AFFIDAVIT

I, Susan L. Hiatt, duly sworn, depose and say that:

1. the assertions below are true and correct to the best of my knowledge, information, and belief;

2. The Appeal Board has considered a determination of the need for power from a nuclear facility to be central to NEPA's directives. Public Service Company of New Hampshire (Seabrook Station, Units 1 and 2), ALAB-422, 6 NRC 33 (1977). If the electricity to be produced by a proposed project is genuinely needed, then the societal benefits achieved by having that electricity are immeasureable. Vermont Yankee Nuclear Power Corp. (Vermont Yankee Nuclear Power Station), ALAB-179, 7 AEC 159, 173 (1974). On the other hand, if there is no need for power, justification for a facility is problematical. Seabrook, supra, at 6 NRC 90. A need for power determination involves questioning "whether there exists a genuine need for the electricity to be produced. This inquiry involves not only an analysis of existing generating capacity and of projections of expected growth . . . [but also] appropriate attention must be given to energy conservation considerations, insofar as they affect the likelihood that predicted demand will in fact occur. At the same time, however, cognizance can be taken of the effect which a shortage of fossil fuel, or a need to divert that fuel to other uses, might have upon demand for non-fossil generating sources." Vermont Yankee, supra, at 7 AEC 175.

3. Beaver Valley 2 is owned jointly by 4 utilities (collectively known as the Central Area Power Coordinating Group, or CAPCO) in the Northern Ohio/Western Pennsylvania area, in the following proportion:

Cleveland Electric Illuminating Co. (CEI)	24.47%
Duquesne Light	13.74%
Ohio Edison	41.88%
Toledo Edison	19.91%
	100.00%

Thus, to properly determine the need for Beaver Valley 2, one must look at the CAPCO system as a whole, as has been done by the AEC/NRC (e.g., FES-OL for Beaver Valley 1, July 1973; NUREG-0884, DES-OL for the Perry Nuclear Power Plant, March 1982.)

4. At the CP stage for Beaver Valley 2 (CP issued May 3, 1974) growth rate in electrical demand for the CAPCO service area was projected at 6.3% per year. (See, e.g., FES-CP for the Perry Nuclear Power Plant, U.S. AEC, April 1974, p. 8-9; FES-OL for Beaver Valley 1, U.S. AEC, July 1973, p. 8-1.) CAPCO's annual projected peak demand and net energy demand for the years 1973 to 1982 are as follows: (Taken from CEI's Environmental Report for Perry, 1973, pp. 1.1-39a and 1.1-39b; for peak demand, the CAPCO peak may not equal the sum of the individual company peaks because they may not all occur at the same hour.)

Annual Peak Demand Forecast (MW)

Year	CEI	DL	OE	TE	CAPCO
1973	3090	2230	3805	1249	10,347
1974	3280	2355	4045	1353	10,998
1975	3470	2470	4300	1453	11,678
1976	3670	2585	4575	1557	12.387
1977	3890	2705	4860	1664	13,1[illegible]
1978	4120	2835	5170	1779	13,[illegible]
1979	4360	2975	5495	1900	14,7[illegible]
1980	4620	3115	5845	2027	15.607
1981	4890	3255	6215	2164	16,[illegible]24
1982	5170	3410	6605	2308	17,493

Annual Net Energy Forecast (1000 MWh)

1973	18,079	13,020	22,013	7002	60,114
1974	18,830	13,630	24,169	7537	64,166
1975	19.821	14,200	25,861	8144	68,026
1976	20,863	14,790	26,381	8718	70,752
1977	21,914	15,420	28,023	9300	74,657
1978	23,127	16,100	29,767	9980	78,974
1979	24,591	16,820	31,614	10,738	83,763
1980	26,158	17,560	33,579	11,501	88,798
1981	27,693	18,290	35,571	12,276	93,830
1982	29,308	19,070	37,894	13,111	99,383

5. Actual data for the years 1973 to 1982 is as follows: (Sources: 1973-1979 data, CEI's Environmental Report, OL Stage, for Perry, pp. 1.1-16 and 1.1-17; 1980-82 data, 1982 annual reports for DL, OE, and TE, and CEI's Long Term Forecast Report filed with the Ohio Department of Development, Division of Energy, June 1, 1983 (for actual peak demand).)

Actual Peak Demand (MW)

Year	CEI	DL	OE	TE	CAPCO
1973	3119	2296	3796	1246	10,432
1974	2934	2158	3648	1249	10,014
1975	2937	2230	3623	1256	9,906
1976	3065	2260	2757	1340	10,345
1977	3350	2371	4088	1393	11,164
1978	3249	2374	3987	1386	10,897
1979	3097	2296	4020	1395	10,435
1980	3304	2474	4210	1310	11,298
1981	3362	2522	4148	1315	11,347
1982	3078	2158	4073	1355	10,664

Note: for the years 1980-82, the CAPCO total is the sum of the individual company peaks.

Also, OE peak load data from the annual report did not agree with data from CEI's ER-OL for Perry: 1977: 4134; 1978: 4038; 1979: 4105 are annual report figures.

Net Energy Supplied (1000 MWh)

Year	CEI	DL	OE	TE	CAPCO
1973	18,176	13,315	22,101	7028	60,620
1974	17,818	13,365	21,942	6967	60,092
1975	17,271	12,929	21,217	7105	58,522
1976	18,331	13,228	22,524	7805	61,888
1977	19,098	13,673	23,539	8077	64,387
1978	19,255	13,341	23,469	8144	64,208
1979	19,645	14,010	24,215	8157	66,027

The data above was taken from CEI's Perry Environmental Report (OL). The table below was taken from the 1978-82 "Sales of Electricity" data in the annual reports, and is presented separately to illustrate the differences in the data. It can be seen that the annual report data is about 95% of the ER data; for subsequent analyses, the 1980-82 CAPCO totals have been adjusted to match the 1973-79 data, and are presented below the following table.

1978	18,364	12,649	22,309	7685	61,007
1979	19,030	13,325	22,960	7709	63,024
1980	18,160	13,301	22,394	7388	61,243
1981	17,508	13,634	24,662	7151	62,955
1982	16,165	11,038	24,025	6918	58,146

Adjusted CAPCO totals:
1980: 64,466
1981: 66,268
1982: 61,206

6. Comparing actual data with the 1973 projections, one finds that the actual peak demand and net energy have been only a fraction of the 1973 projected amounts: (using CAPCO totals)

% = actual/projected x 100%

Year	Peak Demand	Net Energy
1973	100.8%	100.8%
1974	91.0%	93.7%
1975	84.8%	86.0%
1976	83.5%	87.5%

1977	85.1%	86.2%
1978	78.4%	81.3%
1979	70.8%	78.8%
1980	72.4%	72.6%
1981	68.7%	70.6%
1982	61.0%	61.6%

7. From the data above the percent annual change in peak demand and net energy can be calculated (from CAPCO totals).

Year	Peak Demand	Net Energy
73-74	-4.0%	-0.9%
74-75	-1.1%	-2.6%
75-76	+4.4%	+5.7%
76-77	+7.9%	+4.0%
77-78	-2.4%	-0.3%
78-79	-4.2%	+2.8%
79-80	+8.3%	-2.4%
80-81	+0.4%	+2.8%
81-82	-6.0%	-5.1%
averages	+0.3%/year	+0.4%/year

8. It is also useful to compare CAPCO's more recent projections for peak demand and net energy for the years 1980-82 with reality. (Projections taken from CEI's ER-OL for Perry.)

	Projections					actual	% difference
Peak Demand							
Year	CEI	DL	OE	TE	CAPCO	CAPCO	
1980	3450	2395	4135	1352	11,327	11,298	-0.3%
1981	3600	2485	4300	1497	11,877	11,347	-4.5%
1982	3750	2525	4465	1599	12,344	10,664	-13.6%
Net Energy							
1980	19,643	14,300	25,529	8352	67,823	64,466	- 4.9%
1981	20,069	14,750	26,368	8966	70,153	66,268	- 5.5%
1982	21,134	15,070	27,262	9346	72,811	61,206	-15.9%

9. It is obvious that both CAPCO projections (1973 and 1980) have severely overestimated the need for the Beaver Valley 2 facility. CAPCO's current projections are likewise unrealistic. CAPCO's 1980 projections call for a 4.1% annual increase in peak demand and a 3.1% annual increase for net energy (NUREG-0884, p. 2.4). CAPCO's current estimate is for an annual growth rate in demand of 2% (CEI 1982 annual report, p. 7).

10. It is also useful to examine the reserve margin over peak load: (Sources: 1982 annual reports and CEI Long Term Forecast)

Generating Capacity/Reserve Margin Over Peak Load

Year	CEI	DL	OE	TE	CAPCO
1978	4462/37%	3289/38%	5704/41%	1813/31%	15,263/38%
1979	4511/45.6%	3294/43.5%	5709/39%	1825/31%	15,339/41%
1980	4353/32%	3179/28%	5688/35%	1760/34%	14,980/33%
1981	4667/39%	3177/26%	5686/37%	1773/35%	15,303/35%
1982	4699/52.7%	3144/46%	5637/38%	1790/32%	15,270/43%

For actual peak demand, see Item # 5 above. Compare the CAPCO reserve margins with the recommended 20% figure (see, e.g., FES-OL for Beaver Valley 1, p. 8-4).

11. The addition of the Beaver Valley 2 generating capacity will only add to the already more than ample reserve margin, even assuming a 0.4% annual growth in peak demand, as might be projected from recent experience.

It can be shown that no additional capacity will be needed by CAPCO for 40 years beyond 1986, the assumed on-line date for Beaver Valley 2.

Using 1982 peak load data as a baseline, and assuming a 0.4% annual growth rate in demand, the peak demand in 44 years is given by:

$$P_n = P_o (1 + r)^n$$

where P_n = peak demand in 44 years

P_o = 1982 peak demand, 10,664 MW

$r = 0.004$

$n = 44$

$$P_n = 12,712 \text{ MW}$$

Assuming the 1982 generating capacity to remain constant, (15270 MW) this gives a reserve margin of 20% in 44 years. This calculation, of course, does not account for the decommissioning of generating facilities.

It is likely that the 0.4% assumed annual growth rate in demand can be reduced to zero by providing incentives for conservation, e.g., time -of-day rates. Electricity usage is very sensitive to price. See "Nuclear Fizzle" Barron's, August 24, 1981. If there is no growth in demand, only 12,797 MW of generating capacity is needed to maintain a 20% reserve margin over the 1982 peak load. This permits the retirement of 2473 MW.

Even if there is a slight growth in demand, it would be far cheaper for CAPCO to purchase power from other utilities than to continue building Beaver Valley 2. Other utilities have excess power to sell; see "American Electric Power, Long Protected, Finally Suffers From a Decline in Demand", Wall Street Journal, December 15, 1982 (attached), and also the attached sheet entitled "Operating Statistics for CAPCO Companies Compared with Those of Surrounding Electric Utilities" which shows that many utilities have excess capacity and charge less than do the CAPCO companies.

12. That it is likely that the decline in electrical demand is a result of deep-seated social and economic changes in the CAPCO service area, rather than temporary effects of fluctuations in the economy, is shown by the following population figures for Standard Metropolitan Stastical Areas (includes suburbs) in the CAPCO region. Source: U.S. Census Bureau.

SMSA	1970	1980	change
Akron	679,000	660,000	- 19,000
Cleveland	2,063,000	1,898,000	-165,000
Pittsburgh	2,401,000	2,263,000	-138,000
Toledo	762,000	791,000	+ 29,000
Warren-Youngstown	537,000	531,000	- 6,000
		total change	-299,000

Note: in the FES-CP for the Perry plant, it was estimated that population in the CAPCO service area "is expected to be well above average" in growth. (p. 8-1)

13. It is fair to state that the entire justification developed at the CP stage for Beaver Valley 2 has eroded away to nothing. It is therefore appropriate to re-examine the need for power at the OL stage.

14. In 1980 Dr. Richard Rosen of Energy Systems Research Group testified before the Pennsylvania PUC (Direct Testimony of Richard A. Rosen on behalf of the Pennsylvania Office of Consumer Advocate in the Investigation upon the Commission's Own Motion into the Delay in the CAPCO Construction Schedule, #I-79070315, "Rosen Testimony") that Beaver Valley 2, along with the 2 Perry units in Ohio, should be cancelled because the CAPCO system is over baseloaded and the nuclear

construction program is not cost-effective. The Beaver Valley 2 Station, being the most expensive of the 3 units, especially cannot be justified economically (Rosen Testimony at 25). Rosen stated that CAPCO's own planning data showed that Beaver Valley 2 should have been cancelled along with the Erie 1 and 2 and Davis-Besse 2 and 3 nuclear units, the cancellation of which was announced in January 1980. (Rosen Testimony at 38) These conclusions were based on maintaining a 20% minimum reserve margin and using CAPCO's 1979 forecast of 3.4% annual peak demand growth.

15. One of the CAPCO investors has publicly stated that the need for Beaver Valley 2 should be re-evaluated. See "Toledo Edison Plight Could Delay Perry Unit", Cleveland Plain Dealer, June 24, 1983, attached.

16. The rule being challenged herein has as its stated purpose the avoidance of "unnecessary consideration of issues that are not likely to tilt the cost/benefit balance" at the OL stage. Final Rule, 47 FR 12940, March 26, 1982. The Commission's reasoning is that, at the time of the OL proceeding, "the plant would be needed to either meet increased energy needs or to replace older, less economical generating capacity and that no viable alternatives to the completed nuclear plant are likely to exist which could tip the NEPA cost/benefit balance against the issuance of the operating license. Past experience has shown this to be the case. In addition, this conclusion is unlikely to change even if an alternative is shown to be marginally environmentally superior to operation of a nuclear facility because of the economic advantage which operation of nuclear power plants has over fossil generating plants. An exception to the rule would be

made if, in a particular case, special circumstances are shown in accordance with 10 CFR 2.758 of the Commission's regulations." Id.

17. The rule is vulnerable to challenge on several grounds, as may have been anticipated by the Commission in the final sentence above. First, the assertions on the economic advantages of nuclear power have increasingly come under attack. See, e.g., "The Lousy Economics of Nuclear Power", Wall Street Journal, August 2, 1983, attached. The assumptions used to justify the rule are simply no longer valid. Secondly, need for power is not an issue that can be generically determined through rulemaking. Each power system, having unique characteristics, needs to be examined separately (Rosen Testimony at 9). Finally, the rule ignores the massive subsidies which the federal government has given to support the development of nuclear power. A General Accounting Report, "Nuclear Power Costs and Subsidies," 13 June 1979, EMD-75-52, p. 12, has estimated that 12.1 billion taxpayer dollars have been used to subsidize the commercial nuclear industry since 1950. A true cost/benefit ratio would include these subsidies.

18. Certain statements in the proposed rule also deserve comment. The Commission states that NEPA review at the OL stage need not duplicate that at the CP stage, absent new developments or new information (46 FR 39441, August 3, 1981, emphasis added). That is precisely the case here. As shown above, the assumptions used at the CP stage to justify Beaver Valley 2 have turned out to be erroneous.

19. Among these erroneous assumptions is the use of an 80% capacity factor in estimating the performance of nuclear facilities. (see,

e.g., FES-OL for Beaver Valley 1, p. 3-11; FES-CP for Perry 1 and 2, p. 8-16.) The Commission appears to perpetuate this error by claiming that "(e)xperience shows that completed nuclear plants are in fact used to their maximum availability . . ." (46 FR 39441) The fact is that only one nuclear plant in the United States has achieved an 80% capacity factor (cumulative): Farley 2 (81.2%). (Source: NUREG-0020, Vol. 7, No. 3, "Licensed Operating Reactors Status Summary Report" ("Gray Book") March 1983.) The average cumulative capacity factor (DER net) for the 72 reactors listed therein is 58.8%.

20. The proposed rule also claims, as grounds for excluding need issues at the OL stage, that "construction related impacts have already occurred at the site." 46 FR 39441. This ignores the fact that the most severe environmental impacts result from the operation of nuclear facilities, not from their construction. The construction impacts of nuclear plants are comparable to those of coal plants or any other large construction project.

21. The proposed rule states that "(u)nless the nuclear plant has environmental disadvantages in comparison to reasonable alternatives, differences in financial cost do not enter into the NEPA process." 46 FR 39441. The nuclear plant has definite environmental disadvantages in comparison to fossil generation, notably the risk of catastrophic accidents. Environmental disadvantages of fossil plants (air pollution, sulfur dioxide and particulates) can be removed by installing scrubbers and precipitators. Economic analyses thus become relevant to the NEPA process.

22. The proposed rule then cites reports supposedly demonstrating that operational costs of nuclear plants have been less than those of fossil baseload plants. There is, however, information to the contrary. See, e.g., "The Lousy Economics of Nuclear Power", wherein the authors describe a number of factors making nuclear power more expensive. Also cited therein is a study by Exxon Corp. showing nuclear power to be 70-89% costlier per kwh than coal. See also "A Comparison of Nuclear and Coal Costs" by Charles Komanoff, October 9, 1978, presented as testimony before the State of New Jersey Board of Public Utilities on behalf of the New Jersey Department of Public Advocate, Division of Rate Counsel, In the Matter of the Board's Order of Inquiry into the Reasonableness of Electric Utilities Construction Program, Docket No. 762-194 ("Komanoff Testimony"), particularly pp. 158-160, where coal station operating and maintenance costs are shown to be less than those for nuclear plants.

23. Before applying these principles to the present case, one must examine the CAPCO system. CAPCO is highly dependent on coal. 95% of CAPCO electricity is generated from coal (NUREG-0884, p. 2-1) It should be noted that there are vast reserves of coal in the Midwest region. CAPCO is almost totally independent of oil, for either baseload or peaking (Rosen Testimony at 27).

24. Since it has been shown above that there will be little, if any, growth in the demand for electricity in the CAPCO system, the Commission's "substitution theory" becomes relevant. The question is: would it be more economical for CAPCO to operate Beaver Valley 2 than to operate older coal plants, thereby substituting Beaver Valley 2 for coal capacity? Rosen has unequivocally answered

this question NO; it will always be cheaper for CAPCO to operate its older coal plants (which were built at lower capital costs and lower interest rates) more (up to their technical limits), even if the need for baseload capacity were to grow. Rosen Testimony at 28.

25. The operation of older, smaller coal plants will always be beneficial to CAPCO. Coal plants have higher capacity factors, or could have, were it not for the effect of nuclear capacity in the system reducing the efficiency of coal units (Komanoff Testimony at 103). This effect is at work in the CAPCO system, as the Mansfield 2 coal plant, which should be baseload, is operated as a peaking plant (Rosen Testimony at 48-50). Furthermore, the reliability of a utility system is greater if it relies on a larger number of smaller plants than on a smaller number of large units (Komanoff Testimony at 150-152).

26. The special circumstances of this proceeding can be demonstrated in yet another way. It has been shown that capacity factor is a crucial determinant of the comparative costs of coal and nuclear power. See "Nuclear Power Plant Reliability" by David Comey (attached), wherein a 55% capacity factor is shown to be the break-even point between coal and nuclear. If both coal and nuclear plants exceed the 55% capacity factor, nuclear will be cheaper. If both operate at less than 55%, coal will be cheaper. Since coal capacity factors are (or can be) well above 55% (Komanoff has estimated 70%), nuclear economics depends on the nuclear capacity factor.

The crucial question becomes: what is the likelihood that Beaver Valley 2 will operate at or above 55% capacity? An examination of

the Gray Book indicates that fully 1/3 of the 72 plants listed therein have failed to achieve a cumulative capacity factor (DER net) of 55%. Even more important is the relationship of the abysmal performance of Beaver Valley 1 (cumulative capacity factor of 35.1%) to the expected performance of Beaver Valley 2. Twenty multi-unit nuclear sites and their cumulative capacity factors (taken from the Gray Book, are listed below.

Arkansas Nuclear 1	57.4%
Arkansas Nuclear 2	52.5%
Browns Ferry 1	54.1%
Browns Ferry 2	52.0%
Browns Ferry 3	64.2%
Brunswick 1	47.2%
Brunswick 2	41.3%
Calvert Cliffs 1	70.5%
Calvert Cliffs 2	74.8%
Cook 1	64.8%
Cook 2	63.6%
Dresden 2	56.2%
Drseden 3	57.1%
Farley 1	54.2%
Farley 2	81.2%
Hatch 1	53.1%
Hatch 2	60.5%
Millstone 1	62.8%
Millstone 2	65.6%
North Anna 1	54.5%
North Anna 2	63.1%
Oconee 1	58.5%
Oconee 2	59.1%
Oconee 3	60.6%
Peach Bottom 2	62.9%
Peach Bottom 3	64.2%
Point Beach 1	69.6%
Point Beach 2	79.6%
Prairie Island 1	70.7%
Prairie Island 2	76.1%
Quad Cities 1	60.1%
Quad Cities 2	59.5%
Salem 1	45.4%
Salem 2	72.7%
Sequoyah 1	49.8%
Sequoyah 2	71.8%
Surry 1	54.3%
Surry 2	56.6%
Turkey Point 3	60.3%
Turkey Point 4	63.5%
Zion 1	58.6%
Zion 2	58.6%

It can be seen that, with the exception of 3 sites, Farley, Salem, and Sequoyah, the cumulative capacity factor at one unit will be about that of the other(s), ± 10. Thus, Beaver Valley 2 has only a 3/20 or 15% chance of attaining a cumulative capacity factor much greater than 45%, which means that electricity produced from Beaver Valley 2 will be more expensive than that from coal.

Note: not included were the Indian Point 2 and 3 plants and the Fitzpatrick and Nine Mile Point 1 plants, similar plants on same sites, but operated by different utilities. These, however, do follow the pattern, and their inclusion would reduce Beaver Valley's chances of exceeding a 45% capacity factor to 3/22, or 13.6%.

27. Finally, some mention should be made of the future of the uranium market, as the price difference between coal and uranium has been said to be the main advantage of nuclear power. A recent article in <u>Science</u> ("Uranium Enrichment: Heading for the Abyss" 19 August 1983, Vol. 221, pp. 730-733, attached) indicates that prices will probably rise for U.S. enriched uranium, so much so that the United States might be priced out of the uranium enrichment business. While low-cost uranium will be available from foreign sources, a dependence on these sources will be disadvantageous to the United States in the same way that dependence on foreigh oil is vulnerable to political and economic manipulation. The importance of uranium to national defense complicates the matter further. Congress has expressed concern over the viability of the domestic uranium industry and the vulnerability of our energy supply to disruption due to dependence on foreign uranium. See Public Law 97-416, new section 170b of the Atomic Energy Act (42 USC 2210b). This

situation favors the abandonment of Beaver Valley 2 in favor of using domestic coal.

28. Based on all of the above, it must be concluded that a <u>prima facie</u> showing has made that 10 CFR 51.53(c) does not serve the purpose for which it was adopted, that that regulation should be waived, that the need for Beaver Valley 2 should be litigated in this proceeding, and, that such litigation will have as its outcome a ruling denying the operation of Beaver Valley 2. This determination should be made quickly, before further money is uselessly spent on that facility.

Susan L. Hiatt

Susan L. Hiatt

Sworn to and subscribed before me this 6th day of September, 1983.

Notary Public

MARLEY FORD EIGER, Attorney At Law
Notary Public - State of Ohio
My commission has no expiration date.
Section 147.03 R. C.

American Electric Power, Long Protected, Finally Suffers From a Decline in Demand

By Paul Ingrassia
Staff Reporter of The Wall Street Journal

COLUMBUS, Ohio — The slowdown in electricity-use growth over the last decade has hurt many electric utilities, but for years American Electric Power Co. had a safety net: selling to other utilities.

AEP generates more power than any other electric company, and it has long been regarded as a particularly efficient operator of its mostly coal-fired plant network. As the company's sales to industrial, residential and commercial customers inched up over the last five years, its "wholesale" sales to other utilities nearly doubled. Neighboring utilities could often buy peak-period power from AEP more cheaply than they could produce the power themselves.

But this year the Midwest's deep recession has caused area utilities to sharply reduce outside power purchases. And that is hurting AEP. Its third-quarter earnings dropped 38%, it recently cut the salaries of its top 140 officials by 5% and froze all other salaries, and it announced plans to close its New York City engineering office next year, eliminating about 300 jobs. Besides scrapping or deferring additional plants, AEP is studying whether existing plants can be closed for extended periods.

Decline Expected

"We're tightening everything we know how to tighten," says W.S. White Jr., chairman and chief executive officer. "We might have to take more cost-cutting steps, too. Our people have to realize that."

Other electric utilities are suffering, too. Electric power generation dropped 2% nationwide in the first nine months of this year to 1.77 trillion kilowatt hours, says the Edison Electric Institute, a trade group. The group is forecasting the first nationwide year-to-year decline in electric-power generation since 1937.

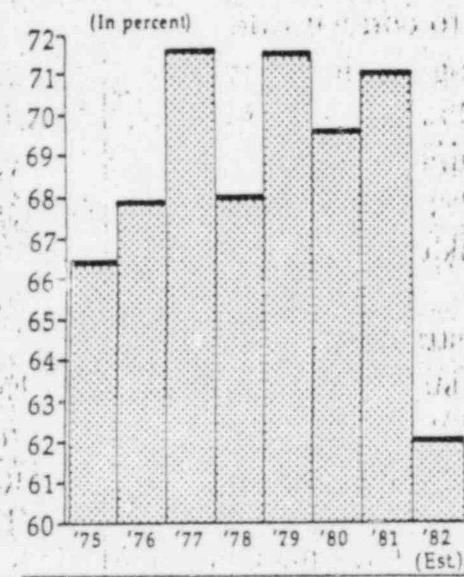
The steepest drops are coming in the industrial Midwest and the Pacific Northwest. Some utility employees there are finding their jobs no longer carry virtual lifetime security. Illinois Power Co. of Decatur, Ill., recently eliminated 121 jobs and deferred pay increases for salaried employees for at least six months. In June, Dayton Power & Light Co. said it would cut its work force by 600 employees, or 16% of the total, by the end of this year.

But AEP is absorbing double punishment. Its overall electricity sales were off 12% in the first nine months of the year, even though sales to homeowners and to commercial users (schools, offices and the like) rose slightly. The reasons: Sales to industrial users dropped more than 18%, and sales to other utilities, which now surpass industrial sales as AEP's biggest market, plunged 20%.

"The ability to make wholesale sales had been providing considerable relief from the burden of carrying surplus generating capacity," says Abraham Gerber, a former AEP official who now works for National Economic Research Associates, a New York consulting firm. "Now that relief isn't as available as it once was."

AEP, a holding company, has eight operating utility subsidiaries. They're located on a diagonal line that runs through the industrial heartland from southwestern Virginia to southwestern Michigan. In 1980 AEP acquired Columbus & Southern Ohio Electric Co. and moved its headquarters from New York City to Columbus, the geographic center of its system as well as the largest city it serves.

AEP American Electric Power
Power-Producing Capacity Used



An engineering innovator, AEP was a leader in developing "super-critical pressure" generating plants, which flash water into the steam needed to turn electric turbines without boiling the water first. It has a nuclear plant in Bridgman, Mich., but mostly relies on 19 coal-fired plants in Eastern coal fields. As a result, AEP's residential customers paid 4.75 cents for each kilowatt hour used last year, compared with a nationwide average of more than six cents.

Growth Forecasts

But AEP's plant-building expertise may have hurt its ability to respond quickly to its reduced load growth in recent years. Mr. White says the company's growth forecasts were too high but that that was unavoidable. "We've cut our load forecasts each year since 1973," he says. "Sometimes I think electric utilities are expected to have a better crystal ball than anyone else."

Sales to other utilities passed industrial sales as the company's top category in 1980. Last year the gap widened; 35% of total sales went to other utilities, while 3[illegible]% went to industry. But this year the "wholesale" market has plunged. Some AEP customers have increased their own generating capability even while their own demand has been soft.

"Last year we cut back substantially on power purchased from the outside, and now we've become a net seller" to other utilities, says Joseph Fitzgerald, system operations manager for Cleveland Electric Illuminating Co. AEP had been Cleveland Electric's biggest outside supplier, but this year the Cleveland utility is getting results from a program to reduce idle time at its own plants. Its power load is down as well.

More Cost-Cutting

"Most Midwest utilities are going through a period now when they'll have relatively high capacity in relation to their loads," says David E. Jones, an energy expert at Battelle Memorial Institute, a research concern. "This will last five to 10 years."

AEP's capacity, including the first unit of a new coal-fired plant in Rockport, Ind., to be finished in late 1984, will carry the company "through the mid to late 1980s" and perhaps even the early 1990s, Mr. White concedes. Meanwhile, the company is taking increasingly stringent cost-cutting steps.

AEP has closed six of its 32 coal mines and partially shut down three others, laying off about 1,500 employees. It has also eliminated some management-development programs. As for the dividend: "I certainly don't want to think about a dividend decrease, but I'm uncomfortable that our dividend level is currently above our earnings level," Mr. White says. (The company earned $2.15 a share in the 12 months ended Sept. 30: the dividend is $2.26 a year.)

Another problem is AEP's 28.5% interest in the troubled Zimmer nuclear power plant, which is being built by Cincinnati Gas & Electric Co. After the Nuclear Regulatory Commission ordered major work on the plant halted last month, the Public Utilities Commission of Ohio said it would reconsider $14 million of a $41.6 million rate increase it recently granted to an AEP unit.

There are some bright spots for the company. In October it agreed to two long-term contracts to sell power to other utilities. One was a 10-year accord with General Public Utilities Corp., which needs to replace capacity lost in the Three Mile Island accident. AEP will also benefit as its construction outlays taper off over the next few years. "We're going to lick our problems," Mr. White says. "We'll be in a good position when things turn around."

WALL ST. JOURNAL, 12-15-82, p. 29

OPERATING STATISTICS FOR CAPCO COMPANIES, COMPARED WITH

Utility & Area covered	Net plant, 1982, $ mil	Capacity, MW	Peak load, MW
Cleveland Electric Illuminating*	$ 3,350	4,624	3,362
Duquesne Light (Pittsburgh)*	$ 2,550	3,118	2,522
Ohio Edison*	$ 4,425	5,686	4,148
Toledo Edison*	$ 1,860	1,773	1,315
Detroit Edison	$ 6,875	8,458	7,171
Southern Indiana Gas & Electric	$ 385	1,012	779
Consumers Power (lower Mich.)	$ 6,450	6,176	4,703
Cincinnati Gas & Electric	$ 2,335	4,110	3,140
Dayton Power & Light	$ 1,840	2,659	2,122
American Elect. Power (Oh, WVa, Ind, Va, Ky, Tenn)	$ 10,250	22,407	20,762
Allegheny Elect. (Pa, Oh, Va, WVa, Myld)	$ 2,975	7,568	5,564
Pennsylvania Power & Light	$ 5,150	6,546	5,207
Indianapolis Power & Light	$ 1,040	2,528	1,896
Commonwealth Edison (Chicago)	$ 11,975	17,185	13,299
Kentucky Utilities	$ 1,115	2,870	2,143
Louisville Gas & Electric	$ 1,275	2,258	1,857
North. Indiana Public Service	$ 2,600	3,086	2,183
Public Service Co. of Indiana	$ 3,300	5,222	3,942
Illinois Power	$ 2,825	3,815	3,100
Niagara Mohawk	$ 3,970	7,619	5,543
New York State Gas & Electric	$ 2,450	2,775	2,193
Rochester Gas & Electric	$ 1,145	1,507	1,048
Philadelphia Electric	$ 6,315	7,574	5,731
Baltimore Gas & Electric	$ 3,075	5,025	3,871
Potomac Electric Power (Wash., D.C.)	$ 2,200	5,037	4,152
Virginia Electric Power	$ 6,140	10,076	8,636
Delmarva (Delaware, Maryland, Va.)	$ 1,300	2,273	1,575
Wisconsin Electric Power	$ 1,830	4,342	3,290
Wisconsin Power & Light	$ 705	1,623	1,262
TVA (eight states in Tenn. Valley)[(a)]	$ -	-	-

THOSE OF SURROUNDING ELECTRIC UTILITIES[a]

Major construction work in progress[b]		Present fuels mix, %[c]				Average revenue per residential kw-hr, ¢
Nuke, MW	Fossil, MW	Coal	Oil & Gas	Nuke	Hydro	
		81		12		7.1¢ * (d)
3,243		79	1	17		7.8¢ *
		98	1	1		6.6¢ *
		71		29		7.2¢ *
1,100	1,350	84	2			6.0¢
	250	98	1			4.8¢
1,357		60	7	14		5.4¢
800	1,200	99	1			4.6¢
		98	2			5.3¢
	5,200	85		10	5	3.6¢
2,010		99				3.6¢
		82	16		2	4.9¢
	1,165	99	1			4.0¢
6,636		45	10	45		6.1¢
	1,150	99				4.1¢
	1,485	93	2		5	4.1¢
	688	98	2			5.5¢
2,260	650	98			2	3.8¢
950		99				5.6¢
		17	38	10	31	5.7¢
1,080	625	62			38	5.3¢
		31		47		5.6¢
2,110		20	14	26	3	7.1¢
	1,220	17	33	33		5.3¢
		88	12			6.2¢
934	(1,900 hydro)	31	8	41	20	5.2¢
		53	29	14		6.8¢
	580	54	2	33	3	4.9¢
	380	74		23		6.0¢
9,679						

* Indicates CAPCO utility, co-owner of Perry nuclear power plant.
a. Data for all statistics except first column is approx. year-end 1981.
Value Line Investment Survey. No Value Line statistics available for
b. For Major construction work in progress (CWIP), brackets point to
c. Where fuels mix percentages don't total 100%, this is due to bulk tran-
d. Rate increases for 1982 not shown; e.g., CEI received a 10% increase

Sources: Annual reports of CAPCO utilities; Electrical World, Jan. 1982;
TVA, a government-owned utility.
names of joint owners.
sfer of electricity from unidentified fuel source(s).
in March 1982 and subsequently requested a 20% increase, pending as of Dec. 1982.

Toledo Edison plight could delay Perry unit

By James Lawless

PD 6-24-83

Toledo Edison Co. chairman John P. Williamson said yesterday construction on Unit 2 of the Perry nuclear power plant may have to be extended to help his company, which announced a major cost-cutting effort.

Toledo Edison, which is part owner of Perry, announced $11 million in cuts in its operational and maintenance budget, on top of $18 million in cuts in 1982.

Williamson said as a result of Toledo Edison's financial problems, Unit 2 of the Perry plant and Beaver Valley nuclear plant in Pennsylvania should be reexamined to see if they need to be built as quickly as scheduled.

The twin-reactor $5.2 billion Perry plant is being built by Cleveland Electric Illuminating Co., which shares ownership with Toledo Edison, Ohio Edison Co. and two Pennsylvania utilities.

Rumors surfaced during the past several weeks that the second Perry reactor might be canceled, but that was denied flatly by both Toledo Edison and CEI spokesman yesterday. However, Public Utilities Commission of Ohio Commissioner Alan R. Schriber said he was asked this week about a potential cancellation by two Wall Street investors.

The speculation also has come from critics of transmission lines, who argue that the second unit will not be needed for years after its 1983 scheduled completion because the utilities have much excess electricity.

"The first unit at Perry has to be completed as quickly as possible," Williamson said, "but the second unit is the subject of some discussion."

William King, a CEI spokesman, said his company had no plans to extend Perry 2 construction.

Williamson said yesterday as many as 100 Toledo Edison employes might lose their jobs, the utility has frozen salaries for all management employes and cut 12 top executives' salaries 5%.

Its unionized employes will get no pay raise this year, he said.

Toledo Edison has asked for a $79 million rate hike from PUCO but the PUCO staff has recommended less than half of that be granted. Further, the utility may lose its request for costs from Perry construction, because the PUCO staff says Unit 1 is not 75% complete.

Roger Buehrer, a Toledo Edison spokesman, refused to speculate about an emergency rate hike before the PUCO acts on the utility's pending rate hike.

THE WALL STREET JOURNAL, TUESDAY, AUGUST 2, 1983

The Lousy Economics of Nuclear

By CAROLINE J.C. HELLMAN
And RICHARD HELLMAN

What are the economics of nuclear power? Should cost be a legal test of whether public utilities build nuclear power plants? These questions have been insufficiently analyzed even though U.S. utilities had committed, at the peak, about $400 billion to nuclear power. Only this past April 20, when the Supreme Court ruled that states can forbid a future nuclear plant on the basis of cost, did economic viability finally become a legal test.

Nuclear power, once exposed to valid economic analysis, flunks the test. It is hard to believe that as late as 1973, when well over $100 billion had been committed to building nuclear plants, and some 18 years after the first orders were placed, no authoritative study had been published. Studies that finally appeared miscalculated or ignored essential factors, resulting in a consistent pattern of underestimating the costs of nuclear power plants and, to a lesser extent, overestimating the costs of coal power plants, the only realistic alternative source of electricity for the next 20 to 30 years.

"Sufflation" is one reason. It is the escalation of original capital-cost estimates due to technological problems, as distinct from general inflation of prices. Sufflation has been substantial for nuclear plants, while coal-plant costs have been close to original estimates.

Construction Time

Construction time is another factor. The industry commonly projects eight to 10 years from the time a nuclear order is placed to commercial operation. Experience suggests that 12 years is more accurate. Conversely, the construction time for coal-fired units generally has been overestimated at six or more years, when 4½ years is consistent with experience. The corrections increase construction costs for interest and inflation for nuclear plants, and decrease them for coal plants.

Capacity factor, which is defined as the ratio of actual to maximum possible energy production, is another element. Every nuclear unit operating in the U.S. today was designed to achieve an 80% capacity factor. Not one has come close. Since 1960, the industry has averaged only 55%; in 1982 it averaged 53%. Even the seven best-performing large nuclear units have averaged only 59%. By contrast, few of the best 1.3 million-kilowatt coal-fired units in the country, operated by the American Electric Power Co. in Appalachia and the upper Midwest, have averaged 85% availability. (Coal availability is compared with nuclear capacity factor because nuclear power is used whenever available, while coal power is "load following," or used after nuclear and hydro power.)

Assumed unit life is a fourth factor. The industry generally assumes a 30-year life for nuclear units. U.S. utilities and the Nuclear Regulatory Commission also have spoken of a 40-year life. This recently was trumped by the high priest of Oak Ridge, Alvin Weinberg, who suggests an 80-year life for existing units. But nuclear plants, due to corrosion and other problems, are unlikely to last beyond 25 years. This has been recognized by several industry sources to a greater or lesser degree. American Electric Power assumes 25 years, Arthur D. Little Co. 28 years and West European utilities 20 years. In contrast to this uncertainty, the life span for coal units is an unchallenged 30 years.

A fifth factor, non-fuel operating and maintenance costs, has almost invariably been projected to be much lower for nuclear power plants than for coal-fired units. Historically, the opposite has been true.

A sixth factor is the industry's unnecessary assumption that nuclear power must be compared exclusively with high-sulfur coal with flue-gas desulfurization. For the next 15 to 20 years, there is an adequate supply of low-sulfur Eastern and Midwestern bituminous coal which, because it requires less FGD, is cheaper. Before we run out of low-sulfur bituminous coal, new technologies like fluidized bed combustion will permit an economic use of abundant high-sulfur fuel without FGD.

Additional factors cannot be quantified because of uncertainty. All raise nuclear costs relative to coal costs.

The so-called yo-yo factor refers to the frequent, involuntary and unpredictable rise and fall of nuclear-power availability. To compensate for this unreliability, utilities must bear the expense of extra reserve capacity.

High-cost distress-replacement power is necessitated by the yo-yo factor. For Three Mile Island's owners, the cost of purchased power in the year of the accident rose 237%, compared with a 16% rise for the U.S.

Another unquantifiable factor, major repairs for unexpected corrosion, embrittlement and other technological problems, can cost as much as the entire original unit.

A fourth unquantifiable cost factor is senescence of nuclear units, or the degradation of performance with age. In contrast, American Electric Power states that its 1.3 million-kilowatt coal units are expected to perform at steady high-capacity factors for at least 30 years.

Lastly, radioactive-waste disposal and the decommissioning of retired plants are so problematic that cost projections currently are impractical.

Electricity from a nuclear plant ordered today would be at least twice as expensive as from coal. The technology was rushed into premature mass commercialization.

What then is the bottom line for the costs of nuclear-power and coal-power units ordered today? Our numbers are based on a private study by Exxon Corp.'s top management to establish a posture toward future investments in nuclear industry. Even using assumptions favorable to nuclear power, Exxon found coal to be somewhat cheaper. When the quantifiable factors we have cited are applied to the Exxon numbers, nuclear power becomes 89% costlier per kilowatt-hour than low-sulfur bituminous coal with FGD. Nuclear power is 70% costlier than high-sulfur bituminous coal with FGD. Since these projections are for New England, which has the highest coal costs in the country, coal's advantage would be even greater on a national basis. The factors that couldn't be quantified would further increase nuclear power's relative cost.

In sum, electricity from a nuclear power plant ordered today would be at least twice as expensive as from coal.

Nuclear power's poor prognosis is illuminated by the industry's zero or negative learning. Logically, in replications or near-replications of a unit, the newer unit should incorporate things learned from the older unit and should perform better. But this hasn't been the case in the majority of such nuclear power plants. We have made 163 comparisons of nearly identical younger and older nuclear units, using four learning criteria. Performance improved significantly in 39% of the comparisons, showed no improvement in 23% and deteriorated significantly in 38%.

How can nuclear power's technological and economic failure be explained? Prematurity is the answer. The technology was rushed into mass commercialization without enough study, testing and costing. During 1962-67, when the size of nuclear units ordered escalated to 1,170,000 kilo-

Power

watts, the largest nuclear unit in operation was 285,000 kilowatts. Moreover, these large nuclear units exceeded the dimensions of equal-capacity fossil-fuel units. Piping, valves and turbo-generators had to be much bigger for nuclear units because they operate at half the temperature, a quarter of the steam pressure and half the turbine speed. The volume of orders also rose prematurely—236 units at the peak in 1975, costing about $400 billion.

Prematurity has created unprecedented technological, safety and cost problems that are exacerbated by a shortage of scientific and engineering talent. Personnel to construct, operate and maintain nuclear units also have been in short supply and poorly trained. Utility managements have been overwhelmed by the complexity and novelty of their nuclear operations.

A fundamental explanation for the pell-mell development of civilian nuclear power is that it has been designed, promoted and regulated, ultimately, by the bomb makers. They have applied risk standards used for military-survival calculations to civilian nuclear-power design, construction and operation.

The Industry's Desperation

Based on prophecies of plentiful, cheap energy, the utilities rushed into nuclear power. They thought the gamble was risk-free because of the safety net afforded by cost-plus regulation. But the economics have deteriorated so much that such cost-plus rates may exceed the public's ability to pay. A measure of the industry's desperation is its proposal that the government buy all existing and future plants, and lease them back to industry for a rent that might even be negative.

The technological and economic design of nuclear power has been the biggest failure of any civilian industry in history. No private risk-taker would ever have built today's nuclear-power industry without unlimited cost-plus provisions and government subsidies.

The industry has been its own worst enemy in refusing to recognize that nuclear power is uneconomic and getting worse. To this day, the Tellers, the Weinbergs, the Atomic Industrial Forum and the Edison Electric Institute are leading the industry down a path of fool's gold.

Miss Hellman is a research assistant professor in energy economics at the University of Rhode Island. Mr. Hellman, a professor of economics at that school, has worked for several U.S. agencies, including the Federal Power Commission. They are the authors of "The Competitive Economics of Nuclear and Coal Power" (Lexington Books, 1983).

Nuclear Power Plant Reliability: The 1973-74 Record

DAVID DINSMORE COMEY

Although I know of only one published rebuttal[1] to my earlier report on nuclear power plant reliability,[2] I have been apprised of several unpublished memoranda in circulation within the nuclear industry. While I would prefer to answer rebuttals that have withstood the test of publication, the 1974 nuclear plant operating data have just been made available and offer an opportunity for answering some of the alleged criticisms levelled against my report.

The six most frequently made criticisms seem to be the following.

1. The 80 percent design capacity factor used by Comey is a "straw man"; no one ever expected nuclear plants to reach such levels of reliability.

The 80 percent design capacity factor was not created by me, but came from nuclear industry sources.

The basic source was the *Final Environmental Statements* prepared by the US Atomic Energy Commission for the currently operating commercial nuclear power plants. In every one of the more than 20 such documents I examined, the cost-benefit calculations assumed an 80 percent capacity factor over the entire life of the plant. If this assumption is as invalid as industry criticism contends, then the analyses done by the AEC pursuant to the legal requirements of the National Environmental Policy Act may be invalid, and there may possibly be a legal basis for challenging the validity of the operating licenses for each of these nuclear plants.

It may be of interest to note in this connexion that a General Electric advertisement in the September issue of *Power Engineering* bore the headline, "The goal: 90% BWR availability. The payoff: lower energy costs." Capacity factors have traditionally averaged about 10 percent below availability factors.

2. Comey's use of the phrase "cost overrun" is misleading; the concept of "cost overrun" related to a differential between actual and design capacity factors has no meaning in evaluating the cost of nuclear power plants.

It may be helpful to consider a specific example. Commonwealth Edison is viewed as the leading nuclear utility, with seven operating nuclear plants. In 1974, these seven plants had an average capacity factor of 39.5 percent.[3] If their record turns out to be a norm for the industry, then twice as many nuclear plants will have to be built to produce the same amount of electricity as would have been produced had the plants operated at the 80 percent capacity factor on which the AEC's cost-benefit calculations were predicated. This means twice as many capital dollars expended, not to speak of additional operating costs.

I see no difference between this situation and a weapons system that only produces half the "bang for the buck" originally projected by the Pentagon. We call the latter "cost overruns"; I see no reason not to apply the same terminology here.

3. Data from one year (1973) are not a sufficient base for detecting a valid trend.

At the time the earlier BPI report was prepared, the only full year for which nuclear plant capacity factor data were available was 1973. Data for all of 1974 are now available.

In the following analyses of the 1973-74 data, I have excluded plants less than 100 MWe in size for the same reasons identified in the earlier report. [Mr. Comey's original report excluded smaller plants because the AEC's principal report on capacity factors excluded all but one, because data on smaller plants are not available, because smaller plants are much older, not typical of present reactor designs, often not base-loaded, and tend to have such numerous outages that they would significantly lower his statistics. *–J.H.*] I have also limited the data to those nuclear plants that were in commercial operation for the entire year 1974, so as to exclude plants in start-up, testing or limited commercial operation. I emphasize this point, because some criticisms of the earlier BPI report mistakenly allege that it included plants not in commercial operation.

The data for the 28 plants that operated commercially for all of 1974 are set forth in Table 1, and their average capacity factors are set forth in Table 2.[4]

The 1974 data indicate a lower average capacity factor than was achieved in 1973, and the cumulative-to-date weighted average [5] is only 54.6 percent. The average for the two years taken together is 55.2 percent. These are quite close to the 54 percent capacity factor figure derived from earlier data and used for purposes of analysis in my previous report.

4. The biphasic curve showing a decline in capacity factors with increased plant age had as few as two plants in some age categories, thus making the curve highly contingent on the operation of a single plant during a single year.

Table 1

Commercial Plants That Operated For All of 1974

Unit Name	*Reactor Type*	*Net Design Power MWe*	*Date Commercial Operation started*	*1974 Net MWHR*	*Capacity Factors 1974*	*1973*	*Cum. To Date*
Connecticut Yankee	PWR	575	1/01/68	4,350,932	86.4	48	78.8
Dresden-1	BWR	200	7/04/60	352,939	20.1	35	49.5
Dresden-2	BWR	809	6/01/70	3,379,588	47.7	74	47.4
Dresden-3	BWR	809	11/16/71	3,200,269	45.2	55	53.7
R.E. Ginna	PWR	490	3/01/70	2,097,216	48.9	87	66.0
Indian Point-1	PWR	265	10/01/62	1,229,060	52.9	0	44.7
Indian Point-2	PWR	873	8/01/73	3,324,048	43.5	NA	33.2
Maine Yankee	PWR	790	12/28/72	3,574,301	51.6	52	49.6
Millstone Point-1	BWR	690	3/01/71	3,604,240	59.6	35	52.6
Monticello	BWR	545	7/04/71	2,923,836	61.2	68	66.2
Nine Mile Point-1	BWR	610	12/01/69	3,296,654	61.7	66	53.9
Oconee-1	PWR	886	7/15/73	3,998,488	51.5	43	53.3
Oyster Creek	BWR	650	12/01/69	3,673,489	64.5	66	74.0
Palisades	PWR	821	12/31/71	78,298	1.1	41	27.9
Pilgrim-1	BWR	670	12/01/72	1,973,033	33.6	73	52.3
Point Beach-1	PWR	497	12/21/70	3,142,055	72.2	67	70.1
Point Beach-2	PWR	497	4/20/73	3,178,408	73.0	73	63.9
Quad Cities-1	BWR	809	2/18/73	3,562,941	50.3	73	48.9
Quad Cities-2	BWR	809	3/10/73	4,469,705	63.1	78	53.2
H.B. Robinson-2	PWR	707	3/07/71	4,813,207	77.7	65	70.1
San Onofre-1	PWR	450	1/01/68	3,145,109	79.8	60	70.0
Surry-1	PWR	823	12/22/72	3,318,073	46.0	53	49.5
Surry-2	PWR	823	5/01/73	2,634,573	36.5	63	49.4
Turkey Point-3	PWR	745	12/14/72	3,623,905	55.5	58	59.2
Turkey Point-4	PWR	745	9/07/73	4,292,374	65.8	45	73.1
Vermont Yankee	BWR	514	11/29/72	2,482,564	55.1	43	46.9
Yankee Rowe	PWR	175	7/01/61	911,452	59.5	68	68.2
Zion-1	PWR		10/02/73	3,477,561	37.8	NA	45.0

Table 2

1973-74 Nuclear Plant Capacity Factor Averages

1973	Commercial Capacity — 26 plants	142,699,040 MWHR
1973	Net Electricity Generated	83,976,864 MWHR
1973	Average Capacity Factor Weighted By MWe Capacity	58.4%
1974	Commercial Capacity — 28 plants	160,544,520 MWHR
1974	Net Electricity Generated	84,108,318 MWHR
1974	Average Capacity Factor Weighted by MWe Capacity	52.4%
1973-74	Total Commercial Capacity	304,243,560 MWHR
1973-74	Net Electricity Generated	160,544,520 MWHR
1973-74	Average Capacity Factor Weighted by MWe Capacity	55.2%
	Cumulative-to-date Average Capacity Factor Weighted by MWe Capacity	54.6%

To meet this criticism, I have restricted the age categories to those containing three plants or more, and covering the two-year period 1973-74.

Figure 1, showing the biphasic curve, indicates that nuclear plants reach their peak capacity factors at the age of about six years of commercial operation and decline thereafter to 39 percent.

The latter figure is not markedly different from the 38 percent figure derived from earlier data and used for purposes of analysis in my previous report.

5. Comey makes capacity factors the only true criterion of nuclear plant performance, whereas availability factors are equally or more important as a performance index.

Since my earlier report explained in detail my reasons for considering capacity factors as a more valid index of nuclear plant performance than availability factors, I see no reason to recapitulate that argument here. It stands on its own feet.

An analysis of availability factor averages shows that even on this basis nuclear plants have not performed up to expectations. The 1973-74 weighted average is only 66.5 percent, and the cumulative-to-date weighted average is only 65.6 percent.[6] This is far short of the 90 percent figure advertised by General Electric.

How do these averages compare with the availability factor averages of base-load coal-fired plants?

The answer is nobody knows. The Edison Electric Institute compilations, the only available published source of capacity and availability factor data for non-nuclear power plants, do not give breakdowns for base-loaded coal-fired plants or even coal-fired plants alone.

The closest data for purposes of comparison are as follows. According to the most recent EEI report,[7] the 894 fossil-fired units surveyed had a yearly average of 86.9 percent availability during the 10 year period from 1964 to 1973, and the cumulative-to-date average availability factor for the 158 plants larger than 390 MWe (presumably the base-loaded ones) was 77.1 percent.[7] It is highly probable the preponderate majority of those 158 large fossil-fired plants are fueled by coal rather than gas or oil.

These figures would seem to indicate that base-load coal-fired plants have a higher average availability factor — and are thus more likely to be available to support grid reliability — than nuclear plants.

6. If Comey's allegation that nuclear plants waste billions of dollars in idle capacity is true, it is important to ask – compared with what?

As I indicated in an earlier rebuttal,[8] the answer is: "Compared with coal-fired plants, since that is our cheapest domestic source of fossil fuel."

How do nuclear plants' average capacity factors in the 54.6 - 55.2 percent range compare with the capacity factors for base-load coal-fired plants?

Again, we do not have sufficiently specific data to make an exact comparison because the only fossil-fired data published come from the Edison Electric Institute, whose compilations do not separate out base-load coal-fired plants as such.

The closest data for purposes of comparison indicate, according to the most recent EEI report,[7] that the yearly average capacity factor for 894 fossil-fired power plants between 1964 and 1973 was 68.9 percent. The cumulative-to-date average capacity factor for the 158 of these plants larger than 390 MWe (presumably the base-loaded ones) was 63.2 percent.

In view of this apparent differential in average capacity factors between nuclear plants and coal plants, which type of plant is the rational choice for an electric utility to order to provide the cheapest electricity over the near-term (1980-1990)?

The most thorough and probative existing analysis of nuclear and coal-fired plant costs is the IRRC report entitled *The Nuclear Power Alternative*.[9] IRRC's report projects that for a 1,000-MWe plant whose construction commences in 1975, a nuclear plant would cost $811.1 million and a coal-fired plant would cost $638.4 million. These are the capital costs of constructing the plants. In order to assign these capital costs to the per kilowatt-hour cost of generating electricity at the plants, IRRC prepared a table which reflects the fact that as the capacity factors decline, and the plants produce less electricity, the capital cost share per kilowatt-hour cost rises rapidly. By adding fuel costs and operating and maintenance costs to the capital cost per kilowatt-hour, we can get a projection of the total 1982 per kilowatt-hour costs of electricity from a 1,000-MWe nuclear plant and a 1,000-MWe coal-fired plant (see Table 3).[10]

Table 4 shows how the cost of electricity in mills per kilowatt-hour depends on what capacity factor each type of plant achieves. The per-kilowatt cost curves between nuclear and coal-fired plants cross at a capacity factor of 55 percent. In other words, if nuclear and coal-fired plants each average more than 55 percent capacity factors, the electricity from the nuclear plants will be cheaper than the electricity from the coal-fired plants. Conversely, if they each operate at capacity factors less than 55 percent, the electricity from the nuclear plants will be more expensive than the electricity from the coal-fired plants.

If one assumes that the average capacity factors for nuclear and coal-fired plants continue into the future at their historical levels of 55.2 percent and 63.2 percent respectively, then the coal-fired plants will produce electricity at a cost of 30.0 mills per kilowatt-hour, compared with the more expensive 32.9 mills per kilowatt-hour cost from nuclear plants.

Even making the arbitrary assumption that

nuclear plant capacity factors will increase by 20 percent above their present level, and coal-fired plants will increase by only 10 percent over their present level, the per kilowatt-hour cost would still be lower for coal-fired plants than for nuclear plants: 27.8 versus 28.2 mills per kilowatt-hour.

Unless nuclear plants dramatically increase their capacity factor record, the economic benefits claimed for them by their proponents are not likely to materialize.

Is it reasonable to expect that nuclear plants will be able to sustain such a 20 percent increase in their average capacity factor?

One factor, at least, suggests not. Because of the radioactivity of reactor and primary coolant systems in light-water reactors, repairs on these systems take more time and more workers than similar repairs on coal-fired plants. In order to avoid exceeding each worker's maximum permissible radiation exposure, a large number of men must work sequentially within a confined space to make repairs on nuclear reactor systems. For example, at Commonwealth Edison's Dresden Nuclear Power Station, a recent prolonged outage took 350 men to make repairs that 12 men could have done quickly on a fossil-fired plant.[11] (Similarly, a repair operation in 1973 at the Indian Point reactor in New York required 2,000 welders to perform a job in six months that would have taken slightly over a week to perform in a fossil fuel fired plant. The recruiting campaign scoured a large portion of the Atlantic coast.)

Since the radioactivity of these plant systems increases with plant age, repairs are likely to become even more time-consuming as the plant gets older, leading to longer outages and decreased capacity factors.

It is therefore likely that we will see a decrease in plant capacity factors as these plants age. In fact, the 1974 data already indicate this: the same 26 nuclear plants that produced 83,976,864 megawatt-hours in 1973 produced only 77,306,709 megawatt-hours in 1974 when they were a year older, a 7.9 percent decrease from the previous year.

Some critics believe that for reasons of safety alone, nuclear power plants should not be built. Others argue that it is unethical for two or three generations to consume electricity by producing radioactive wastes that present a hazard for 20,000 future generations.

I have tried to restrict discussion in my present analysis to the economic costs. On this basis alone, nuclear power plants seem to be at a disadvantage compared with coal-fired plants.

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2. David Dinsmore Comey, "Nuclear Power Plant Reliability: A Report to the Federal Energy Administration" (BPI-7444). Testimony presented September 10, 1974 at the FEA Project Independence hearing on Nuclear Power and Advanced Energy Systems. The report was published in the November issue of the *Bulletin of the Atomic Scientists* under the title of "Will Idle Capacity Kill Nuclear Power?", pp. 23-28.

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3. This is their average, weighted by MWe capacity; an unweighted average is 39.8 percent.

4. The sources of the data in Table 1 are as follows:

The 1973 capacity factor data are taken from *Nuclear Power Plant Availability and Capacity Statistics for 1973*. US Atomic Energy Commission Office of Operations Evaluation, Report No. 00E-0S-002, May 1974. They evidently were rounded off to the nearest percent.

The cumulative-to-date capacity factors are taken from the January 1975 "grey book," *Operating Units Status Report*, US Nuclear Regulatory Commission, January 24, 1975. There is good reason to believe that these capacity factors may be higher than they should be (because of the use of "maximum dependable capacity" — rather than design capacity — in calculating capacity factors). See Blowdown, March 1975.

I do have faith in the 1974 capacity factor data, which I calculated myself using the original plant data filed by each of the utilities with the US Atomic Energy Commission pursuant to Regulatory Guide 1.16.

Until the NRC converts back to a less biased method of computing capacity factors, the grey books should be used with caution.

5. By cumulative-to-date average capacity factor I mean the average capacity factor for the entire time period for each plant since it went into commercial operation. The cumulative-to-date capacity and availability factor data in Tables 1 and 5 are taken from the January 1975 grey book, and I find some of them dubious. For example, the cumulative-to-date capacity data for Oconee-1, Surry-2, and Turkey Point-4 are higher than the two yearly averages recorded since they went into commercial operation, and Turkey Point-3 could have achieved its cumulative-to-date capacity factor only if it operated at 164 percent of capacity in 1972.

Thus the real cumulative-to-date capacity factor average figure for these 28 plants may be lower than the 54.6 percent computed using grey book data.

Figure 1
Nuclear Plant Capacity Factors Vs. Age of Plant 1973-74

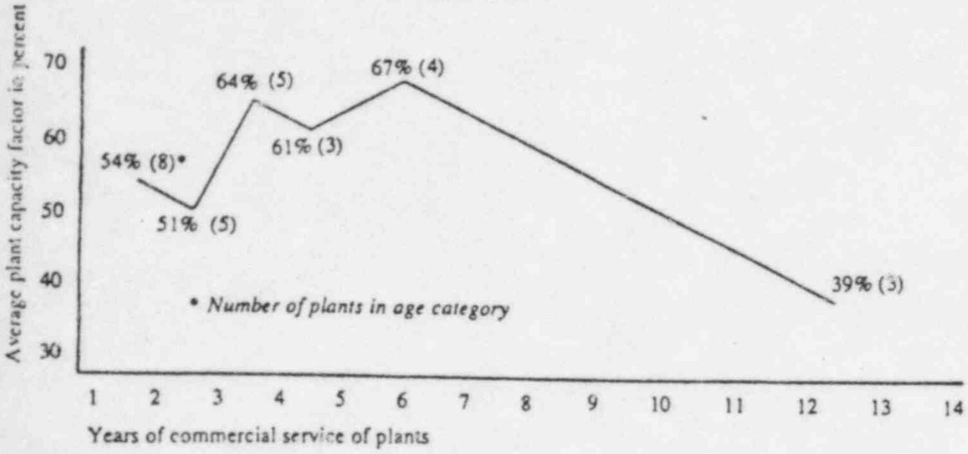


Figure 2
1982 Busbar Costs Vs. Capacity Factor

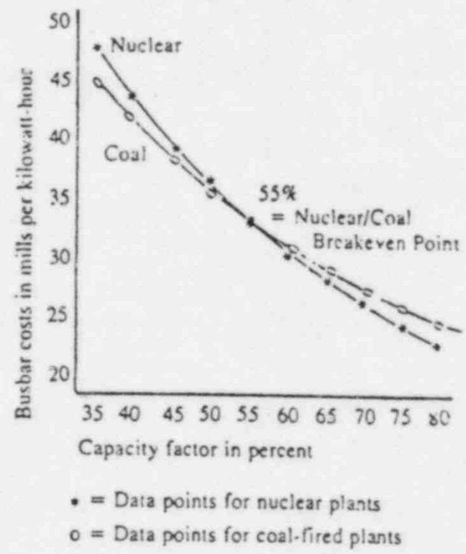


Table 3
Projected 1982 Busbar Costs in Mills Per Kilowatt-Hour

	Nuclear	*Coal*
Capacity Factor — %	55	55
Capital Costs	25.2	19.8
Fuel Costs	5.6	10.0
Operation & Maintenance	2.2	3.2
Total Costs — Mills/KWHR	33.0	33.0

Table 4
1982 Busbar Costs Vs. Capacity Factor

Capacity Factor %	*Cost – Mills/KWHR* *Nuclear*	*Coal*
35	48.4	45.5
40	43.2	41.5
45	39.0	38.1
50	35.7	35.3
55	33.0	33.0
60	30.7	31.1
65	28.7	29.4
70	27.0	27.9
75	25.5	26.6
80	24.3	25.6

6. The 1973 and 1974 availability factor data were calculated by myself using the original plant data filed by each utility pursuant to Regulatory Guide 1.16. The cumulative-to-date availability data were taken from the January 1975 grey book and are subject to the same *caveat* expressed in the previous footnote.

7. *Report on Equipment Availability for the Ten-Year Period 1964-1973*, (EEI Publication No. 74-57), issued by the Edison Electric Institute, New York, NY, December 1974.

8. David Dinsmore Comey, "Chasing Down the Facts," *Bulletin of the Atomic Scientists*, February 1975, pp. 40-42.

9. *The Nuclear Power Alternative*, (Special Report 1975-A, January 1975). The 108-page report is available from IRRC, Inc., Suite 806, 1522 K St., NW, Washington, DC 20005. It draws no conclusions about nuclear power, merely presenting the proponents' and critics' positions objectively. It is not only the best single document in existence on the nuclear power debate, but it is perhaps the finest piece of institutional research I have ever seen from an investment advisory service. (The report is expensive to purchase. Readers interested in viewing a copy should write Friends of the Earth in San Francisco.)

10. To compute capital costs, I used the table from p. 94 of the IRRC report, which is based on AEC estimates and an Arthur D. Little, Inc. report prepared for Northeast Utilities.

To compute the fuel costs, I used the 5.6 mills per kilowatt-hour figure for nuclear fuel projected by the AEC and multiplied it by the 1.78 differential factor between nuclear and coal fuel costs experienced by Commonwealth Edison (see footnote 8).

To compute the operating and maintenance costs, I projected Commonwealth Edison's present operation and maintenance costs for their nuclear and coal plants at an annual rate of increase of 9 percent.

11. Radio TV Reports, Inc. transcript of CBS Evening News, January 16, 1975.

Uranium Enrichment: Heading for the Abyss

A financial and political crunch is in store as DOE tries to build a $10-billion enrichment plant amid a worldwide surplus of reactor fuel

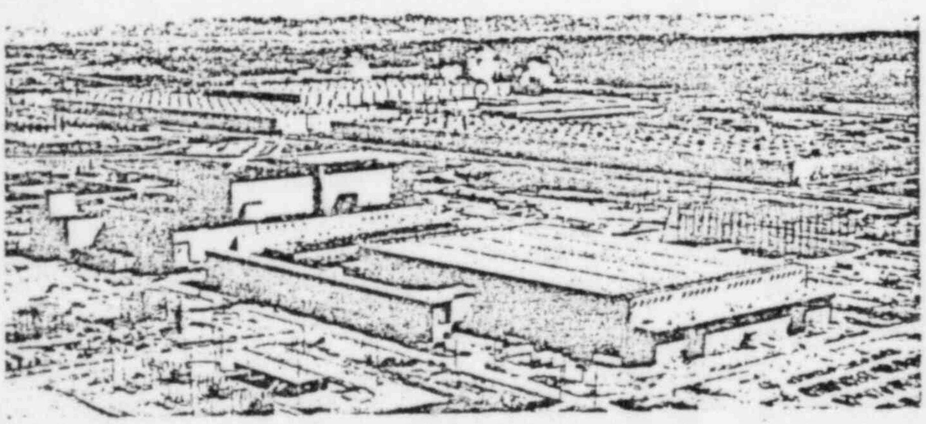
The federal government's $2.3 billion a year business enriching uranium for nuclear power plants is heading toward a major crisis. A victim of the plummeting fortunes of the nuclear industry and some disastrous miscalculations by the Department of Energy (DOE), it is caught with billions of dollars of construction in progress just as projected demand for enriched uranium is sinking like a stone. As a result, the enrichment program will soon have a mass of red ink on its books and a big fight with Congress on its hands.

At the center of the mounting controversy is a mammoth $10-billion enrichment plant that is now rising on the industrial landscape of Portsmouth, Ohio. Known as the Gas Centrifuge Enrichment Plant, or GCEP (pronounced gee-sep), it is the biggest construction project in the nation—a behemoth that will cost more than twice as much as the Clinch River Breeder Reactor.

The Department of Energy, which manages the enrichment program, argues that GCEP represents the best hope for getting the enrichment business onto a more stable economic footing in the 1990's. But to its critics, the plant is a boondoggle whose capacity is not needed and whose construction will drive up the price of enriched uranium in the near term. They claim that GCEP will be obsolete before it is completed, and argue that it should at least be put on hold until new technologies—based on lasers or advanced centrifuges—are available in the early 1990's.

Getting GCEP built in the face of growing opposition and dwindling demand for enriched uranium is not the only problem facing the program.

- The government's three existing enrichment plants have recently undergone a major overhaul, costing $1.5 billion, to increase their capacity by 60 percent and improve their performance. Yet demand is so depressed that these expensively refurbished plants are now being operated at only about 35 percent capacity and one may soon have to be shut down.
- A huge "secondary market" has recently emerged as utilities, saddled with surplus uranium they ordered several years ago under fixed contracts, are unloading the material to other utilities at substantial discounts. According to DOE estimates, there may be enough enriched uranium slopping around in the secondary market to meet worldwide demand for 2 or 3 years. The surplus is expected to grow in the next few years and will not be worked off until the early 1990's, which means that demand and prices will remain depressed for the foreseeable future.
- DOE is currently paying more than $100 million a year in penalties to the Tennessee Valley Authority (TVA) for electricity it had contracted to buy to operate enrichment plants but which is no longer needed. Next year, these penalties will be more than $200 million and by 1992, the accumulated payments will total a staggering $1.23 billion, according to a recent estimate by the General Accounting Office (GAO).
- Ten years ago, the United States held a worldwide monopoly on sales of enriched uranium, but its share of the non-U.S. market has now slumped to about one-third and DOE's prices are being undercut by its foreign competitors. This price differential could worsen in the next few years as DOE tries to raise revenues to pay for GCEP.



The Portsmouth centrifuge plant

The nation's biggest construction project—if it is all built.

How DOE got itself into this mess is relatively straightforward: in the 1970's it grossly overestimated the demand for enriched uranium and made a number of decisions it later came to regret. At the time, the policies seemed sensible, but "with 20/20 hindsight, the decisions were wrong," says Shelby T. Brewer, head of nuclear power programs at DOE.

A decade ago, the most pressing problem facing the enrichment program was how to build capacity fast enough to keep up with soaring demand for reactor fuel. The federal government began enriching uranium for the fledgling nuclear power industry in the late 1960's, using three massive plants that were built in the 1940's and early 1950's to produce highly enriched uranium for nuclear weapons.* The Atomic Energy Commission (AEC), which built and operated the plants, essentially ran a service business, enriching uranium for both domestic and foreign utilities and charging enough to cover costs. By 1974, so many nuclear plants were under construction or on order worldwide that the AEC calculated that demand for enriched uranium would exceed capacity by the early 1980's. The AEC then made the first of several decisions that would come back to haunt the enrichment program: it announced that it would accept no more new orders. The order books remained closed until 1978.

Because the United States was then the sole commercial supplier of enriched uranium in the non-Communist world, AEC's abrupt moratorium had far-reaching repercussions. One consequence was a major boost to Europe's enrichment business. With no competition for new orders, two groups which built enrichment plants in the 1970's—Eurodif, a consortium of French, Spanish, Belgian, and Italian government and private inter-

*About 0.7 percent of natural uranium is the fissile isotope uranium-235. The rest is uranium-238. For use in a light water reactor, the uranium-235 content must be increased ("enriched") to about 3 percent. Weapons-grade uranium is about 95 percent uranium-235.

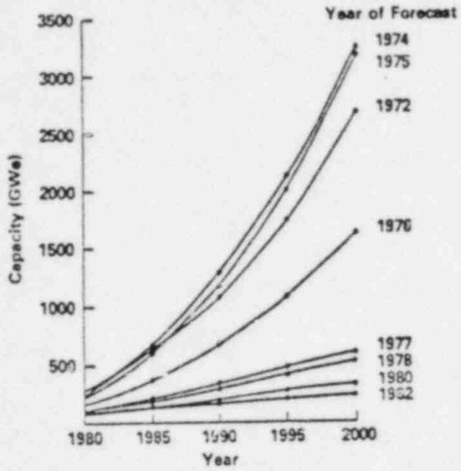
ests, and Urenco, a consortium of Brit-ish, West German, and Dutch interests—picked up two-thirds of the enrichment business outside the United States by the end of the decade.

The United States, meanwhile, was scrambling to increase its own capacity. A 10-year effort to expand output from the three existing plants—located in Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio—was already under way. But even with this expansion, the AEC estimated in 1975 that as many as 8 to 12 new plants would be needed by the end of the century. Congress was duly persuaded to give the go-ahead for immediate construction of one new facility.

In 1977, the Carter Administration announced that the plant, to be built alongside the existing enrichment facility at Portsmouth, would use a new technology. The three postwar plants all employ a process called gaseous diffusion in which uranium hexafluoride gas is forced through thousands of porous barriers. Because lighter molecules containing the fissile uranium-235 isotope tend to diffuse through the barriers more quickly than those containing uranium-238, the concentration of fissile material increases as the uranium hexafluoride passes through the plant. The process has a major drawback: it is a voracious consumer of electricity. Since electricity prices were going through the roof in the 1970's, the Carter Administration decided that the new Portsmouth facility would use gas centrifuges, a novel but potentially much less energy-intensive enrichment technology. In this process uranium hexafluoride is spun at high speeds in a series of massive centrifuges. The new plant—GCEP—was originally scheduled to be in full production by 1986.

While all this was going on, however, the bottom fell out of the nuclear power business as utilities, faced with escalating construction costs and declining growth in electricity consumption, canceled or deferred scores of power plants. The impact on uranium enrichment has been dramatic. Since 1975, when Congress gave the go-ahead for GCEP, the projected demand for U.S. enriched uranium in the year 2000 has dropped by more than a factor of 10 (see chart). As a result, the GAO and the Congressional Research Service both concluded last year that DOE's existing gaseous diffusion plants have more than enough capacity to meet demand until the end of the century and beyond. In other words, the original justification for building GCEP has evaporated.

U.S. Supplied Nuclear Power Growth



Enrichment's sinking fortunes

No matter; DOE now says that although GCEP may not be justified simply to meet rising demand, it is needed to stabilize the cost of enrichment and stave off foreign competition. Without it, "the United States would price itself out of the enrichment business," claims Brewer. In essence, DOE is saying that enrichment is no different from, say, steelmaking: in spite of worldwide overcapacity, the United States must build new, more efficient plants and retire its old ones if it is to stay competitive.

There is certainly good evidence that the United States is losing enrichment business and that it may lose a lot more. For one thing, thanks in part to those penalties DOE is paying TVA and to the rise of the dollar against European currencies, the substantial price advantage enjoyed by the United States in the 1970's has disappeared. It is now being undercut by Eurodif, Urenco, and the Soviet Union (which is now selling some enriched uranium on the international market). Then there is the secondary market. According to DOE estimates, some two-thirds of the material in the secondary market is of European origin and it is being offered in the United States at substantial discounts.

The first indication of a shift in the market came in August 1982, when Florida Power and Light bought some European uranium on the secondary market. Four months later, South Carolina Gas and Electric became the first U.S. utility to sign a contract directly with Eurodif rather than DOE.

It is debatable, however, whether building GCEP is the best way to shore up the U.S. enrichment business in the long term, and the plant will certainly add to the economic and political problems in the short term.

The immediate difficulty is that the construction costs of GCEP in the next few years will push the costs of the enrichment program well above revenues from sales of enriched uranium. In 1987 alone, according to DOE estimates, the program will be about $500 million in the red. This means that either Congress and the Office of Management and Budget must approve a departure from the current pay-as-you-go policy, under which DOE balances costs and revenues on an annual basis, or DOE will have to raise its prices drastically. The former would make the program highly vulnerable politically, and the latter would certainly price the United States out of the enrichment business.

As for the plant's long-term economics, they depend on whether all or only part of the plant is built, how rapidly the state of the art in centrifuge technology advances, and how much further projected demand for enriched uranium sinks.

The current plan, which is now under review within DOE, is to build GCEP in eight modules, each of which is a massive process building housing thousands of centrifuges. The first two buildings are under construction, and their centrifuges are expected to be installed and running by 1988. The other buildings would be added in stages, with final completion of the entire plant scheduled for 1994. DOE anticipates that centrifuge technology will advance as GCEP is built so that the machines installed in the final buildings will be two to three times more efficient than those in the earlier modules.

By the end of this fiscal year, DOE will have spent some $1.8 billion on GCEP and, by the time the first two process buildings are completed, it will have gone through half the projected capital cost of the entire eight-module plant. (The total plant cost is now put at some $9 billion, in 1984 dollars.) The high initial capital cost is explained in part by the fact that DOE decided to construct central facilities capable of handling the work of all eight modules. This, of course, provides a built-in incentive to finish the plant once the initial buildings are completed: later modules will be cheaper to build and, because they will employ more efficient machines, they will be far more productive.

DOE's current justification for building GCEP is that, because it will use only about 5 percent of the electricity consumed by a gaseous diffusion plant to produce a given quantity of enriched uranium, it will help reduce the long-term price of enrichment. But last year, GAO questioned that claim because, it said, DOE was still using unrealistically high estimates of demand; at lower demand levels, GCEP's cost advantage dis-

appears, GAO con[illegible] soon to be published by the Congressional Budget Office, however, will argue that GCEP will be cost effective if the advanced centrifuges now scheduled for only the final buildings were installed in the entire plant. This would mean ripping out the less efficient machines a few years after they are installed and replacing them with the advanced centrifuges.

In essence, this would require building part of the plant twice. That may reduce costs in the long term, but it would increase outlays in the short term and aggravate the political problem of getting Congress to come through with the money. It also invites the question, why install the less efficient machines at all? Why not put the whole thing on hold until the advanced machines are available? That, in fact, is precisely what Representative Richard Ottinger (D–N.Y.), a critic of GCEP, proposed last year.

In this regard, it should be noted that centrifuge development is proceeding so rapidly that the advanced machines could be ready much earlier than originally expected. According to Richard Grant, who is heading the centrifuge program for Boeing, key elements of the machines are already under test and commercial production could come as early as 1988–1989—some 3 to 4 years ahead of schedule.

There is, however, another factor that should play a crucial role in deciding what to do with GCEP: the development of a technology based on lasers that may offer substantial cost advantages over even advanced centrifuges. DOE, urged on by Congress, is now pumping about $100 million a year into the development of laser enrichment.

The process, first developed by scientists working for the Avco Everett Research Laboratory, involves subjecting a stream of atomic uranium vapor to a series of very finely tuned laser beams. Energy is absorbed only by atoms of uranium-235, which eventually lose an electron. The resulting uranium-235 ions are then collected by passing the vapor stream through a magnetic field, which deflects the ions while the neutral uranium-238 atoms pass straight through.

Avco Everett, in partnership with an Exxon subsidiary, spent some $77 million of their own funds developing the technology during the 1970's. But in 1980 they decided that the time was not ripe to build a private enrichment plant and proposed a joint venture with DOE to commercialize the technology. In the meantime, however, the Lawrence Livermore National Laboratory was working on a parallel laser process that by the early 1980's was also ready to be scaled up. For reasons that have never been adequately explained, DOE turned down the Avco Everett/Exxon proposal and, in April last year, announced that it would build a demonstration plant based on the Livermore process. (Avco Everett disbanded its enrichment team, but has managed to salvage some of the work: it is now using the lasers in a Defense Department program to develop laser communications with submarines.)

When it selected Livermore, DOE planned to have a demonstration laser facility in operation by 1990, but it has recently brought forward the target date to 1987. (The speedup will be achieved by use of lasers being built at Livermore to separate isotopes of plutonium in a defense program.) As it happens, that is about the time when the advanced centrifuges are expected to be ready for commercial development.

Shelby Brewer

Counting on GCEP to lower prices.

This has led supporters of the laser program to argue that no firm commitment should be made to complete GCEP until both the laser process and the advanced centrifuges have been properly evaluated. DOE "should put everything [at GCEP] on hold as best they can and then compare the two processes," says James Davis, who is heading the Livermore effort. Davis has no doubts about which would win. The laser process at present promises to be much less capital-intensive than centrifuge technology, and its operating costs, although still somewhat uncertain, are expected to at least match those of advanced centrifuges.

So far, the enrichment program has attracted little interest on Capitol Hill beyond the committees that oversee DOE and appropriate the funds. GCEP, for example, [illegible] attracted anything like the attention devoted to the much less expensive Clinch River Breeder Reactor. But that may change in the coming months as the program's problems become more widely known. Later this year, for example, Senator Gordon Humphrey (R–N.H.), a critic of GCEP, plans to hold hearings with a subcommittee he chairs that has jurisdiction over TVA, to look into the massive penalties DOE is forking over to the utility. And next year, Ottinger, who chairs a key House energy subcommittee, will get a crack at the program when it comes up for authorization.

Already, the House Committee on Science and Technology and the appropriations committees have put DOE on notice that there could be rough times ahead. They have approved funds for only the first two modules of GCEP and demanded a study of what should be done beyond that. DOE, meanwhile, has shaken up the management of the program, bringing in to head it John R. Longenecker, a 34-year-old engineer who formerly managed DOE's Clinch River program. Longenecker said in an interview that the whole program—including stopping GCEP—is under examination, and a new plan will be formulated by the end of the year.

The options facing DOE and Congress are complicated and painful. To cancel GCEP now would mean writing off the $1.8 billion already spent plus some $350 million in cancellation charges. It would also run the risk of seeing the operating costs of the gaseous diffusion plants climb steadily, with no relief if the laser process does not live up to expectations. But to continue with GCEP will require some major infusions of cash in the next few years from a Congress concerned about budget deficits and about hidden subsidies to the nuclear industry. Building GCEP now, moreover, may well preclude building a laser plant in the 1990's, even if laser technology ultimately turns out to be superior. The alternative, putting GCEP on hold to wait for advanced centrifuges or lasers, would incur considerable costs if the plant is later reactivated. Finally, if construction were halted after only two modules, the plant will be of dubious economic value because of those huge capital expenditures DOE has already sunk into central facilities for the entire eight-module operation.

One potentially attractive solution to all this is to turn the whole business over to private industry. Getting enrichment out of the federal appropriations process would mean that new construction could

be financed by borrowing on the capital markets rather than from current revenues. Decisions would also be made on a strictly business basis, and industry, which stands to benefit from lower enrichment prices, would bear the risks. The Reagan Administration, which is ideologically committed to getting the federal government out of running businesses, would very much like to turn enrichment over to the private sector, but it is not at all clear how it could be done.

One proposal, under consideration in the White House, is simply to announce that the federal government will not finance any more construction after the first two modules of GCEP. That would at least focus attention on how future capacity should be financed, but it would do little to help avert the budget crunch in the next few years. A more radical idea, put forward by the conservative Heritage Foundation, would be to turn over management of existing plants to a group consisting of utilities that currently have contracts to purchase enriched uranium from DOE. This management corporation would essentially lease the plants for a fee to pay off their depreciat- ... future plants. In any case, given the huge uncertainties facing the enrichment business, private industry is not leaping at the investment opportunity.

For DOE, the immediate problem is how to get through the next few years, especially in view of that huge secondary market depressing demand and prices. "Somehow," says Brewer, "we must get through the valley of the shadow—this secondary market problem—and emerge with the best technology." Billions of dollars are riding on how DOE chooses to do it.—COLIN NORMAN

Study of Atomic Veterans Fuels Controversy

Criticism of a study of U.S. soldiers in Hiroshima and Nagasaki illustrates the pitfalls of dressing up a political study as purely a scientific investigation

The National Research Council (NRC) recently fired another salvo in an ongoing battle between several veterans organizations and the scientific community over the merits of conducting an epidemiological study of U.S. soldiers who were in Japan shortly after the end of World War II. The veterans, led by a retired mail carrier from Oregon, claim that an unusual number of soldiers who passed through Hiroshima and Nagasaki have developed multiple myeloma, a bone cancer, as a result of exposure to residual radiation after the bomb blasts in 1945.

The NRC, in a controversial report released on 16 July, suggested that the veterans' claims are unwarranted and that an epidemiological study would probably be a waste of time. Specifically, it said that only nine cases of multiple myeloma had been confirmed among members of the occupation force "stationed in or near Hiroshima and Nagasaki." This, said the NRC, constitutes an incidence no greater than that in the general population.

Although the report has been welcomed by the Department of Defense, it has outraged the veterans and attracted pointed criticism from several outside scientists. The National Association of Atomic Veterans, a lobby organized to win financial compensation for veterans who blame their ailments on radiation exposure, has denounced the report as "medically criminal." Glenn Alcalay, an official of the group, says that the NRC ignored some victims of myeloma on a list of U.S. occupation force members compiled by his organization. "If the people who were ignored or are dead from the disease are counted, we're dealing here with an epidemic," he says.

Although there seems to be broad agreement that Alcalay is wrong about a cancer epidemic, several independent scientists agree with him that the NRC report has some serious shortcomings. "The NRC is probably correct in its conclusions, but I think their methodology is slovenly," says Bernard Greenberg, a biostatistician who is dean emeritus at the University of North Carolina School of Public Health. Similarly, Edward Radford, a radiation epidemiologist at the University of Pittsburgh, says "I would doubt very much if there was a significant exposure to radiation by the U.S. occupation force, but I think that the study adds nothing to a discussion of whether there really is more myeloma than one would expect." He and Greenberg agree with the veterans organizations that the NRC failed to look diligently for myeloma victims, and that it may have used an inappropriate control group to estimate whether the occupation force members suffer from excess cancers.

The response of the NRC, which is the operating arm of the National Academy of Sciences, is essentially to acknowledge the presence of shortcomings in the report and to explain that it was intended from the outset to serve a primarily political, not scientific, purpose. "We're not in a purely scientific world here," says Seymour Jablon, a radiation expert who coordinated the study as director of the NRC's Medical Follow-up Agency. "We're in a world of pressures—from the veterans on one side and of course from the government on the other." Jablon is unwilling to describe the report as sound science. "I don't think I want to answer that question," he says.

The idea for the report came from an NRC study in 1981 on the feasibility of conducting a full-scale epidemiological investigation. A panel chaired by Brian MacMahon of the Harvard School of Public Health had been formed at the request of the Pentagon for the purpose of deflecting growing congressional interest in such an investigation, Jablon says. "The Pentagon was searching for a way to resist what they saw as an unwarranted demand for an expensive undertaking. And so they turned to the NRC."

The panel listened to testimony from veterans organizations, the Defense Nuclear Agency, and the National Cancer Institute and concluded that the potential benefit of an epidemiological investigation was not worth the "formidable" cost. The panel reasoned that radiation doses received by the soldiers were simply too low to cause any detectable excess cancers, unless existing assumptions about the effect of radiation on human health are incorrect.*

In what MacMahon describes as a sop to the veterans, the NRC panel did recommend closer scrutiny of a list of alleged myeloma victims compiled by Vic-

*The other panelists were Robert Anderson of the University of New Mexico, John Auxier of Oak Ridge National Laboratory, Stuart Finch of Rutgers University, Alun Jones of Chalk River Nuclear Laboratories in Canada, and Arthur Upton of the New York University Medical Center.