facilities or utility line expansions will be subject to interagency review.*

Comment by: Chrys Baggett (North Carolina State Clearinghouse)

Response: Environmental reviews of specific generations and transmission facilities will be coordinated with State of North Carolina agencies as appropriate.

856

Comment: *I am concerned about radioactive waste from TVA's Nuclear Plants. There is no safe means of disposal.*

Comment by: David Bordenkircher, John Harwood, Ruth Peeples, Walter & Dorothy Stark, L. M. Johnson, Sr., Betty Martin (Friends of the River), Scott Banbury, Clark Buchner (Sierra Club, Tennessee Chapter), Faith Young, Michelle Carratu, Susan Switzer, Susan Bailey, John Johnson (Earth First), Ann & Mike Sanders, Susana Harwood, Beth Wallace, Salo, Ray Williams, Karl Grotke, Dottie Hodges, Shirley Schaaf, Tohert, Hermann, Kim Grube, K. Varnum, Garry Shores, Kathy Priore, Karah Bates, M. Case, Amy Perry, Jean Cheney, John Schwarz, Jr., Lynn Leach (Alabama Environmental Council), Karen Lovell, C. Strain, Sahara, Yvonne Seperich, C. T. Brewster, Stephen Stedman, Sharron Eckert, Stephanie Calvert, Mary Schwarz, Myles Jakubowski (Sunbeam Household Products), Robert Peeples, Deborah Cuva, Marion Zachiel, A. B. Evans, Isahl Hemm, Mary Anne Terry, Katherine Osborn, Luther Gulick, William Emmott, Jo Anne Clark, M. Nathan Perry, N. E. Whitfield, F. W. Munson, Ben & Winn Welch, R. & G. Ludwig, Chris Gulick

Response: The Nuclear Waste section of Volume 2, Technical Document 1, page T1.122 describes high-level and low-level waste and how TVA will manage radioactive waste from its nuclear plants. The Nuclear Plant Impact section of Volume 2, Technical Document 2, page T2.46 describes the environmental consequences from the operation of TVA nuclear plants.

Used fuel has been stored safely at nuclear plant sites since the late 1950s, when the first nuclear energy plants began making electricity. TVA plans to continue to store spent nuclear fuel on-site at plant locations where it is generated until the Department of Energy accepts physical custody for ultimate disposal.

TVA is among the best in the industry at reduction of low-level waste using compaction, incineration, and decontamination techniques. TVA ships low-level waste to a disposal facility near Barnwell, South Carolina in specially designed boxes, drums, or

steel containers. There has never been a serious transportation incident involving the disposal of radioactive material.

The Barnwell facility was scheduled to be closed on December 31, 1995, and TVA had planned for on-site storage until the new facility in North Carolina opened in 1998. On July 1, 1995, South Carolina left the Southeast Compact and opened the facility to waste generators in all states except North Carolina until the site reaches capacity in approximately 7 to 10 years. TVA plans to continue to use the Barnwell disposal facility or the North Carolina facility for the foreseeable future.

The Energy Vision 2020 document has been modified due to the change in Barnwell's status.

857

Comment: *Power generating sources need not be intrusively noisy (e.g., solar, wind, wave options), but generally have a degree of noise associated with them (e.g., power plant, hydro options). Noise is commonly associated with single events associated with facility construction and operation, which can be intrusive, as well as with fuel delivery to the facility. Site-specific evaluations of proposed projects should consider alternative sites having minimal nearby sensitive receptors, ensure compliance with Occupational Safety and Health Administration regulations and local noise ordinances, assess attributable noise impacts, and propose mitigation as appropriate. Such energy generation sources should also be in compliance with the Environmental Protection Agency target noise levels and the noise guidelines developed by the Federal Highway Administration and the Department of Housing and Urban Development, where appropriate. The Environmental Protection Agency target noise levels are detailed in the so-called "Levels" document (USEPA, 1974. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety." EPA/550-9-74-004).*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: Noise assessment will be a part of any site-specific environmental reviews, as appropriate.

858

Comment: *TVA should address more fully how it will pay for the cost of decommissioning its nuclear plants and the decommissioning process should be described and how the plant will look.*

Comment by: Richard Simmers, John van der Harst, Jeannine Honicker, Mary English (University of Tennessee)

Response: TVA's policy on the collection of funds for decommissioning is explained, and activities associated with the decommissioning fund are described in the section on TVA's Nuclear Plants in Volume 2, Technical Document 3, page T3.8.

Investment of power funds have been made since 1982 to provide for accumulation of funds for decommissioning nuclear plants. TVA's policy is to collect funds for decommissioning through rates based on a constant dollar amount adjusted for inflation over the life of the operating license of a nuclear plant. Decommissioning expense has been recovered from ratepayers annually based on the present value of amounts not provided through earnings on the fund.

The proposed future use of a nuclear plant site is an important factor in determining how a plant site will look after decommissioning. At this time, it is premature to specify how sites may be used.

Decommissioning options considered in Energy Vision 2020 are:

1. The DECON Option involves the prompt removal of fuel assemblies, source material, radioactive fission and corrosion products, and all other radioactive and contaminated materials above the Nuclear Regulatory Commission unrestricted release levels, from the plant. The reactor pressure vessel and internals would be removed, along with removal and demolition of the remaining systems, structures, and components with contamination control employed as required. The site may then be released for unrestricted use. This is the most expensive of the three options.
2. The SAFSTOR Option involves removing all fuel assemblies, nuclear source material, radioactive liquid, and solid wastes from the plant. The remaining physical structure would then be secured and mothballed. External doors and hatches would be locked and secured to prevent unauthorized entry. Systems needed to monitor the facilities would be used throughout the dormancy period. A full-time security force would have to be maintained at the plant. After a time period of up to 60 years, the facility would then be decontaminated to the Nuclear Regulatory Commission unrestricted release levels and the site would be released for unrestricted use. This option is essentially deferred decontamination, which takes advantage of the natural dissipation of almost all of the radiation. Dismantling of structures would occur after the dormancy period.
3. The ENTOMB Option consists of sealing or entombing residual radioactive or contaminated materials and components within a structure that prevents access by unauthorized personnel. All nuclear source material, fuel assemblies, radioactivity liquid wastes, and solid wastes would be removed prior to entombment. The entombment boundary would normally contain those portions of the reactor building above certain levels of radioactivity. A structurally long-lived material, such as concrete, would be used to seal the building. The objective of entombment is to keep the contaminated material and structure encased until the Nuclear Regulatory Commission's unrestricted access levels are reached. This would likely take up to 100 years to achieve and, for a few radioactive isotopes associated with nuclear reactors, a longer period could be necessary. Although the Nuclear Regulatory Commission considers entombment and the other two options to be acceptable, its regulations presently require that decommissioning be completed within 60 years of shutdown. Absent a change in the regulations, it would therefore be necessary to institute some level of decontamination activities at the end of the entombment period to return the site to unrestricted use. In such an event, the SAFSTOR option would resemble the ENTOMB option.

Decommissioning cost estimates in Energy Vision 2020 are based on the most expensive of the options, the DECON option.

859

Comment: *Loss of institutional control at the Department of Energy's high-level permanent repository has not been addressed. There is not signage technology that will endure for 10,000 years.*

Comment by: Dennis Haldeman, Jennifer Lapidus & Hannah Bennett

Response: This is expected to be addressed by the Department of Energy in the development of a long-term storage disposal site. Energy Vision 2020 addresses disposal in Volume 2, Technical Document 1, page T1.122.

860

Comment: *The spent fuel from Watts Bar Nuclear Plant cannot be shipped off-site due to a ruling by the Sixth Circuit Court of Appeals which said the highways cannot be used.*

Comment by: Ann Harris

Response: The Nuclear Waste Policy Act of 1982 required the Department of Energy to develop a permanent geological repository for spent nuclear fuel and to develop a transportation infrastructure for moving the fuel from utility plant sites to the repository. Transport of spent fuel would be required to meet Department of Transportation, Environmental Protection Agency, and Nuclear Regulatory Commission regulations. Currently, spent fuel shipments are being made between existing nuclear plant facilities in several states in compliance with these regulations. Earlier this year, the Department of Energy announced that a repository would not be in operation before the year 2010, therefore, it could not fulfill its obligation to accept spent fuel for storage in 1998. In response to this situation, new legislation has been proposed in both the House of Representatives and the Senate to amend the 1982 Act to allow the Department of Energy to develop an interim storage facility to begin accepting spent fuel by 1998. The proposed legislation also includes provisions for developing the necessary transportation infrastructure to move spent fuel to the interim storage facility and eventually to the permanent repository.

861

Comment: *There are no rules or regulations regarding nuclear waste anywhere in the nation.*

Comment by: Ann Harris

Response: The regulations, legislation, and agencies involved in the management of nuclear waste are discussed in the section on Nuclear Waste in Volume 2, Technical Document 1. Nuclear waste is heavily regulated.

862

Comment: *There are proven links between radioactivity and cancer. People in this area are experiencing a 16 percent increase in breast cancer mortality. Nuclear power is dangerous.*

Comment by: Howard Switzer (Sun/Earth Tempered Organic Architecture), Beth Zilbert (Greenpeace), Monique Mollet, Anne Redwine, Jeannine Honicker, Leith Patton, Hamp Dobbins, Jr., Stephanie Calvert

Response: The report alleging fatalities from breast cancer are increasing in areas affected by nuclear facilities was released by Greenpeace at press conferences in several locations. It was not published in any technical journal and was released without peer review. Other reports issued by Greenpeace have been criticized by respected health physicists for selectively using statistics to support the desired outcome.

The 1995 Greenpeace report, "Nuclear Power, Human Health and the Environment: The Breast Cancer Warning in the Great Lakes Basin" is an example where proof of the assertions was not supported by the analysis according to a peer review by two experts in environmental and cancer epidemiology at the University of Massachusetts. A report issued in March 1995 by the Minnesota Department of Health, Chronic Disease and

Environmental Epidemiology found that breast cancer mortality trends over the period 1950 to 1992 in the 10 counties near nuclear power plants in the state of Minnesota show no discernible difference from the statewide trend.

The largest study of cancer rates, by the National Cancer Institute, found no increased levels of cancer around nuclear plants. Rather this study found that breast cancer mortality increased more in states without nuclear power plants than in states with such facilities.

Repeated surveys around TVA's operating nuclear plants have shown no detectable increase in radiation levels over normal background levels. The nearest plant neighbor gets about 10 times more radiation from watching a color television than from the nuclear facility. TVA does not expect to see cancer rates increase because of the operation of any of its nuclear units.

863

Comment: *The federal government has this year reneged on its plans for a permanent repository.*

Comment by: Susan Switzer

Response: The Nuclear Waste Policy Act of 1982 required the Department of Energy to develop a permanent geological repository for spent nuclear fuel and to begin accepting this fuel for storage by 1998. Earlier this year, the Department of Energy announced that a repository would not be in operation before the year 2010; therefore, it could not fulfill its obligation to accept spent fuel for storage in 1998. In response to this situation, new legislation has been proposed in both the House of Representatives and the Senate to amend the 1982 Act to allow the Department of Energy to develop an interim storage facility to begin accepting spent fuel by 1998. The interim storage facility would use currently available technology to store spent fuel assemblies in heavily shielded containers. This interim storage facility would be continuously monitored and would safely store the spent fuel until such a time as the permanent repository is operational.

864

Comment: *As a former TVA employee, I became aware that TVA did not know what it was doing when it was designing and building its nuclear plants. Pipes in the plants were unknown and in case of fire they would not know which ones to turn on.*

Comment by: Rela Edwards

Response: TVA has identified all critical piping and other systems in its nuclear plants, including those important for fire control. In addition, TVA has a well-equipped and trained fire brigade team on site at each operating nuclear facility 24 hours per day, 7 days per week to respond to all fire emergencies. Fire brigade members are trained in the use and testing of all fire-fighting equipment. Mutual aid agreements with area fire departments are in effect to provide back-up fire support, if necessary.

Pre-fire plans which provide strategy and tactical information and guidelines to support fire emergencies have been developed to meet Nuclear Regulatory Commission and insurance company requirements. The pre-fire plans provide information on locations of available fire-fighting equipment and how to operate fire suppression systems in the area, as well as identifying any hazards which the brigade may encounter. Sketches are provided for each plant area to serve as a quick reference.

865

Comment: *Disregarding the cost factor, nuclear plants must have infallible equipment and infallible workers because a meltdown would leave our cities uninhabitable and the Price-Anderson Act put a ridiculous limit on compensation to home and business owners lucky enough to escape. If nuclear plants were safe, insurance companies would be glad to offer insurance.*

Comment by: Fred Wright

Response: The Price-Anderson Act, which is an amendment to the Atomic Energy Act, requires nuclear power reactor licensees to have and maintain financial protection (i.e., liability insurance) to enable them to respond to public liability claims (e.g., personal injury and property damage) that might result from a nuclear incident associated with the operation of a nuclear power reactor.

TVA purchases a $200 million nuclear liability insurance policy from American Nuclear Insurers. American Nuclear Insurers is comprised of a group of insurance companies (e.g., Aetna, Allstate, Continental, State Farm, etc.) which pools their resources to offer this insurance.

The Price-Anderson Act includes a secondary layer of financial protection consisting of a retrospective premium which can be assessed of each operating nuclear reactor.

These two layers provide $8.9 billion of financial protection available to respond to an incident.

866

Comment: *I have recently read about four more accidents at Russian nuclear plants. So I think we really have to take into account the safety reports at Sequoyah and Watts Bar Nuclear Plants. The plan needs to address nuclear safety.*

Comment by: Anne Redwine, Bruce Wood

Response: Through careful, conservative planning for safety, the potential risk of nuclear reactors has been reduced to a very low level. Nuclear plants supply energy reliably, safely, and with little environmental impact. The Nuclear Regulatory Commission monitors operations every day and conducts comprehensive reviews that cover all aspects of the plant. The nuclear industry and TVA are dedicated to safe and efficient nuclear plant operations.

Two serious accidents have occurred in 30 years of commercial energy production—the Three Mile Island accident and the Chernobyl accident. No one was injured or died as a result of the accident at Three Mile Island. In the United States, nuclear energy plants use a series of physical barriers to prevent the release of radioactivity. About half of the uranium fuel at Three Mile Island melted, but only minute amounts of radioactive material escaped into the environment because the multiple barriers contained the release of radioactivity. The radiation exposure from Three Mile Island was much less than most of us receive each year from naturally occurring radioactive materials in soil, rocks, air, food, and water.

The Chernobyl plant in the Soviet Union had design flaws and no containment structure. As a result of the Chernobyl accident, radioactive material did escape. More than 200 people were hospitalized for radiation exposure and burns, and approximately 30 people died. Reports indicate that more people have died. A plant like Chernobyl could not be licensed in the United States.

867

Comment: *The loss of wetlands, particularly jurisdictional wetlands, should be avoided by all sources of energy generation selected by TVA for the 25-year horizon of the programmatic environmental impact statement. Since the trend of the short-term plan for the TVA preferred resource options appears to be conversion and renovation of existing sites rather than construction of new sources, wetland losses may not be a serious concern for the near term. However, existing facilities may be expanded and the long-term plan construction of new sources such as wind and solar options at new sites could involve wetland filling, while the upstream and downstream water levels of hydros could be altered, which would expose or inundate wetland habitat. Wetland avoidance, restoration, enhancement, creation, and preservation should be incorporated into the TVA energy strategy.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA considers wetlands an important natural resource. In addition, under Executive Order 11990 (Protection of Wetlands), TVA is required, to the extent practicable, to avoid impacting wetlands with new construction. In TVA's activities, a permit is normally required from the United States Army Corps of Engineers under Section 404 of the Clean Water Act prior to disturbing a wetland.

868

Comment: *Environmental problems of the proposal to use caves as compressed air storage facilities have not been studied.*

Comment by: Powell & Sharon Foster

Response: The air storage medium that is the basis for the compressed air energy storage options in Energy Vision 2020 are salt domes, not caves. Caves were not considered as a storage medium for the compressed air energy storage options because of insufficient storage volume and uncertainty about containment integrity (i.e., excess air leakage/loss).

Salt domes are considered effective storage mediums. Salt domes have been employed extensively for several decades by the oil and gas industry as suitable mediums for the storage of these products. Also, the Electric Power Research Institute and the Alabama Electric Cooperative investigated the environmental impacts of air storage in salt domes as a part of the Alabama Electric Cooperative's 110-megawatt compressed air energy storage facility in McIntosh, Alabama. There were no detrimental environmental impacts identified.

869

Comment: *If future studies show harmful effects of electric magnetic fields on humans, the Environmental Protection Agency would expect TVA to take a more aggressive approach towards addressing old transmission lines and substations. The results of such studies can be expected sometime during the 25-year horizon of the programmatic environmental impact statement.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: TVA is closely monitoring, as well as participating in, ongoing electro-magnetic field research. If future studies show harmful health effects, TVA will, of course, take appropriate action.

870

Comment: *The Environmental Protection Agency recommends that the sentence in Volume 2, Technical Document 2, page T2.47 stating that "if chemical control is used, only Environmental Protection Agency-approved nonrestrictive herbicides and licensed applicators would be used," be amended to read that "if chemical control is used, only U.S. Environmental Protection Agency-registered nonrestrictive herbicides and licensed applicators would be used." The Environmental Protection Agency recommends use of manual/mechanical control of right-of-way vegetation in lieu of herbicides in most cases. If herbicides are used, their use should be selective, minimized, and consistent with product label directions. As indicated above, only products registered with the Environmental Protection Agency that are appropriate for the target species and application area should be used.*

Comment by: Heinz Mueller (United States Environmental Protection Agency)

Response: This sentence has been changed in the final Energy Vision 2020 report.

871

Comment: *Garbage burning results in highly toxic ash, destroys recycling markets, and leads to further deforestation.*

Comment by: Dennis Haldeman

Response: Despite efforts to promote recycling, disposal of garbage is still a major problem. Garbage burning does not increase the amount of garbage produced or the consumption of forests. The refuse-derived fuel options considered by TVA (see Volume 2, Technical Document 6, page T6.18) include removal and recycling of about 20 percent of the material. In the absence of refuse-derived fuel burning, the non-recyclable materials as well as many of the recyclable materials would likely be a waste disposal problem for local governments. They would likely end up in landfills, which are becoming more expensive to operate, are difficult to develop, and can pose a variety of environmental problems. Burning refuse-derived fuel can help alleviate those problems.

SOCIOECONOMIC RESOURCES

872

Comment: *Socioeconomic impacts will be clearly negligible or result in enhancement since all strategies are predicted to improve economic conditions significantly above the "No Action" alternative.*

The results of analysis of economic development impacts are presented in Volume 2, Technical Document 2, Figures T2-12 and T2-13 where the changes in income and employment are shown for each strategy. Impacts due to projected expenditures in the region, as well as costs to the consumer were analyzed and the results appear to illustrate that economic growth is to be expected with all alternatives considered.

Comment by: TVA Retirees Association

Response: Your comment has been reviewed and noted.

873

Comment: *In order to assess potential effects on historical and archeological resources, specific locations for proposed projects must be identified and the state historic preservation officers contacted. This is necessary in order to fulfill the requirements of the National Historic Preservation Act.*

Comment by: Herbert Harper (Tennessee Historical Commission)

Response: Energy Vision 2020 analyzes a range of strategies and proposes a portfolio of options but does not propose specific project sites. As specific sites are proposed for use, additional environmental reviews will be performed, including requirements of the National Historic Preservation Act.

874

Comment: *The more coal we burn, the less vital our tourist trade. They do not come here for Wal-Mart, but for natural beauty.*

Comment by: Retha Ferrell

Response: TVA recognizes the importance of the environment and its relationship to tourism in the region. (See Volume 2, Technical Document 1, page T1.115, Recreational Resources.) Through the multi-attribute trade-off method, TVA was able to compare strategies on the basis of their potential effects on the environment as well as their performance on other evaluation criteria such as economic development, and to revise strategies in order to mitigate unacceptable effects. Issues such as air pollution impacts in the Great Smoky Mountains National Park were explicitly addressed in Energy Vision 2020.

Although the analyses done for Energy Vision 2020 indicate that under the final strategies coal combustion would increase, compared to current combustion rates, associated sulfur dioxide and nitrogen oxides would decrease.

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support obligations, as well as issues expected to arise in connection with the final Hague Conference negotiations on a convention on protection of children (jurisdiction and recognition of custody decrees) and other matters concerning children. Finally, with a view to enhancing private law unification in the Americas, the process and resources committed by the OAS to the OAS-sponsored Specialized Conferences on Private International Law will be discussed, and recommendations sought for practical ways in which that process can be improved. Alternatives to the OAS process may also be considered.

Persons interested but unable to attend the meeting are welcome in writing to request documents and to submit comments or proposals to the office indicated below. Additional topics may be considered depending on time available. In order to facilitate planning for the meeting, members of the public are requested to propose in writing to the office below any topics on which they may wish to comment.

Members of the general public may attend up to the capacity of the meeting room and participate subject to the direction of the Chair. The meeting will be held in Conference Room 1107 at the Department of State; entry should be only via the Diplomatic entrance at 22d and ''C'' Streets, N.W. As access to the building is controlled, in order to expedite entry, the office indicated below should be notified by mail or fax not later than Monday, March 11 of the name, address, firm or affiliation if any, social security number and date of birth of persons wishing to attend.

Additional meeting—following the general Advisory Committee meeting, a meeting of the Committee's study Group on cross-border insolvency will meet on Saturday, March 16, from 10 a.m.–3 p.m. That meeting will take place at the International Law Institute, 1615 New Hampshire Avenue, N.W. Persons wishing to attend should notify the office below in advance.

For information on the Department's program in this field or for copies of documents on particular topics, please contact by mail the Office of the Assistant Legal Adviser for Private International Law (L/PIL), attention Harold S. Burman, at 2430 ''E'' Street, N.W., Suite 355 South Building, Washington, D.C. 20037–2800, or notify Ms. Gonzales by fax at (202) 776–8482.

Dated: February 21, 1996.

Peter H. Pfund,

Assistant Legal Adviser for Private International Law, U.S. Department of State.

[FR Doc. 96–4470 Filed 2–27–96; 8:45 am]

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[Public Notice No. 2348]

State Department Advisory Committee Study Group Meeting on UNCITRAL Project on Cross-Border Insolvency

The Study Group on Cross-Border Insolvency of the Secretary of State's of State's Advisory Committee on Private International Law (ACPIL) will hold its next meeting on Saturday, March 16 from 10 A.M. to 3 P.M. to review international efforts to harmonize rules on cross-border insolvency cases involving commercial entities.

The meeting will review the recent Report by the United Nations Commission on International Trade Law (UNCITRAL) Working Group on Insolvency Law, which met in November 1995 to consider possible standards for procedural aspects of cross-border insolvency. No decision has been made as to the form any proposed rules should take, i.e. whether to prepare UN guidelines, consensual rules, a model or uniform law, or a multilateral treaty. The Advisory Committee Study Group meeting will facilitate preparation of possible United States positions for the next meeting of the UNCITRAL intergovernmental Working Group in April, 1996, and consider other United States initiatives as well.

UNCITRAL decided at its Plenary session in May, 1995 to work primarily on procedural, rather than substantive, rules. Based on the Report referenced above, this is likely to cover judicial cooperation, jurisdiction, access to proceedings for foreign trustees and other interests, the relationship between primary, ancillary and secondary proceedings, and related matters. Other procedure concerns may be taken up at this stage in the U.N. process, depending on the interests of participating countries. Future issues, such as substantive law involving priorities of claims and distribution could be considered, if at all, at a later stage.

The relationship of the UNCITRAL project generally to U.S. interests, and its impact on facilitation of international trade will be considered. Current projects by other organizations will be referred to where relevant, including the American Law Institute's project on harmonization of bankruptcy law between the NAFTA states, the International Bar Association's Concordat, the recent European Union proposed treaty on cross-border insolvency, as well as work by INSOL, the American Bankruptcy Institute, and others.

Background documents include the Report of the UNCITRAL Working Group, Dec. 1, 1995, UN Doc. A/CN.9/419; and a Report by INSOL (International Association of Insolvency Practitioners) on the Joint Project of UNCITRAL and INSOL, March 1, 1995. Copies of these documents, as well as the IBA and European Union documents referred to, are available from the Legal Adviser's Office at the address indicated below.

The meeting will be held at the International Law Institute, 1615 New Hampshire Avenue, N.W., Washington, DC 20009 and is open to the public up to the capacity of the meeting room and subject to the rulings of the Chair. Since space is limited, persons wishing to attend should advise Ms. Gonzales of the Office of Legal Adviser (L/PIL), Suite 355 South Building, 2430 ''E'' Street, N.W., Washington, DC 20037–2800, fax (202) 776–8482. Persons who cannot attend the meeting are welcome to submit comments to the Legal Adviser's Office. For further information on this project or on UNCITRAL, please contact Harold S. Burman at the above address or at (202) 776–8420. For information on meeting arrangements, please contact Stuart Kerr of the International Law Institute at (202) 483–3036.

Dated: February 21, 1996.

Harold S. Burman,

Executive Director, Secretary of State's Advisory Committee on Private International Law.

[FR Doc. 96–4469 Filed 2–27–96; 8:45 am]

BILLING CODE 4710–08–M

TENNESSEE VALLEY AUTHORITY

Integrated Resource Plan

AGENCY: Tennessee Valley Authority.

ACTION: Issuance of Record of Decision.

SUMMARY: This notice is provided in accordance with TVA's procedures implementing the National Environmental Policy Act. TVA has decided to adopt the preferred alternative identified in its final programmatic environmental impact statement (EIS), ''Energy Vision 2020, Integrated Resource Plan.'' The Final EIS was made available to the public on December 21, 1995. The TVA Board of Directors decided to adopt the preferred alternative at its February 21, 1996, public meeting. Under the preferred alternative, TVA has identified a portfolio of energy resource options that it can deploy to meet future energy demands on the TVA power system over the next 25 years. In addition, a short

term action plan identifies actions that TVA plans to take over the next three years.

FOR FURTHER INFORMATION CONTACT: Lynn Maxwell, Manager, System Integration, Tennessee Valley Authority, 1101 Market Street, MR 3K, Chattanooga, Tennessee 37402, (423) 751–2539.

SUPPLEMENTAL INFORMATION: TVA is a corporate agency of the United States Government. It operates the Nation's largest public power system. This power system provides power to an 80,000 square mile area, in parts of Tennessee, Alabama, Georgia, Mississippi, Kentucky, North Carolina, and Virginia. Through independent power distributors, TVA serves more than 7.5 million people. TVA also directly serves more than 60 large industrial and Federal installations. The power produced by TVA constitutes approximately 4 to 5 percent of all of the electricity generated in the Nation.

Under the 1992 National Energy Policy Act, TVA has been directed to employ a least-cost energy planning process for the addition of new energy resources to its power system. This Act also requires TVA to provide distributors of TVA power an opportunity to participate in the planning process. In response to this directive, TVA began an integrated resource planning (IRP) process in February 1994. Although TVA prepares project-specific environmental reviews for proposed energy resource decisions, TVA committed to employing a public IRP process and decided to use the EIS process to obtain public input on the IRP itself. Energy Vision 2020 is the result of this commitment and process.

An IRP is simply a plan which broadly identifies the actions which a utility anticipates taking to meet demands for electric service and to achieve its long-term goals and objectives. TVA announced at the outset that its long-term objective was to maintain and enhance its competitiveness. ''Competitiveness'' for purposes of Energy Vision 2020 was viewed as not only maintaining low electric rates and reliable service, but also fostering sustainable economic development and protecting environmental quality.

Future Demands on the TVA System

In order to determine future power needs on a utility system, both the utility's existing energy resources and forecasted future demands must be considered. TVA's existing energy resources have a total generating capacity of 25,600 megawatts. (This does not include TVA's Browns Ferry Nuclear Unit 3 and Watts Bar Nuclear Unit 1. These units were only recently restarted and started, respectively (November 1995). Browns Ferry Unit 3 is already returned to commercial operation and Watts Bar Unit 1 is expected to begin commercial operation in Spring 1996. The combined capacity of these two units is 2,235 megawatts.) Under its medium load forecast, TVA expects to need an additional 6,250 megawatts of energy resources by Year 2005 and 16,500 megawatts by Year 2020. Peak loads on the system in Year 2020 are expected to be about 40,300 megawatts.

TVA uses state-of-the-art energy forecasting models to predict future demands on its system. Because of the substantial uncertainty in predicting future demands, TVA develops three load forecasts: a high, medium, and low. The high forecast has a 90 percent probability of not being exceeded. The medium forecast has a 50 percent probability of not being exceeded. The low forecast has a 10 percent probability of not being exceeded. The Year 2020 peak loads under the high and low forecasts are 56,400 megawatts and 24,400 megawatts, respectively. If future demands approach the high forecast, TVA would need up to 36,000 megawatts of additional energy resources to meet that demand. If demands are closer to the low forecast, TVA would need no additional resources.

Alternatives Considered

The energy resource alternatives formulated for Energy Vision 2020 were the result of an extensive public and analytical process. Several different mechanisms were used to obtain public input at the scoping stage, including surveys of local opinion leaders, extensive interaction with members of a stakeholders group for over a year, 12 public meetings, and a nine-month period in which to submit written comments. After release of the draft IRP and EIS, TVA provided more than 80 days for public review and comment. During this period, TVA held nine public meetings throughout the TVA region on the IRP and EIS.

The primary analytical method used for Energy Vision 2020 was the multi-attribute tradeoff method. This approach allowed TVA to quantitatively integrate the identified environmental impacts of proposed energy resource strategies and to formulate alternative strategies to mitigate adverse environmental impacts while retaining other beneficial characteristics of specific strategies.

Energy resource strategies are created from different combinations of energy resource options. Energy resource options are either supply-side options (*e.g.*, new generating resources such as coal-fired or nuclear units, gas-fired combustion turbines, repowering of existing units, integrated gasification, or wind turbines), or customer service options (*e.g.*, demand-side management actions, including energy efficiency improvements and energy conservation, or beneficial electrification). In TVA's Energy Vision 2020 process, these options were first screened for acceptable performance using multiple criteria, including environmental criteria. These criteria were developed from public input and TVA's objectives.

TVA developed 2,000 energy resource strategies from more than 100 supply-side and 60 customer service options. These strategies were then analyzed through the use of computer models to identify combinations of resource options that best met the evaluation criteria and that effectively dealt with various uncertainties (such as increased stringency of environmental regulations, changes in natural gas prices, or changes in forecasted demands).

The multi-attribute tradeoff method allowed potential environmental impacts of each strategy to be compared to all other evaluation criteria (such as debt, electric rates, and economic development) and to all other strategies on an objective basis. This process identified where real tradeoffs existed. One of the most important tradeoffs occurred between better environmental performance and electric rates because achieving better environmental performance typically produces higher costs and higher electric rates. However, the integrated resource planning process used by TVA allowed it to reformulate strategies repeatedly to produce strategies that performed better across all criteria, including environmental criteria. Potential tradeoffs among criteria were reduced or eliminated. This was done by replacing resource options with undesirable or less desirable effects with options which produced more desirable effects. Eventually, this integration process produced seven final alternative strategies that performed well across all of the criteria, including environmental criteria.

As a result of the multi-attribute integration process, the final seven strategies consisted of similar, although not identical, energy resource options and they tended to produce similar environmental impacts. All of the strategies performed reasonably well from an environmental impact

standpoint and all performed better environmentally than the ''no action'' alternative. (TVA defined ''no action'' as the actions that it would likely have taken to meet future demands in the absence of the proposed IRP. Those actions include adding more combustion turbines and coal fired units to the system.)

For almost every air and water quality impact category, the seven final strategies showed improvement. Although coal usage on the TVA system is projected to increase under all of the final alternative strategies, sulfur dioxide emissions are projected to decrease in Year 2020 from 1996 levels by 47 to 51 percent depending on the strategy. System nitrogen oxide emissions are projected to decline in Year 2000 from 1996 levels by 10 to 20 percent, then increase, but still remain 3 to 13 percent below 1996 levels. This indicates that TVA's contribution to ozone, visibility, and acid rain related impacts should be reduced regardless of the final strategy employed. In contrast, greenhouse gas emissions from the TVA system are projected to increase under all strategies by 25 to 38 percent. This increase is still less than that projected for the no-action alternative (it results in a 52 percent increase) and on a per unit of electric energy basis produced 10 to 15 percent less than that produced by the existing system. This means that the efficiency of the TVA system is improved under the final seven alternatives.

Water quality impacts vary little across the final alternatives. EIS analyses indicated that improving the efficiency of TVA's existing hydroelectric units would be environmentally beneficial compared to impacts associated with building new hydroelectric units or other supply-side resources. The only noticeable difference among the final alternatives is that those strategies which employ more repowering options produce less water quality impacts. A similar reduction in potential air quality impacts also occurs when more repowering options are used.

Most potential land-related impacts are site-specific and would result from implementation of specific resource options. These kinds of impacts will be examined in subsequent site specific reviews. Energy Vision 2020 did look at more generic land-related impacts that are associated with the potential ''footprint'' of resource options. The larger the footprint (the size of the site needed for an option) the more likely there will be adverse land-related environmental impacts. Energy Vision 2020 concluded that due to the availability of appropriate sites in the TVA region, potential land impacts do not pose a constraint. It also concluded that wind turbines posed the greatest risk of adverse land impacts because of their footprint (2,000 megawatts of wind turbines would require up to 50,000 acres).

Preferred Alternative

Rather than select a discrete energy resource strategy from among the final seven strategies as its ''preferred'' alternative, TVA identified a ''portfolio'' of energy resource options as its preferred strategy. All of the energy resource options included in the final seven strategies have been included in this portfolio. In addition, the portfolio includes several other resource options that respond particularly well to certain uncertainties. It also includes other options and actions that the TVA Board directed be included to respond to public comments on the draft IRP and EIS that TVA needed to include more renewable energy resources and demand side management programs.

One of the important conclusions that TVA reached in Energy Vision 2020 was that future events (uncertainties) will likely require changes in any discrete energy strategy. The utility industry is entering an era of significant changes as it moves from a regulated to a less regulated environment. This substantially heightens the already large uncertainties associated with long-range utility planning. Consequently, flexibility in resource option selection and implementation is highly valued. Flexibility heightens a utility's ability to respond to events as they unfold.

The portfolio alternative provides more flexibility than any discrete strategy. Much like a portfolio of stocks is chosen to manage risk and accomplish specific objectives, TVA's preferred portfolio alternative better enables TVA to meet customer needs at an acceptable level of risk and still meet the objectives of balancing costs, rates, environmental impacts, debt, and economic development.

Portfolio options include: combustion turbines, the purchase of options for both base load and peaking power, improvements to the existing hydro system, purchases from independent power producers, combined cycle repowering of coal-fired plants, use of landfill and coalbed methane and refuse derived fuel, converting TVA's Bellefonte Nuclear Plant to an integrated combined cycle gasification plant with a chemical coproduct, one additional coal unit at TVA's Shawnee fossil plant, demand-side management programs, beneficial electrification programs, compressed air energy storage, wind turbines, a coal refinery, a biomass energy facility, and cascaded humidified advanced turbines. As events unfold, TVA can decide which of the portfolio options to deploy. Prior to deploying a specific resource option, TVA would conduct an appropriate site- or project-specific environmental review that tiers off of Energy Vision 2020.

The impacts that result from TVA's portfolio alternative depend on the energy resource options eventually deployed. Although these impacts cannot be definitively assessed at this programmatic level, the impacts identified for the final seven strategies are likely to bound those of the portfolio. It is unlikely that implementation of portfolio options will achieve better or worse environmental performance than those identified for the final seven alternative strategies.

The TVA Board decided to adopt the portfolio alternative as TVA's long-range energy resource strategy for the reasons given above. The portfolio provides the TVA Board and future Boards with a flexible energy plan that will help guide the strategic actions necessary for TVA to serve its energy customers efficiently, and to compete and succeed in the electric utility marketplace in the future. Because the Energy Vision 2020 process integrated economic development and environmental goals with other financial goals, TVA's portfolio of energy resources will allow it to use innovative approaches to meet future demands at competitive prices while providing opportunities for economic growth and a quality environment rich in natural resources.

Because the multi-attribute tradeoff integrated process produced final strategies with very similar environmental impacts, there is not an alternative which is clearly environmentally preferable. However, TVA's preferred alternative, the Energy Vision 2020 portfolio, contains all of the resource options that perform best under the environmental criteria and from this perspective, the portfolio can be viewed as environmentally preferable.

Mitigation and Monitoring Measures

As TVA deploys specific energy resource options, it will appropriately mitigate site-specific environmental impacts. However, the most important mitigative measure associated with Energy Vision 2020 is the multi-attribute tradeoff method used to develop and evaluate energy resource strategies. This method allowed TVA to reformulate strategies in order to reduce potential environmental impacts.

Dated: February 22, 1996.

William J. Museler,

Senior Vice President, Transmission/Power Supply Group.

[FR Doc. 96–4497 Filed 2–27–96; 8:45 am]

BILLING CODE 8120–01–P

DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

Environmental Impact Statement, Essex County, New York

AGENCY: Federal Highway Administration (FHWA), New York State Department of Transportation (NYSDOT).

ACTION: Notice of intent.

SUMMARY: The FHWA is issuing this notice to advise the public that an environmental impact statement will be prepared for a proposed highway project in the town of Jay, Essex County, New York.

FOR FURTHER INFORMATION CONTACT: Harold J. Brown, Division Administrator, Federal Highway Administration, New York Division, Leo W. O'Brien Federal Building, 9th Floor, Clinton Avenue and North Pearl Street, Albany, New York 12207, Telephone: (518) 431–4127, or Richard A. Maitano, Regional Director, New York State Department of Transportation, Region 1, 84 Holland Avenue, Albany, New York 12208, Telephone: (518) 474–6178.

SUPPLEMENTARY INFORMATION: The FHWA, in cooperation with the NYSDOT, will be preparing an Environmental Impact Statement (EIS) on a proposal to replace the County Route (CR) 22 bridge over the east branch of the Ausable River. The proposed improvement will involve the replacement of the existing bridge, and reconstruction of the route for a length sufficient to accommodate the new bridge location.

The bridge replacement would improve Glen Road (CR 22) as a transportation link over the east branch of the Ausable River.

Alternatives under consideration include: (1) No action; (2) rehabilitation of the existing structure; and (3) replacement with a new structure. Variations to horizontal and vertical alignment will also be studied with the various build alternatives.

Based on studies done to date, issues that need to be analyzed in depth include the visual resources, historic and cultural resources, land use, adjacent right-of-way, recreational rivers, and floodplains. The project's effect on features such as the National Register eligible Jay Covered Bridge, the east branch of the Ausable River, and the Adirondack Park will be addressed.

Letters describing the proposed action and soliciting comments will be sent to appropriate federal, State and local agencies, public officials, various organizations and citizens who have previously expressed interest in this proposal. No formal scoping meeting is planned at this time. A public information meeting will be held after additional study. After the Draft EIS is prepared, it will be made available for agency and public review and comment. This will be followed by a public hearing for which a public notice will be given of the time and place of the hearing.

To ensure that the full range of issues related to the proposed action are addressed and all significant issues identified, comments and suggestions are invited from all interested parties. Comments or questions concerning this proposed action and the EIS should be directed to the FHWA or NYSDOT at the addresses provided above.

(Catalog of Federal Domestic Assistance Program Number 20.205, Highway Research, Planning and Construction. The regulations implementing Executive Order 12372 regarding intergovernmental consultation on federal programs and activities apply to this program.)

Issued on: February 20, 1996.

Harold J. Brown,

Division Administrator, Federal Highway Administration, Albany, New York.

[FR Doc. 96–4538 Filed 2–27–96; 8:45 am]

BILLING CODE 4910–22–M

DEPARTMENT OF THE TREASURY

Submission to OMB for Review; Comment Request

February 8, 1996.

The Department of Treasury has submitted the following public information collection requirement(s) to OMB for review and clearance under the Paperwork Reduction Act of 1980, Public Law 96–511. Copies of the submission(s) may be obtained by calling the Treasury Bureau Clearance Officer listed. Comments regarding this information collection should be addressed to the OMB reviewer listed and to the Treasury Department Clearance Officer, Department of the Treasury, Room 2110, 1425 New York Avenue, NW., Washington, DC 20220.

Internal Revenue Service (IRS)

OMB Number: 1545–1076.

Form Number: IRS Form 8807.

Type of Review: Revision.

Title: Certain Manufacturers and Retailers Excise Taxes.

Description: Form 8807 is used to compute the excise tax on fishing equipment, bows and arrows, trucks and trailer chassis and bodies and tractors and the luxury tax on passenger vehicles. (IRC sections 4051, 4161, and 4001).

Respondents: Business or other for-profit, Individuals or households.

Estimated Number of Respondents/Recordkeepers: 46,746.

Estimated Burden Hours Per Respondent/Respondent:

	8807 Part I	8807 Part II	Worksheet I
Recordkeeping	3 hr., 21 min.	4 hr., 18 min.	1 hr., 26 min.
Learning about the law or the form	12 min.	0 min.	0 min.
Preparing and sending the form to the IRS	16 min.	4 min.	1 min.

Frequency of Response: Quarterly.

Estimated Total Reporting/Reporting Burden: 148,618.

Clearance Officer: Garrick Shear (202) 622–3869, Internal Revenue Service, Room 5571, 1111 Constitution Avenue, N.W., Washington, DC 20224.

OMB Reviewer: Milo Sunderhauf (202) 395–7340, Office of Management and Budget, Room 10226, New Executive Office Building, Washington, DC 20503.

Lois K. Holland,

Departmental Reports Management Officer.

[FR Doc. 96–4532 Filed 2–27–96; 8:45 am]

BILLING CODE 4830–01–P

Submission to OMB for Review; Comment Request

February 6, 1996.

The Department of Treasury has submitted the following public information collection requirement(s) to OMB for review and clearance under the Paperwork Reduction Act of 1980,