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DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment

Prepared for

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Washington, D. C.
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Executive Summary

INTRODUCTION

This report assesses the adequacy of infrastructure to support the near-term deployment of new nuclear power plants in the United States. Today, there are 103 operating U.S. nuclear reactors. According to the Energy Information Agency's Annual Energy Outlook, nuclear power plants produced 20.9% of the electric power generated during 2003 in the U.S. The Annual Energy Outlook projects nuclear generating capacity will increase from 99.2 gigawatts in 2003 to 102.7 gigawatts in 2025 based on power uprates of existing plants and the restart of the Tennessee Valley Authority's Brown's Ferry Unit 1 in 2007. With no new nuclear plant construction, the Annual Energy Outlook projects that nuclear power plants will produce just 15.1% of U.S. electric power in 2025. While the timing of new U.S. nuclear power plant construction remains an open issue, the readiness of the existing U.S. and international infrastructure to support a major U.S. nuclear plant construction program will be important to the success of this program.

The U.S. Department of Energy (DOE) initiated the Nuclear Power 2010 (NP2010) Program in February 2002 as a joint government/industry cost-shared program to develop advanced reactor technologies and demonstrate new regulatory processes that would lead to a private sector decision to order a new U.S. nuclear power plant. As part of the NP2010 Program, DOE tasked MPR Associates, Inc. to evaluate the infrastructure necessary to support construction of new U.S. Generation III+ (GEN III+) nuclear power plants in the 2010 timeframe. This infrastructure assessment's primary objective was to identify any specific infrastructure weaknesses and to recommend appropriate actions and lead times for mitigating potential impacts on GEN III+ plant construction schedules.

Our infrastructure assessment approach included the development of the baseline resources required for construction of a single plant based on available GEN III+ plant information. MPR confirmed the reasonableness of the baseline resources with Nuclear Steam Supply System (NSSS) vendors and Engineering, Procurement, and Construction (EPC) contractors. We then held discussions with NSSS vendors, equipment manufacturers, material suppliers, module fabricators, EPC contractors, U.S. Department of Labor, labor unions, trade organizations, and the Nuclear Regulatory Commission to investigate their capabilities to support the near-term deployment of GEN III+ units. These capabilities were then compared with the resource requirements associated with a hypothetical scenario involving the construction of up to eight nuclear units during the period from 2010 to 2017 to identify any resource shortfalls. For this assessment, shortfalls were any instances of insufficient infrastructure resources or deficiencies that require actions more than five years before the commercial operation date of the first GEN III+ units, not including COL application work, site-specific design work, and normal early procurement activities. In areas where shortfalls were identified, further investigations were conducted to develop recommendations and lead times needed to mitigate any impacts on the construction schedules.

CONCLUSIONS AND RECOMMENDATIONS

The necessary manufacturing, fabrication, labor, and construction equipment infrastructure is available today or can be readily developed to support the construction and commissioning of up to eight nuclear units during the period from 2010 to 2017. However, this assessment identified several areas where the infrastructure and available resources are limited as well as some open issues related to codes and standards. These items are risks to the successful construction of GEN III+ units on the desired schedules. This assessment identifies strategies that can be used during the design and construction periods to mitigate these risks. The main challenge for the U.S. nuclear power industry will be to have the right resources available at the right place and the right time to build and commission the first U.S. GEN III+ units on schedule and on budget. Major conclusions and recommendations from this assessment are summarized below.

Digital Plant Control Systems and Plant Simulators

A significant threat to the successful construction of GEN III+ units is the design and approval of the digital plant control systems. Although NSSS vendors have not specified the design of these systems in their Design Certifications, such hardware is available from U.S. and international manufacturers for the digital plant control systems and the plant simulators required for U.S. GEN III+ units. However, current NRC guidance endorses older versions of IEEE standards and deleted IEEE standards for digital plant control systems, and the NRC guidance concerning the critical area of Software Safety Analysis is quite general and needs to be modified to support the efficient design and the NRC review of plant control system software. As a result, extra lead time will be required for the NRC to develop new guidance, for that guidance to be reflected in system designs and analysis (e.g. human factors evaluations), and for the NRC to complete their review and approval of the digital plant control systems.

We recommend that the NRC modify their procedures and regulations concerning the design, review, and approval of digital plant control systems and plant simulators for GEN III+ units. These changes are needed to allow for the effective design and review of new plant control systems and plant simulators and to put this design review process on a schedule that is compatible with actual project schedules. We estimate this action would need to begin nine years before the commercial operation date (four years before the start of site preparation) for the first U.S. GEN III+ units. This is a critical item for the success of the NP2010 Program and DOE should consider cost-shared efforts with the IEEE and the nuclear industry to revise standards and provide input on revision of applicable Regulatory Guides by the NRC if other resources are not available.

Reactor Pressure Vessel Nuclear-Grade Large Ring Forgings

The most significant manufacturing concern and the associated construction schedule risk is that reactor pressure vessel (RPV) fabrication could be delayed by the limited availability of nuclear-grade large ring forgings. These forging are currently only available from one Japanese supplier. Additional lead time may need to be included in RPV procurement schedules depending on the ability of this one supplier to supply the required RPV large ring forgings in a timely manner.

We recommend that NSSS vendors monitor the availability of large ring forgings and adjust their procurement schedules to ensure large ring forgings are available for RPV fabrication. If

necessary and with financial support from their customers, NSSS vendors should purchase the large ring forgings early and arrange deliveries to support normal RPV fabrication schedules. If the demand for new nuclear units is sufficient, NSSS vendors should develop additional capacity for the supply of nuclear-grade large ring forgings.

Qualified Personnel

Hiring the highly-skilled and highly-valued construction workers needed to build nuclear units is expected to be a challenge. Qualified boilermakers, pipefitters, electricians, and ironworkers are expected to be in short supply in local labor markets. The use of workers from other communities and states (travelers) will be required for these construction trades. All other construction trades (i.e., laborers, insulators, equipment operators, teamsters, etc.) should be available in sufficient numbers to support GEN III+ unit construction projects.

We recommend several actions to mitigate the risks associated with the limited availability of highly-qualified personnel:

- NSSS vendors and EPC contractors should complete the plant design (including the routing of small bore piping, tubing, and conduit to the maximum amount practical) prior to starting construction, prepare a detailed construction schedule, and plan for sufficient staffing for rapid response teams at the point of work for problem resolution. To the maximum extent possible, personnel with experience designing and building nuclear units should be used to design and construct GEN III+ units. These steps are needed to sustain the high labor productivity rates necessary for achieving the desired construction schedules and project costs. The past consequences of not having this level of design completion and project preparation have been that labor requirements and construction schedule durations were often doubled.

- EPC contractors as a group should negotiate and sign a national labor agreement with major labor unions to provide flexibility in staffing nuclear construction projects (e.g., allowing union members from different areas to work at any nuclear plant construction site). This step helps ensures the needed construction workers will be available.

- The NRC, nuclear utilities, NSSS vendors, component suppliers, material suppliers, and EPC contractors should ensure that appropriate Quality Assurance (QA) and Quality Control (QC) programs are in-place and are properly implemented for the design, fabrication, construction, and inspection of GEN III+ units. Prior experience, detailed in NUREG-1055, shows that QA and QC problems caused major difficulties in earlier nuclear plant construction projects. These steps ensure that the work gets done right the first time and that additional construction labor and schedule time are not needed to correct deficiencies.

- Nuclear power plant operators should recruit and train health physicists, operators, and maintenance technicians at their existing nuclear plants to serve as replacements at their existing plants and to staff the new GEN III+ units. This ensures that the plant operator’s staff is available for training and for supporting the start-up, commissioning, and testing of new GEN III+ units.

Material Procurement

Competing and increasing worldwide demands for material supplier resources can impact lead times associated with the procurement of material needed for the manufacture and fabrication of equipment for U.S. GEN III+ units. Other countries are using the same resources to provide equipment for their nuclear plant construction programs. In addition, other industries are using these material supplier resources to provide the material required for their expansion programs. These demands on important material suppliers are a risk to the successful construction of GEN III+ units.

We recommend that NSSS vendors and EPC contractors monitor foundry lead times for castings through discussions with their pump and valve manufacturers, monitor pipe supplier lead times for high-nickel alloy forged pipe through discussions with their pipe suppliers and module fabricators, and monitor nuclear-grade metal supplier lead times for high-nickel alloy metals through discussions with their pipe suppliers, tube suppliers, and equipment manufacturers. If necessary, procurement schedules should be adjusted to ensure the required materials are available to support manufacturing, fabrication, and construction schedules.

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1 Introduction

1.1 BACKGROUND

Today, there are 103 operating nuclear reactors in the United States. According to the Energy Information Agency's Annual Energy Outlook (Reference 1), nuclear power plants produced 20.9% of the electric power generated during 2003 in the U.S. The Annual Energy Outlook projects nuclear generating capacity will increase from 99.2 gigawatts in 2003 to 102.7 gigawatts in 2025 based on power uprates of existing nuclear plants and the restart of the Tennessee Valley Authority's Brown's Ferry Unit 1 in 2007. With no new U.S. nuclear plant construction, the Annual Energy Outlook projects that nuclear power plants will produce just 15.1% of U.S. electric power in 2025. While the timing of new U.S. nuclear power plant construction remains an open issue, the readiness of the existing U.S. and international infrastructure to support a major U.S. nuclear plant construction program will be important to the success of this program.

In February 2001, the U.S. Department of Energy (DOE) organized a Near-Term Deployment Group (NTDG) to examine prospects for deployment of new nuclear plants in the U.S. in this decade. The NTDG identified obstacles to deployment and recommended actions for obstacle resolution. In October 2001, the NTDG published "A Roadmap to Deploy New Nuclear Power Plants in the U.S. by 2010," (Reference 2). A key recommendation of the NTDG roadmap was to conduct an assessment of nuclear industry infrastructure.

Roadmap recommendations were used by DOE to form the basis for a new initiative, the Nuclear Power 2010 (NP2010) Program. The NP2010 initiative is a joint government/industry cost-shared program to develop advanced reactor technology and demonstrate new regulatory processes leading to a decision for a private sector order for a new nuclear power plant in the U.S. with plant construction to start by 2010. NP2010 is an integrated program that aggressively pursues regulatory approvals and design completion in a phased approach to support construction of new U.S. nuclear plants in the 2010 timeframe.

In support of the NP2010 program, DOE created a team to perform additional studies, including the "Study of Construction Technologies and Schedules, O&M Staffing and Cost, Decommissioning Costs and Funding Requirements for Advanced Reactor Designs," (Reference 3) and the "DOE NP2010 Construction Schedule Evaluation" (Reference 4). These studies are complete and they identified manufacturing and fabrication infrastructure and construction infrastructure as issues that need further evaluation to ensure the industry's ability to support the construction schedules proposed by the reactor vendors.

In February 2004, the first edition of the "U.S. Department of Energy/Nuclear Power Industry Strategic Plan for Light Water Reactor Research and Development" (Reference 5) was published. This Infrastructure Assessment Report specifically addresses Strategic Plan

Objective 1-3 (assess the adequacy of the fabrication and manufacturing infrastructure) and Objective 1-4 (assess the adequacy of the skilled construction trade sector) for supporting near-term deployment. The Secretary of Energy Advisory Board (SEAB) has made a similar recommendation to investigate infrastructure necessary for nuclear plant construction.

In response to a request from the SEAB, DOE initiated a study to evaluate the impact of a new nuclear power plant construction program on U.S. job creation. The result is the "U.S. Job Creation Due to Nuclear Power Resurgence in the United States" report dated November 2004 (Reference 6). That report includes a "Study of the Impact on Domestic Manufacturing and Supply Infrastructure Resulting from New Nuclear Plant Deployment" as an Appendix. The Jobs Creation Report and attached study focus on jobs and complement the work associated with this "DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment Report." The Jobs Creation Report estimated that the construction of 40 GEN III+ nuclear units would add to the U.S. economy by repatriating 37,000 manufacturing jobs, adding 72,000 plant construction and plant operation jobs, and adding 400,000 to 500,000 indirect jobs.

Progress towards the near-term deployment of new nuclear power plants in the U.S. has been made in several areas. Early Site Permit (ESP) applications have been submitted for nuclear power plants in Illinois, Mississippi, and Virginia. The Tennessee Valley Authority (TVA) is studying the cost of building a twin unit Generation III+ (GEN III+) plant at the Bellefonte Nuclear Plant site in Scottsboro, Alabama, where the construction of a Generation II plant was halted. In addition, several industry consortiums have formed with plans to test the NRC's new nuclear plant licensing procedures by submitting applications for combined construction and operating licenses (COLs).

At the time this assessment was in progress, three GEN III+ plant designs were being considered for inclusion in COL applications and U.S. near-term deployment. The GEN III+ plants being considered are based on the following Nuclear Steam Supply System (NSSS) reactor designs, namely the:

- General Electric (GE): Economic Simplified Boiling Water Reactor (ESBWR);
- Toshiba-Version, GE-Design: Advanced Boiling Water Reactor (ABWR); and
- Westinghouse: Advanced Pressurized Water Reactor (AP1000).

Recently some potential owner/operators have expressed interest in the Framatome ANP (Areva) European Pressurized Water Reactor (EPR) design, but this occurred too late to expand the scope of the report to include a fourth reactor design.

1.2 PURPOSE

As part of the NP2010 Program, DOE initiated this infrastructure assessment to identify weaknesses in domestic or global manufacturing, fabrication, or construction infrastructures and to identify actions and corresponding timetables required to correct any shortfalls (insufficient infrastructure resources or deficiencies that require actions more than five years before the commercial operation date of the first GEN III+ units, not including COL application work, site-

specific design work, and normal procurement activities) in time to support the construction and startup of new U.S. GEN III+ nuclear power plants.

This assessment evaluates the manufacturing, fabrication, labor, and construction equipment requirements associated with building GEN III+ plants. This evaluation is not intended to be all-encompassing, but sufficient areas were investigated to ensure the results are credible and useful. Requirements are compared with the available infrastructure resources to identify any shortfalls. When shortfalls are identified, actions and timetables are recommended for mitigation. This assessment and report have been prepared for DOE under Order No. DE-AT01-020NE23476.

1.3 Scope

The scope includes the following infrastructure assessment work:

- Establish generic resource requirements applicable to building any one of the three GEN III+ plant designs.
- Assess manufacturing and fabricator infrastructure capable of producing equipment and prefabricated modules for GEN III+ plants including the associated quality assurance programs.
- Assess availability of construction and construction support labor pools and compare these labor resources with the labor needs associated with building GEN III+ plants.
- Assess any shortfalls between resource requirements and infrastructure capabilities. Establish lead times necessary to restore or add to the infrastructure capabilities needed to build GEN III+ plants.
- Report on NRC plans for personnel necessary to support GEN III+ plant licensing, construction, inspection, testing, and commissioning.
- Report on Codes and Standards issues that impact GEN III+ plant design, equipment manufacture, module fabrication, construction, inspection, or operation.
- Provide recommendations and timelines for actions by NSSS vendors, equipment suppliers, fabricators, labor organizations, utilities, constructors, and DOE.

A glossary of terms and acronyms used throughout this report is provided in Appendix A.

1.4 Approach

Resource requirements were established based on available GEN III+ plant information. These requirements were confirmed with NSSS vendors and EPC contractors. NSSS vendors, equipment manufacturers, module fabricators, labor organizations, EPC contractors, material suppliers, and the NRC were contacted to discuss their capabilities and their abilities to provide the resources necessary to support GEN III+ plant construction. Resource requirements were compared with the currently available capabilities and near-term capabilities. Capacity shortfalls were identified. Recommendations and estimated lead times are provided for actions by DOE and the nuclear industry to mitigate the identified shortfalls.

Resource Requirements

Based on available GEN III+ plant information, a generic set of resource requirements were identified for a single unit GEN III+ plant. Based on these resource requirements, a resource loading was estimated based on a five-year schedule with site preparation taking 12 to 18 months, construction (first concrete to fuel loading) taking 36 to 42 months, and commissioning and testing taking six to 12 months. While first-of-a-kind GEN III+ plant construction and commissioning may take longer than the five-years estimated for various reasons, this report uses a five-year schedule as a conservative basis for establishing resource requirements. The five-year schedule is more conservative than a longer schedule because it puts more pressure on manufacturing, fabrication, and construction equipment resources with more equipment and modules required over a shorter period of time. Similarly, the five-year schedule is conservative because it increases peak labor requirements and puts pressure on the available labor resources.

Twin unit resource loading was conservatively estimated based on the resource loading for two single units and completing the second unit 18 months after completion of the first unit. In actuality, resources required to construct twin units are less than double the resources for two single unit plants because of shared infrastructure.

Peak resource requirements were established based on building eight units (six single unit plants and one twin unit plant) with construction (first concrete) on two single unit plants starting in 2010 and commercial operation of the last single unit in 2017. Building eight GEN III+ units during the initial eight years of GEN III+ plant construction is considered a conservative basis for establishing resource requirements. The identified resource requirements were used as a basis for investigating and evaluating the available manufacturing, fabrication, labor, and construction equipment infrastructure capabilities.

Manufacturing

Components for nuclear plants are manufactured on a worldwide basis. MPR evaluated the available manufacturers and identified the gaps between current capabilities and the resource requirements identified for providing equipment and materials for multiple plants. The manufacture of N-stamped and nuclear-grade components and materials was assessed. NSSS vendors, N-Stamp Certificate Holders, other manufacturers, and material suppliers were contacted to determine current capabilities and abilities to expand production capabilities.

Fabrication

Shop fabrication of equipment modules, structural modules, piping modules, and piping is critical to reducing nuclear plant construction schedules and costs. MPR evaluated the available fabricators and identified gaps between current capabilities and the resource requirements identified for providing modules for multiple plants. Global resources were considered for the first new U.S. nuclear power plants. Discussions were held with NSSS vendors, N, NA, NPT, and NS-Stamp Certificate holders, companies that could reactivate their nuclear fabrication programs, shipbuilders, and other U.S. companies that are currently fabricating large equipment modules for heavy industry and power plant applications.

Labor

MPR evaluated the labor market to identify any gaps between current capabilities and the resource requirements identified to construct multiple plants. This report investigates the availability of specialty crafts and labor resources available in Illinois, Mississippi, Virginia, and

Alabama where the first GEN III+ units are currently expected to be built. Discussions were held with the U.S. Department of Labor, the Nuclear Energy Institute (NEI), labor unions, trade organizations, EPC contractors, State Department of Labor analysts, NRC, manufacturers, and fabricators to determine labor availability and training programs and lead times for training skilled labor. Labor productivity issues have been considered. We have assumed that systems will be in place to ensure labor productivity rates are not reduced by factors that can impact large nuclear construction sites.

Construction Equipment

While most construction equipment necessary for nuclear power plant construction is readily available, some special construction equipment may be in short supply. MPR evaluated special construction equipment availability to identify gaps with the resource requirements. Lead times were determined for manufacturing the additional special construction equipment. Discussions were held with Very Heavy Lift (VHL) crane suppliers, automatic welding equipment suppliers, pipe bending machine suppliers, and rebar assembly machine suppliers.

Balance of Plant

Balance of Plant (BOP) systems and structures are not considered by this infrastructure assessment. BOP systems include such items as cooling towers, administration buildings, warehouses, water treatment systems, roads, and switchyards. Unlike the nuclear island equipment and structures that are the focus of this infrastructure assessment, BOP systems and structures are not normally critical path items. Infrastructure is normally available to build BOP systems and structures. Similar BOP systems and structures are required when building fossil power plants, process plants, and commercial buildings. The infrastructure capacity to build BOP systems and structures far exceeds the BOP resource requirements associated with eight GEN III+ units.

2 Conclusions and Recommendations

For perspective, we note that the supply of equipment and materials for nuclear power plant construction is an on-going global endeavor. Over thirteen nuclear units are currently under construction in Asia. An additional nuclear unit is under construction in Finland. Japan and Korea are planning to start construction on up to fourteen more nuclear units during the period from 2005 to 2011. China plans to build more than twenty new units between now and 2020. U.S. manufacturers and fabricators are currently providing equipment and prefabricated modules for the nuclear units under construction in Asia.

2.1 Conclusions

The necessary manufacturing, fabrication, labor, and construction equipment infrastructure is available today or can be easily developed to support the construction and commissioning of up to eight U.S. nuclear units during the period from 2010 to 2017. However, this assessment identified several areas where the infrastructure and available resources are limited as well as some open issues related to codes and standards. These items are risks to the successful construction of GEN III+ units on the desired schedules. This assessment identifies strategies that can be used during the design and construction periods to mitigate these risks. In the global marketplace for nuclear plant equipment and materials, the planning and coordination of procurement activities for U.S. plants will be critical. The main challenge for the U.S. nuclear power industry will be to have the right resources available at the right place and the right time to build and commission the first U.S. GEN III+ units on schedule and on budget.

Table 2-1 is located at the end of this conclusions section and this table provides a summary of the main conclusions of this assessment. Shortfalls were identified four general areas, namely, codes and standards, manufacturing capability, qualified personnel, and material procurement. Details on these shortfalls are provided below along with additional conclusions and important observations for each assessment area.

Manufacturing

Reactor pressure vessel (RPV) fabrication could be delayed by the limited availability of the nuclear-grade large ring forgings that are currently only available from one Japanese supplier (Japan Steel Works, Limited). Additional lead time may need to be included in the RPV procurement schedule depending on ability of this one supplier to supply the required RPV large ring forgings in a timely manner. This potential shortfall is a significant construction schedule risk and could be a project financing risk.

Manufacturing infrastructure and capacity is in place to support the near-term deployment of eight GEN III+ units in the United States. Both domestic and international manufacturers would be needed to provide equipment for eight U.S. nuclear units. The existing domestic and international manufacturing infrastructure utilization rates would need to be increased to support

the anticipated U.S. demand for nuclear equipment. However, manufacturers have indicated that they can hire and train the needed workers in time to support new GEN III+ unit construction.

Competing demands for manufacturing and material supplier resources can impact lead times associated with the procurement of equipment for U.S. GEN III+ units. Other countries are using the same resources to provide equipment for their nuclear plant construction programs and other industries are using these manufacturing resources to provide equipment to expand. Currently, the Peoples Republic of China’s increased demand for equipment and material is having a global impact on manufacturers and the material suppliers that provide manufacturers with the material they need to produce finished equipment. China’s demand for equipment and materials for conventional power plants and industrial expansion is impacting global markets, even before the planned expansion in China’s nuclear construction program.

Major equipment (reactor pressure vessels, steam generators, and moisture separator reheaters) for the near-term deployment of GEN III+ units would not be manufactured by U.S. facilities. Japanese, Korean, and European manufacturers have the capacity to provide major equipment for U.S. GEN III+ units.

U.S. and international manufacturers have the capacity to produce steam turbine generators, condensers, pumps, valves, and Class 1E electrical equipment needed to support U.S. GEN III+ unit construction. Although one U.S. pump manufacturer has a backlog that runs through 2009 (primarily based on Chinese orders) and pump and valve manufacturers are concerned that the foundries they depend on may not be able to ramp up production to supply the castings necessary to support their manufacturing operations, U.S. manufacturers have indicated they have the ability to ramp up production to supply the required nuclear components. New factory workers would have to be trained and some manufacturers would have to set up new production lines to increase production.

Bulk nuclear-grade materials (seismic snubbers, prefabricated pipe supports, cable tray, conduit, power cable, and control cable) are available in quantities to support the near-term deployment of GEN III+ units. However, high-nickel content nuclear grade metals and pipe are in short supply at this time. Nickel shortages have impacted the supply of high-nickel content alloy pipe and metals. While new nickel production is planned, the long-term supply and demand for metals is never exactly in balance. Extra lead times may be needed to procure the metals and forged the pipe required to support GEN III+ unit construction.

Fabricators

Qualified U.S. and international module fabricators have the capacity today to provide the prefabricated modules necessary for new U.S. GEN III+ units. The U.S. has substantial capabilities for producing mechanical equipment modules, piping modules, piping spools, structural modules, and electrical modules.

Additional U.S. infrastructure that is currently supporting the U.S. Navy’s nuclear program will likely be available to support GEN III+ deployment. However, extra lead time would be required to utilize these manufacturing facilities and shipyards for equipment and module fabrication. The shipyards would need to modify their QA programs and reconfigure their fabrication areas to build modules for GEN III+ units. These changes would require one or more years.

Labor

Qualified boilermakers, pipefitters, electricians, and ironworkers (rebar) are expected to be in short supply in states with small populations and limited craft labor pools. This concern is an important shortfall for the construction of GENIII+ units. The use of workers from other communities and states (travelers) will be required at nuclear unit construction sites for these construction trades. All other construction trades (i.e., laborers, insulators, equipment operators, teamsters, etc.) are available in sufficient numbers to support GEN III+ construction.

The U.S. Department of Labor projects total U.S. employment of 165,000,000 in 2012 with 7,700,000 employed in all construction industries and 420,000 employed providing utility services construction. A portion of the utility service construction subset is involved building new power plants. We have estimated a peak labor requirement of 8,000 construction worker to construct eight GEN III+ nuclear units with a total labor requirement of 12,000 workers. Hiring the highly skilled and highly valued construction worker needed to build nuclear units is expected to be a challenge. Only a portion of construction workers normally used to build fossil power plants would have the skills necessary to build nuclear power plants.

Other construction projects and the normal spring and fall power plant maintenance outages will compete for the available construction labor resources. This competition will be a particular challenge in states with small labor pools. The relatively long duration of nuclear construction projects is expected to help attract the skilled workforce necessary to support GEN III+ projects.

The total number of construction workers in the U.S. is expected to grow by 15% from 6,700,000 in 2002 to 7,700,000 in 2012. When the combined effects of industry growth, worker attrition, and retirements are considered, new construction workers equivalent to 36% of the current construction labor workforce must be recruited, trained, and retained during this ten year period to increase the total number of construction workers and to replace workers that find new jobs or retire. This is the same challenge faced by other industries and organizations as the current generation of workers retire. Recruiting highly skilled and highly valued construction workers needed to build and maintain nuclear power plants is currently a challenge and will likely remain a challenge.

Based on discussions with major trade unions and associations, we conclude that programs are in place and are being developed to train the qualified welders needed to support new nuclear power plant construction. Programs like the SENSE Welding School Program, the Apprentice Training Program, and the Helmets to Hard Hats Program have been developed and are being implemented to bring new workers into the construction trades. Union, community college, and career training programs exist to train new construction workers. The challenge has been to recruit U.S. citizens into the technically demanding and high-paid construction trades.

Plant owners are expected to be challenged to recruit and train the Health Physicists, licensed Reactor Operators, licensed Senior Reactor Operators, and maintenance staffs for their new GEN III+ units. This issue also affects the 103 operating nuclear units and is receiving industry attention. For example, the Health Physics Society has recruiting and training programs for Health Physicists. Electric Power Research Institute (EPRI) and American Society for Nondestructive Testing (ASNT) have programs to train and retain nondestructive evaluation (NDE) technicians.

"The single most important factor in assuring quality in nuclear plant construction is prior nuclear experience (i.e., licensee experience in having constructed previous nuclear power plants, personnel who have learned how to construct them, experienced architects-engineers, experienced constructors, and experienced NRC inspectors)," Reference NUREG-1055, page A.4. This factor was important in the 1970s and we believe "previous nuclear experience" will be equally important in the 2010s. Having the right people is more important than having the right number of people. You have a shortfall if you do not have the right people.

Prior experience, detailed in NUREG-1055, shows that QA and QC problems caused major difficulties in earlier nuclear plant construction projects. The NRC, utilities, NSSS vendors, component suppliers, and EPC contractors should ensure that appropriate Quality Assurance (QA) and Quality Control (QC) programs are in-place and are implemented for the design, fabrication, and construction of GEN III+ units. These actions will help ensure the construction of new GEN III+ units is accomplished on schedule and on budget.

Construction Equipment

The VHL cranes necessary for the open-top construction of GEN III+ units are available for lease and additional VHL cranes can be manufactured as needed to support construction of eight or more nuclear units at the same time. Pipe bending machines and automatic welding machines are available as needed to support new plant construction.

Automatic rebar assembly machines and a computer-aided rebar layout and design program are available from Japan for use at nuclear plant construction sites. This system reduces labor requirements for fabricating flat mat and wall panels by approximately 50% and should be considered for U.S. deployment.

NRC

The NRC will need to ramp-up their licensing and inspection staffs by several hundred personnel to support the licensing and inspection associated with the near-term deployment of eight new GEN III+ units. While ramping up staff levels, assigning staff with prior nuclear plant construction experience to support GEN III+ activities, replacing of a generation of retiring NRC employees, training new employees, and retaining employees will be a challenge, the NRC Management believes they have an adequate plan to address this challenge.

Codes, Standards, and Regulations

A significant threat to the successful construction of GENIII+ units is the design and licensing of digital plant control systems. Although NSSS vendors have not specified the design of these systems in their Design Certifications, such hardware is available from U.S. and international manufacturers for the digital plant control systems and the plant simulators required for U.S. GEN III+ units. However, current NRC procedures and regulations for digital plant control systems endorse older versions of IEEE Standards and deleted IEEE standards and the NRC guidance concerning the critical area of Software Safety Analysis is quite general and needs to be modified to support the efficient design and the NRC review of plant control system software. As a result, extra lead time will be required for the NRC to develop new guidance, for that guidance to be reflected in the system designs and analysis (e.g., human factors evaluations), and for the NRC to complete their reviews and approvals.

Other potential codes and standards issues are not expected to have a significant impact on the licensing or the construction of GEN III+ units.

General

The lead time necessary for a utility to order a GEN III+ plant could vary significantly depending on a number of factors, namely:

- The licensing effort and schedule necessary to obtain a COL;
- The Design Certification status of the GEN III+ design selected for the plant;
- NSSS vendor progress towards completion of the plant's detailed design including any remaining first-of-a-kind-engineering (FOAKE) activities;
- The amount of site-specific design work that needs to be done;
- The number of recent orders for nuclear power plants worldwide;
- Availability of long lead time equipment and materials;
- Availability of labor to operate, maintain, and construct the plant; and the
- Availability of project financing on a timely basis.

MPR estimates that utilities will need to place orders for the first GEN III+ plants from seven to ten years prior to the commercial operation date.

Table 2-1. Conclusions and Recommendations Summary

Category	Conclusion[1]	Recommendation[2]
Open Design and Regulatory Issues	NRC procedures and regulations needed to be modified to support plant digital control system and plant simulator design.	1
Manufacturing Capacity	Nuclear-grade large ring forgings are only available from one supplier and are in limited supply.	2
Qualified Personnel	Qualified boilermakers, pipefitters, electricians, and rebar ironworkers are in short supply.	3, 4, and 5
Qualified Personnel	Health physicists, operators, and maintenance personnel are in short supply.	6
Qualified Personnel	Rebar ironworkers are in short supply.	7
Material Procurement	Lead times to procure pump and valve castings are extended.	8
Material Procurement	Lead times to procure high-nickel alloy pipe and high-nickel alloy metals are extended.	9 and 10

Notes:

1. Major potential infrastructure shortfalls identified in this assessment.
2. Cross reference to recommendations intended to mitigate the listed shortfall.

2.2 RECOMMENDATIONS

Table 2-1 includes cross references for key recommendations to the major conclusions of this assessment. These recommendations are described in detail below. These recommendations include actions to eliminate the potential infrastructure shortfalls and design and construction strategies to mitigate the impact of the shortfalls.

Open Design and Regulatory Issues

1. The NRC should modify their procedures and regulations concerning the design, review, and licensing of digital plant control systems and plant simulators for new GEN III+ units. These changes are needed to effectively design and review new plant control systems and plant simulators and to put this design review process on a schedule compatible with typical project schedules. This action would need to begin nine years before the commercial operation date (four years before the start of site preparation) for the first U.S. GEN III+ units. DOE should consider cost-shared efforts with the IEEE and the nuclear industry to revise standards and provide input on revision of applicable Regulatory Guides by the NRC if other resources are not available.

Manufacturing Capacity

2. NSSS vendors should monitor the availability of large ring forgings and adjust procurement schedules to ensure large ring forgings are available for reactor pressure vessel (RPV) fabrication. The lead time for this action is eight years prior to commercial operation date two years before normal RPV procurement). If necessary, large ring forgings should be purchased early to support normal RPV fabrication schedules. Currently, these forgings are only available from one Japanese supplier. If the demand for new nuclear units is sufficient, NSSS vendors should develop additional suppliers of nuclear-grade large ring forgings. This issue represents a potential and significant GEN III+ unit construction schedule risk that could impact project financing.

Qualified Personnel

3. NSSS vendors and EPC contractors should complete the plant design (including the routing of small bore piping, tubing, and conduit to the extent practical) prior to starting construction, prepare a detailed construction, and plan for sufficient staffing for rapid response teams at the point of work for problem resolution. To the maximum extent possible, personnel with experience designing and building nuclear units should be used to design and construct GEN III+ units. These steps will be needed to sustain the high labor productivity rates necessary for achieving the desired construction schedules and costs. This action would need to begin eight years before the commercial operation date.

4. EPC contractors as a group should negotiate and sign a national labor agreement with major labor unions to provide flexibility in staffing nuclear construction projects (e.g., allowing union members from different areas to work at any nuclear plant construction site). This step helps ensure the needed construction workers will be available. The lead time for this action is seven years before the commercial operation date of the first U.S. GEN III+ unit.

5. The NRC, nuclear utilities, NSSS vendors, component suppliers, material suppliers, and EPC contractors should ensure that appropriate Quality Assurance (QA) and Quality Control (QC) programs are in place and are properly implemented for the design, fabrication, construction, and inspection of GEN III+ units. Prior experience, detailed in NUREG-1055, shows that QA and QC problems caused major difficulties in earlier nuclear plant construction projects. The lead time for this recommended action is eight years before the commercial operation date.

6. Nuclear utilities should recruit and train health physicists, operators, and maintenance technicians at their existing nuclear plants to serve as replacements at their existing plants and to staff the new GEN III+ units. The lead time for this recommended action is seven years before the commercial operation date.

7. NSSS vendors and EPC contractors should consider the U.S. deployment of automatic rebar assembly machines and the associated computer-aided rebar layout and design program for use at nuclear plant construction sites. The lead time for this recommended action is seven years before the commercial operation date.

Material Procurement

8. NSSS vendors and EPC contractors should monitor foundry lead times for castings through discussions with their pump and valve manufacturers and if necessary adjust their procurement schedules to ensure castings are available to support pump and valve manufacture. The lead time for this action is seven years before the commercial operation date.

9. NSSS vendors and EPC contractors should monitor pipe supplier lead times for high-nickel alloy forged pipe through discussions with their pipe suppliers and module fabricators and if necessary adjust their procurement schedules to ensure pipe is available to support module fabrication and construction. The lead time for this action is seven years before the commercial operation date.

10. NSSS vendors and EPC contractors should monitor nuclear-grade metal supplier lead times for high-nickel alloy metals through discussions with their pipe suppliers, tube suppliers, and equipment manufacturers and if necessary adjust their procurement schedules to ensure nuclear-grade metals are available to support pipe manufacture and equipment fabrication. The lead time for this action is seven years before the commercial operation date.

3

Resource Requirements

This Section provides an estimate of the manufacturing, fabrication, labor, and construction equipment resources required to build GEN III+ units. This estimate provides a common basis for discussing infrastructure requirements and capabilities with equipment manufacturers, module fabricators, constructors, labor unions, and construction equipment manufacturers and owners. A single set of requirements is provided to represent the three GEN III+ unit designs currently being considered for near-term deployment. Average estimated labor requirements per unit are provided. Maximum labor requirements are projected based on multiple single unit plants and a twin unit plant being constructed at the same time.

3.1 MANUFACTURING

Manufacturing requirements are provided in this section to document the largest equipment components associated with the three GEN III+ unit designs with a focus on Nuclear Steam Supply System components and nuclear safety-related components. The infrastructure assessment did not attempt to assess the infrastructure available to supply all the components used in a nuclear plant. Domestic and global sources are expected to provide the following equipment for the near-term deployment of GEN III+ units.

Reactor Pressure Vessels
Reactor pressure vessels (RPVs) can range in size up to 23 feet inside diameter by 90 feet high and can weigh up to 1,200 tons. Each GEN III+ unit has one RPV and one RPV head.

Steam Generators/Moisture Separator Reheaters
Steam generators can range in size up to 79 feet tall with an 18 foot diameter upper section and a 14 foot diameter lower section. Each steam generator can weigh up to 730 tons. Moisture separator reheaters can range in size to 100 feet long and 13 feet in diameter. Each moisture separator reheater can weighs up to 440 tons. Each GEN III+ unit uses either two steam generators or between two and four moisture separator reheaters.

Control Rod Drives and Fuel Elements
Up to 200 fine-motion control rod drives are used per reactor. Up to 1,000 fuel elements are used per reactor.

Steam Turbine Generators and Condensers
Steam turbine generators (STG) range in size up to 1540MVA and have low pressure (LP) turbine with last-stage blades that are 52 inches long. The high pressure steam turbine can weigh up to 550 tons. Up to three LP rotors would each weigh up to 250 tons. The generator stator would weigh up to 500 tons and the generator rotor would weigh up to 250 tons. The STG condenser lower sections each weigh up to 660 tons with dimensions of 57 feet by 31 feet by 34 feet. Each STG would have up to three condensers.

Pumps

Up to ten reactor coolant pumps are used for each reactor. Up to two turbine-driven feedwater pumps and two motor-driven feedwater pumps are used for each reactor. Each unit has up to nine large (>400HP) safety-related pumps, 24 other large pumps, ten small (<400HP) safety-related pumps and 82 other small pumps. The AP1000 and ESBWR designs have "passive safety" features and do not require any safety-related pumps.

Valves

GEN III+ units are expected to use up to 2,100 valves for the reactor systems. Approximately 1,000 motor operated valves (MOVs) and air operated valves (AOVs) are used in each unit with up to 700 of these valves 3 inch and larger. Each unit would have a total of 3,000 to 6,000 valves that are 3 inch and larger and 6,000 to 12,000 valves that are 2.5 inch and smaller. The total number of valves used in a GEN III+ unit is 9,000 to 18,000 valves with up to 2,100 values of the total used in the plant's reactor systems.

Class 1E Switchgear and Equipment

GEN III+ units are expected to have the following Class 1E equipment: up to three medium voltage switchgear panels, three 5MW emergency diesel generators, nine 480V motor control centers, four 125VDC uninterruptible power supply systems, and three 120VAC uninterruptible power supply systems. The AP1000 and ESBWR designs have "passive safety" features and do not require any emergency diesel generators.

Control Equipment

GEN III+ units are expected to have 2,000 to 3,500 instruments, digital plant control systems, main control panels, reactor protection panels, local panels, and a plant simulator.

3.2 FABRICATION

The extensive use of prefabricated modules is planned to expedite the construction of GEN III+ units. Up to 600 prefabricated modules would be used. Up to 350 prefabricated modules and piping assemblies would need to be fabricated offsite. Piping assemblies are defined as complex pipe spools that do not have structural bases or structural supports. The maximum size of a module or sub-module fabricated off-site would be 12 feet by 12 feet by 80 feet to allow shipment by rail or truck. Larger structural and equipment modules would be field-assembled from multiple sub-modules. Up to 250 reinforcing steel modules and piping assemblies would be prefabricated "out-of-the-hole" in on-site field fabrication facilities.

Mechanical Equipment Modules

Up to 140 mechanical equipment modules are required for each plant for the most modularized design. Mechanical equipment modules would include equipment, piping, pipe supports, valves, instrumentation, tubing, conduit, cable tray, junction boxes, a structural base, and structural supports.

Piping/Electrical/Valve Modules and Piping Assemblies

Up to 130 piping modules, combination piping/electrical/valve modules, valve modules, and piping assemblies are required for each unit.

Structural Modules
Up to 60 structural modules are required for each unit. The largest structural modules would consist of numerous sub-modules that would be factory preassembled and match-marked for field assembly to create super modules that weigh up to 800 tons. Some of the structural modules would include leave-in-place formwork for concrete placement.

Electrical Equipment Modules
Up to 20 electrical equipment modules are required for the most modularized units.

Reinforcing Steel Modules and Piping Assemblies
Up to 250 reinforcing steel modules and piping assemblies would be fabricated out-of-the-hole in on-site field fabrication facilities.

3.3 LABOR

Based on currently available data from the GEN III+ vendors, the estimated construction labor manhours are different for each of the three designs. For the purpose of assessing the U.S. labor infrastructure, the average per unit construction labor for the three designs was used. Please note that construction craft labor is only a portion of the on-site labor required to build a new nuclear power plant. In addition to the construction craft labor, on-site labor supporting GEN III+ unit construction also includes craft supervision, site indirect labor (i.e., warehouse personnel, clerical and payroll staffs, security personnel, etc.), Quality Control Inspectors, vendor staffs, the EPC contractor's managers, engineers, and schedulers, the Owner's Operating and Maintenance (O&M) staff, start-up personnel, and the NRC's inspection staff. While the Owner's plant management, engineering, and security staffs would be on-site during the construction period, the labor estimates do not include these staffs.

Construction Craft Labor
Estimated total construction craft labor manhours for building the three GEN III+ designs were reviewed. Estimated manhours for constructing single units of the ABWR, the ESBWR, and the AP1000 designs were averaged to provide the basis for assessing per unit construction craft labor manhour requirements. Based on providing a conservative basis for assessing craft labor infrastructure requirements, no labor reductions have been included for constructing the second unit during the near-term deployment of one twin unit GEN III+ plant. Total craft labor manhours per unit are based on construction in the United States using modern open top construction techniques using Very Heavy Lift cranes, the extensive use of prefabricated modules, a 60 month schedule (site preparation to commercial operation including 12 to 18 months for site preparation, 36 to 42 months for construction from first concrete to fuel load, and six to 12 months for commissioning and testing), and systems being in place to maintain high craft productivity rates. Estimated average total construction craft labor manhours are eight million manhours per unit for building the average GEN III+ plant in the United States. The peak construction craft labor is estimated at 1,600 personnel per unit.

Peak construction craft labor requirements have been estimated based on building up to eight units during the period from 2010 to 2017. While no contracts have been awarded to build GEN III+ plants in the United States, organizations like NuStart Energy Development LLC, a Dominion Resources Inc led group, and the TVA are actively working to investigate, permit, license, and ultimately build GEN III+ plants. Based on current activities, utilities associated

with these organizations are believed to be leading candidates to construct of GEN III+ plants in the United States.

Based on the TVA's stated intent to build a twin unit plant, it was estimated that one twin unit plant will be built during the initial build period (2010–2017). It was estimated that this twin unit plant will be built with the second unit entering commercial operation eighteen months after the first unit. Most proposed construction schedules have a 12 to 18 month period between the commercial operation dates of units in twin unit plants. The 18-month period was used because the TVA is planning for 18 months between units and this optimizes craft utilization and efficiency. With only one twin unit plant estimated to be constructed during the near-term deployment period, the 18-month period between commercial operation dates does not have an impact on the estimated resource requirements for near-term deployment.

Table 3-1 presents the estimated start of construction (first concrete) and commercial operation dates for the eight units expected to be constructed during the initial build period. The construction of the first three units takes five calendar years and the construction of the last five units takes four calendar years based on when construction starts during the calendar year. All the units take approximately four years (42 to 48 months) to construct, commission, and test from first concrete to commercial operation.

Table 3-1. Projected Construction Start and Commercial Operation Dates

Unit Designation	Construction Start (First Concrete)	Commercial Operation Date
Plant 1, Unit 1	2010	2014
Plant 2, Unit 1	2010	2014
Plant 3, Unit 1	2011	2015
Plant 4, Unit 1	2012	2015
Plant 5, Unit 1	2012	2015
Plant 6, Unit 1	2013	2016
Plant 3, Unit 2	2013	2016
Plant 7, Unit 1	2014	2017

Figure 3-1 illustrates the number of units under construction at any given time. This figure assumes that construction will start on additional GEN III+ units after 2014 to maintain a construction rate necessary to commission two units per year starting in 2018.

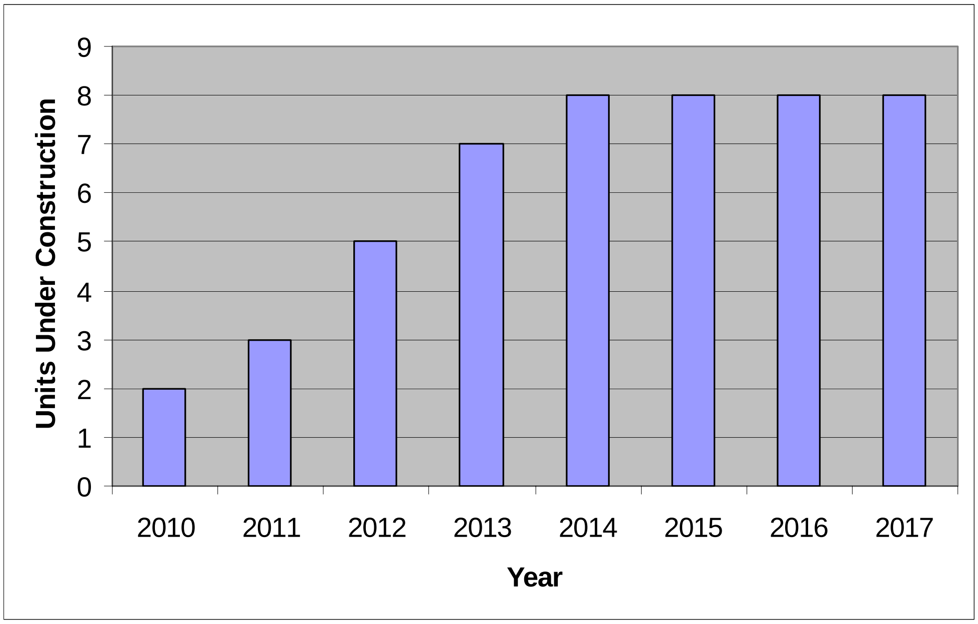

Figure 3-1. Total Number of Units under Construction

Based on the project labor staffing provided by GEN III+ plant NSSS suppliers, the schedule presented in Table 3-1, and the number of units under construction presented in Figure 3-1, the maximum total labor required at all sites was estimated based on the number of peak single unit equivalent staffs required to construct eight units. Figure 3-2 provides an illustration of the total labor equivalents required with a by unit breakdown by half year. Figure 3-2 also shows how labor per unit ramps-up and ramps-down during the site preparation, plant construction, and commissioning, and testing periods.

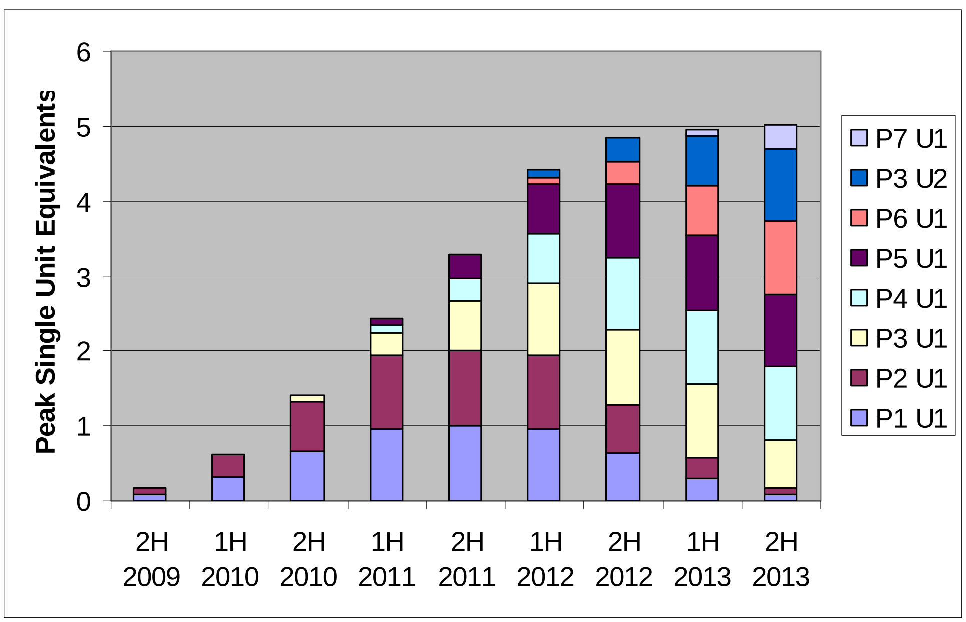

Figure 3-2. Total Labor Equivalents

Table 3-2. Peak Construction Craft Labor Requirements

Craft Description	Craft Percent	Peak Personnel Average Single Unit	Peak Personnel Multiple Units
Boilermakers	4	60	300
Carpenters	10	160	800
Electricians/Instrument Fitters	18	290	1450
Iron Workers	18	290	1450
Insulators	2	30	150
Laborers	10	160	800
Masons	2	30	150
Millwrights	3	50	250
Operating Engineers	8	130	650
Painters	2	30	150
Pipefitters	17	270	1350
Sheetmetal Workers	3	50	250
Teamsters	3	50	250
Total Construction Labor	**100**	**1600**	**8000**

Craft Supervision

Craft supervision varies by craft from 3% to 7%. It is estimated that craft supervision averages 5% of craft labor and 80 personnel per GEN III+ unit. It is noteworthy that a craft labor crew's foremen are not included in craft supervision. Crew foremen are included as part of craft labor.

Site Indirect Labor

Site indirect labor can range from 10 to 15% of constructions labor. Site indirect labor includes the personnel required to support the craft labor and craft supervision. Indirect labor includes warehouse personnel; small tools supply personnel, equipment maintenance and lubrication personnel, clerical and payroll staffs, security personnel, site cleaning crews, building cleaning crews, and food service workers. We estimate site indirect labor is 10% of construction labor for the nuclear plant site and is 160 personnel per GEN III+ unit.

Quality Control Inspectors

It is estimated that 40 quality control inspectors are required at each unit site during the peak construction period.

NSSS Vendor and Subcontractor Staffs

It is estimated that 140 administrators, engineers, and loss control personnel are required at each unit site during the peak construction period. This estimated does not include the craft supervision, quality control, and system start-up personnel associated with vendors and subcontractors since these personnel are counted separately.

EPC Contractor Staff
It is estimated that the EPC contractor will have a staff of 100 at each unit site during the peak construction period. This staff will include project management, engineering, schedulers, and clerical personnel.

Owner's Operating and Maintenance Staff
It is estimated the Owner will have an operating and maintenance staff of 200 supporting commissioning, start-up, and maintenance of unit systems during the peak construction period. The total Owner's on-site staff would be 650 for a single unit and 400 for the second unit of a twin unit plant (Reference 3). The total Owner's staff would be on-site by fuel load.

Start-Up Personnel
It is estimated that 60 start-up personnel will be on-site during the peak construction period.

NRC Inspectors
Based on the number of NRC inspectors used during nuclear plant construction during the 1980's and 1990's and the need to monitor off-site manufacturing and fabrication activities, it is estimated that the NRC will have ten to 20 NRC inspectors on-site and at off-site locations during the peak construction period and the testing period.

Peak On-Site Labor Summary
Table 3-3 summarizes the total craft labor and on-site labor supporting construction and start-up during the peak construction period. It is estimated that a total of 800 personnel will be on-site supporting 1600 craft labor and start-up activities during the peak construction period. The total peak labor on-site is estimated at 2400 personnel.

Table 3-3. Peak On-Site Labor Requirements

Personnel Description	Peak Personnel Average Single Plant	Peak Personnel Multiple Plants
Craft Labor	1600	8000
Craft Supervision	80	400
Site Indirect Labor	160	800
Quality Control Inspectors	40	200
NSSS Vendor and Subcontractor Staffs	140	700
EPC Contractor's Managers, Engineers, and Schedulers	100	500
Owner's O&M Staff	200	1000
Start-Up Personnel	60	300
NRC Inspectors	20	100
Total	**2400**	**12000**

After 2014, it is estimated that additional GEN III+ units will be built at the same rate (eight units being built at any time with two units per year entering commercial operation). Based on a peak labor requirement of 2400 to construct a single unit and the required peak single unit labor equivalents (5) illustrated in Figure 3-2, Figure 3-3 illustrates the ramp-up to the sustained total labor required to build GEN III+ units during the near-term deployment period.

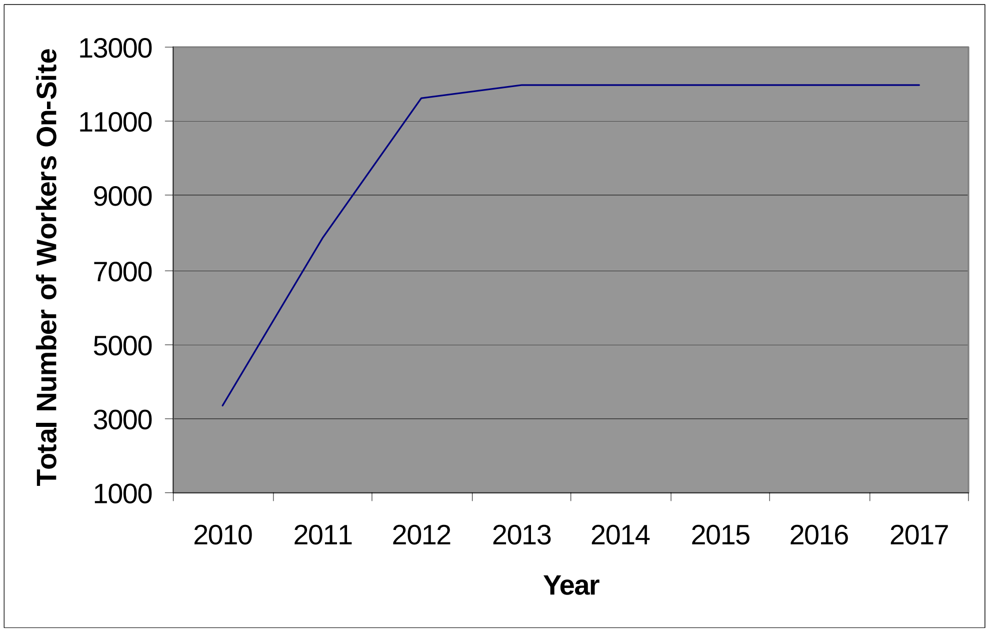

Figure 3-3. Total Labor Requirements

3.4 CONSTRUCTION EQUIPMENT

Very Heavy Lift (VHL) Cranes

GEN III+ unit construction requires a VHL crane with the capacity to lift and place up to 1200 ton modules and components at a 130 foot radius and a height of 200 feet. GEN III+ plant construction requires a VHL crane with a main boom capacity of up to 1500 tons and an auxiliary boom capacity of up to 250 tons. In some instances, plant construction requires the VHL crane to pick up and travel with large modules. Based on discussions with a NSSS vendor, one VHL crane would be required at each construction site. With proper planning and scheduling, a single VHL crane could support the construction of the two units at a twin-unit plant. A total of seven VHL cranes would be required to support GEN III+ near-term deployment.

Pipe Bending Machines

Pipe bending machines would be utilized by module and pipe spool fabricators and for support of plant construction activities.

Automatic Welding Machines
Different types of automatic welding machines would be utilized for welding large bore piping, containment liners, condenser tubesheets, and condenser shells.

Automatic Rebar Assembly Machines
Automatic rebar assembly machines are currently used by Japanese civil constructors. The ABWR schedule assumes an automatic rebar assembly machine will be used to improve rebar fabrication productivity and reduce labor manhours associated with fabricating rebar mats and wall panels. One automatic rebar assembly machine could be used at each construction site.

3.5 CONSTRUCTION BULK MATERIALS

The following bulk materials quantities are estimated for the construction of a single GEN III+ unit:

- Concrete – 460,000 cubic yards (not including concrete for site preparation).
- Reinforcing Steel and Embedded Parts – 46,000 tons.
- Structural Steel, Miscellaneous Steel, and Decking – 25,000 tons.
- Large Bore Pipe (> 2½ inch) – 260,000 feet.
- Small Bore Pipe – 430,000 feet.
- Cable Tray – 220,000 feet.
- Conduit – 1,200,000 feet.
- Power Cable – 1,400,000 feet.
- Control Wire – 5,400,000 feet.
- Process and Instrument Tubing – 740,000 feet.

A significant portion of the large bore pipe would be brought to the site in prefabricated modules and as prefabricated large bore pipe spool pieces. A portion of the small bore pipe, cable tray, conduit, and tubing would also be brought to the site in prefabricated modules.

4
Manufacturing

The capability of domestic and foreign manufacturers to support near-term deployment objectives is evaluated in this Section. Several suppliers were surveyed for each significant equipment type. Survey results were evaluated relative to the resource requirements established in Section 3. A record of the information collected during the survey is provided for each participating vendor. The resource analysis provided in this Section is based on the NP2010 objective of constructing eight Gen III+ units between 2010 and 2017. Appendix B provides lists of ASME certified suppliers of nuclear components (N-Stamp certificate holders and NPT-Stamp certificate holders) with facilities in the U.S. Appendix C provides an infrastructure assessment contact list. Table 4-1 follows to provide a manufactured equipment resource analysis summary. Resource requirements are compared with available resources and any shortfalls are noted.

4.1 MAJOR EQUIPMENT

Major equipment is provided by Nuclear Steam Supply System (NSSS) vendors, namely General Electric, Toshiba, and Westinghouse. The major equipment is built to the NSSS vendors design either by the NSSS vendor or a NSSS vendor's subcontractors that are monitored by the NSSS vendor's Quality Assurance personnel. Table 4-2 provides information on the major equipment manufacturers expected to support the near-term deployment of GEN III+ units in the United States. It is expected that most of the major equipment would be procured from foreign manufacturers since the U.S. NSSS vendors and U.S. manufacturers are only able to produce a portion of the major equipment required for near-term deployment.

Eight reactor vessels are required between 2010 and 2014. A maximum of three reactor vessels would be required to be delivered to GEN III+ construction sites during the most active year. Eight sets of fuel elements are required between 2014 and 2016. Sixteen steam generators or 16 to 32 moisture separator reheaters (depending on whether the plant is a PWR or BWR) are required between 2011 and 2015. A maximum of six steam generators and 12 moisture separator reheaters would be required during the most active year. Eight steam turbine generators and up to 24 condensers would be required between 2010 and 2015. A maximum of three steam turbine generators and nine condensers would be required during the most active year of the near-term deployment.

Table 4-1. Manufacturing Resource Analysis

Item	Requirements	Capabilities	Shortfall	Lead Time (Years)
1	Eight Reactor Pressure Vessels delivered between 2010 and 2014, maximum three per year	Six manufacturers with capacity to build more than six Reactor Pressure Vessels per year. No current U.S. manufacturers.	No	
2	Up to 200 Control Rod Drives per unit	Three manufacturers	No	
3	Eight sets of Fuel Elements delivered between 2014 and 2017, maximum three sets per year	Two U.S. suppliers with capacity to support 103 operating U.S. nuclear plants, Brown's Ferry 1, and eight new units.	No	
4	Eight Steam Generators or 16 to 32 Moisture Separator Reheaters delivered between 2011 and 2015	Seven+ Manufacturers.	No	
5	Eight Steam Turbine Generators	One U.S. manufacturer and six foreign manufacturers.	No	
6	Twenty-four Condensers	Two U.S. manufacturers and four foreign manufacturers.	No	
7	Eleven hundred Pumps, maximum 310 per year		No	
8	One hundred fifty-two thousand Valves, maximum 36,000 per year		No	
9	Ninety-six Class 1E Switchgear and MCCs		No	
10	Fifty-six Class 1E UPS Systems		No	
11	Twelve Class 1E 5MW Emergency Diesel Generators – delivered between 2012 and 2016 – max. three per year	One U.S. manufacturer with capacity to build 72 gensets per year.	No	
12	Eight Main Plant Digital Control Systems and Seven Plant Simulators	Design and software development expected to require extra time on first three U.S. GEN III+ systems.	Yes	2-3
13	Seismic Snubbers		No	
14	Prefabricated Supports	Three U.S. suppliers.	No	
15	Nuclear Bulk Materials (i.e., concrete, conduit, cable tray)		No	
16	Equipment Testing Facilities - Seismic		No	
17	Equipment Testing Facilities - Electrical		No	
18	Material Suppliers - Castings	Foundry lead times are increasing. Capacity expansion required.	Yes	1
19	Material Suppliers - Large Ring Forgings	Only one supplier for nuclear-grade large ring forgings	Yes	2-3
20	Material Suppliers - Metals	Alloys, nickel in short supply. Cyclic problem.	Yes	1
21	Material Suppliers - Pipe	Extra lead time may be required.	Yes	1
22	Material Suppliers - Electrical		No	

Table 4-2. Major Equipment Suppliers

Manufacturer	Reactor Pressure Vessels	Fuel Assemblies	Steam Generators and Moisture Separator Reheaters	Steam Turbine Generators	Condensers
General Electric	No	Yes	No	Yes	No
Toshiba	Yes	Yes	Yes	Yes	Yes
Westinghouse	No	Yes	No	No	No
Alstom	No	No	Yes	Yes	Yes
Ansaldo Camozzi	Yes	No	Yes	Casings	Yes
Doosan Heavy Industries	Yes	No	Yes	Yes	Yes
Equipos Nucleares, S.A. (ENSA)	Yes	No	Yes	No	No
Hitachi	Yes	Yes	Yes	Yes	No
Ishikawajima-Harima Heavy Industries (IHI)	Yes	No	Yes	No	No
Mitsuibishi Heavy Industries	Yes	Yes	Yes	Yes	No

General Electric

General Electric Nuclear Energy (GE Nuclear Energy) currently offers their Advanced Boiling Water Reactor (ABWR) design. In addition, they are in the process of obtaining Design Certification for their Economic Simplified Boiling Water Reactor (ESBWR) design, which is expected to be available for construction in the United States in the 2010 timeframe. GE holds an ASME N-stamp certificate. GE Nuclear Energy is currently headquartered in San Jose, California however they are preparing to move their offices to Wilmington, North Carolina.

GE Nuclear Energy is currently constructing an ABWR plant in Lungmen, Taiwan. The portion of the major equipment for the Lungmen project that GE will manufacture is the nuclear fuel elements, neutron detectors, and a portion of the reactor pressure vessel internals. The remainder of the major equipment will be manufactured by non-U.S. subcontractors, such as Toshiba and Hitachi. GE is making preparations to offer a steam turbine generator for future ABWR projects.

GE Nuclear Energy stated that certain long lead items will need to be ordered prior to the start of site preparation to ensure the items are available in time to support an aggressive construction schedule. In particular, they identified the reactor pressure vessel as the item with the longest lead time. The steam turbine generator and safety relief valves were also identified as long lead items. Reactor pressure vessel manufacturing capacity is currently limited by the availability of nuclear-grade large ring forgings (24' diameter by 13' long, 127 tons) that are currently only available from a single supplier, namely the Japan Steel Works Limited. There are other facilities that can produce the large ring forgings, but not yet at the nuclear-quality level required. GE has indicated that they do not expect any other supply problems based on their

view of the actual number of plants that will be built in the U.S. They also stated that their suppliers have already invested in sufficient infrastructure.

Toshiba

Toshiba manufactures major equipment for a modified version of GE Nuclear Energy's ABWR design and a Japanese BWR-5 of Toshiba's own design. Toshiba is assessing what steps need to be taken to obtain NRC Design Certification for their ABWR design. Toshiba is expected to offer their ABWR design for sale in the United States. Toshiba has supplied the NSSS for 18 operating nuclear plants in Japan including the first ABWR built (Kashiwasaki-Kariwa Unit 6). They also offer nuclear plant systems for the international market. Toshiba is a Japanese company headquartered in Tokyo. Their U.S. offices are based in Houston, Texas. Their major equipment manufacturing facilities are located in Japan.

The NSSS components that Toshiba manufactures include the reactor pressure vessel, vessel internals, fine-motion control rod drive mechanisms, fuel assemblies, reactor internal pumps, steam turbine generators, and condensers. Toshiba has stated that they can produce approximately one NSSS per year.

Westinghouse

Westinghouse Electric Company LLC (Westinghouse) currently offers their AP1000 nuclear plant design. This GEN III+ design includes passive safety features that simplify the plant's safety system and reduces the quantity of safety-related pumps, valves, piping, electrical equipment, and building space required. Westinghouse is a subsidiary of British Nuclear Fuels Limited (BNFL) headquartered in Daresbury, Great Britain. Westinghouse is headquartered in Pittsburgh, Pennsylvania.

Westinghouse currently manufactures fuel elements in Columbia, South Carolina and reports they are the world's largest supplier of nuclear fuel. If necessary, Westinghouse can expand their Columbia facility. Westinghouse assembles instrumentation and control systems. Westinghouse either manufactures reactor vessel internals or would purchase the reactor vessel internals from one of four suppliers.

Westinghouse would purchase reactor pressure vessels, control rod drive mechanisms, steam generators, steam turbine generators, and condensers from other manufacturers. Westinghouse works with Doosan Heavy Industries, Mitsubishi Heavy Industries, Ansaldo Camozzi, Equipos Nucleares, S.A. (ENSA), and other companies to procure major equipment.

Doosan Heavy Industries and Construction

Doosan serves several heavy industries including manufacture of NSSSs and turbine generators for PWR units. Doosan has been the constructor for thirteen nuclear plants and is currently constructing eight plants. Doosan's headquarters and manufacturing facilities are located in Seoul, Korea. Their U.S. branch office is located in Englewood Cliffs, New Jersey. They are ASME N-stamp certified. Doosan supports manufacture of new plants in addition to supporting operating plants internationally. They are currently providing replacement steam generators for Tennessee Valley Authority's Watts Bar plant.

Doosan states they have the capability of supporting construction of approximately one and one-half nuclear units per year. Their existing commitments will be satisfied by 2008. They are

currently pursuing a contract to support the construction of two new plants (four units) in China. They could support eight new plants in the United States between 2009 and 2016 without expanding production excluding other commitments. Doosan indicated that they are currently not operating at full capacity. If they did expand production, they would do so using existing facilities. Doosan indicated it would be difficult to recruit the skilled labor necessary to open a second fabrication facility.

Hitachi

Hitachi Limited (Hitachi) is a constructor of BWR nuclear plants and a supplier of nuclear power plant equipment. Hitachi has been involved with the construction of 20 nuclear units in Japan and supported GE Nuclear Energy's supply of the two unit ABWR plant at Lungmen, Taiwan. Hitachi can supply reactor pressure vessels, fine motion control rod drive mechanisms, fuel assemblies, steam turbine generators, pumps, control systems, and simulators.

Ishikawajima-Harima Heavy Industries

Ishikawajima-Harima Heavy Industries (IHI) was not contacted but is a recognized Japanese supplier of reactor pressure vessels, moisture separator reheaters, and heat exchangers.

Mitsubishi Heavy Industries

Mitsubishi Heavy Industries (MHI) is a constructor of PWR nuclear plants and a supplier of nuclear power plant equipment. MHI has been involved with the design and construction of 23 nuclear units in Japan. MHI designs and supplies PWRs. MHI can supply reactor pressure vessels, fuel assemblies, steam generators, steam turbine generators, and condensers.

Ansaldo Camozzi

Ansaldo Camozzi is headquartered in Milan, Italy. Ansaldo manufactures reactor pressure vessels, steam generators, moisture separator reheaters, steam turbine casings, and condensers for nuclear plants. Ansaldo has ASME N and NPT certificates and has been ISO 9001 certified since 1994. They are currently providing replacement steam generators for the Palo Verde Nuclear Generating Station in Phoenix, Arizona. Ansaldo is currently performing a feasibility study to investigate if it would be practical to manufacture nuclear grade components at their Ingersoll Machine Tool facility in Rockford, Illinois.

Conclusion

Having sufficient major equipment for new U.S. nuclear units will depend on non-U.S manufacturers. Except for fuel and some sub components, U.S. manufacturers would not manufacture the major equipment for plants built in the United States in the 2010 timeframe. Since the major equipment is specific to the nuclear industry, it cannot be obtained from commercial sources by using commercial grade dedication. There are many international producers of NSSS major equipment and some have manufacturing operations that can produce major equipment for one to one and one-half plants per year. With this capacity, multiple vendors could support NP2010 near-term deployment requirements. With significant nuclear plant construction expected in Japan, China, and Korea, orders should be placed as early as possible to minimize the risk that major equipment delivery delays could delay construction schedules. The international suppliers contacted in the survey are certified to meet U.S. regulations and are interested in expanding their business to include the U.S. market. There is limited availability (one manufacturer) of the high-quality large ring forgings that are required to manufacture reactor pressure vessels. Additional high-quality large ring forging capacity needs

to be developed or extra lead times need to be included in the procurement cycles for purchasing the required large ring forgings.

4.2 PUMPS

To support construction of eight GEN III+ units on the hypothetical schedule used in this report, one thousand one hundred (1,100) pumps of various types and sizes would be required between 2010 and 2015. A maximum of 310 would be required in a given year.

The pump types considered are reactor internal pumps, reactor coolant pumps, feedwater pumps, large and small safety-related pumps and other large and small sized pumps. There are a number of U.S. and foreign manufacturers producing pumps for nuclear power plants.

Sulzer Pumps

Sulzer Pumps designs and manufactures large pumps for several industries including the nuclear power industry. Their product line includes primary and secondary safety pumps, reactor coolant pumps, auxiliary feedwater pumps, residual heat removal pumps, circulating water pumps, and others. Sulzer holds an ASME N-stamp certificate and is currently supplying the international market for new nuclear power plants and is supplying replacement pumps for U.S. nuclear power plants. Sulzer headquarters are located in Switzerland. Sulzer Pumps (U.S.) Inc. has manufacturing plants in Portland, Oregon and Canada. Sulzer Pumps also owns the Johnson Pump Company.

Sulzer stated that they currently hold approximately 15% market share in the U.S. nuclear power pump market and that they could at least maintain that level if eight new plants were built in the U.S. between 2009 and 2016. They indicated that increasing production to meet that demand would require increasing their production rates by using some of their excess capacity and no new facilities would be needed. Ramping production to meet NP2010 objectives would require adding staff to their existing facilities, which they expect would take approximately six months. Sulzer stated that increasing production in their quality assurance department would not be a problem because many of the personnel that formally held QA engineer positions are currently holding different positions elsewhere in the company and that they could be moved back if necessary.

Sulzer expressed concerns that the industry on the whole would suffer from a lack of supply in castings if new plants were built here. They have recently experienced supply problems from their castings supplier.

Flowserve Pumps

Flowserve sells primary coolant pumps, nuclear safety-related pumps, and conventional pumps for nuclear power plants. Flowserve has several manufacturing facilities including plants located in North Carolina, Maryland, California, and Tennessee. Their pump division headquarters is located in Irving, Texas. They are ASME N-stamp certified.

Chempump

Chempump manufactures commercial and nuclear grade pumps. Their pumps are canned motor type pumps that are small to medium-sized. Chempump is located in Warminster, PA. It is a Division of Teikoku USA Inc. Chempump is N-stamp certified. Chempump reports that the

portion of their business focused on supporting operating U.S. plants and the portion of their business supporting new nuclear plants overseas are each less than 5% of their total business. Their current capacity is 20-25 pumps per month or 240 to 300 pumps per year. This output represents 10% of their maximum possible capacity, which could be reached in approximately 12 to 18 months. Thus, an output of approximately 3,000 pumps per year maximum could be reached. They report an order of pumps takes approximately 20 to 24 weeks to process for large orders.

Foreign Manufacturers

Nuclear grade pumps are also offered by foreign manufacturers including but not limited to Hayward Tyler (British), Pump Gannard (French), KSB (German), Hitachi Industrial (Japan), and Ebara (Spanish).

Conclusions

Overall there will likely be enough pumps produced to support near-term deployment. Several domestic pump manufacturers have maintained their N-stamp certification to support operating plants. In addition, there are several foreign manufacturers that also offer pumps for use in the U.S. Additional supply would also be available by dedicating commercial pumps for nuclear service. One test lab surveyed indicated that dedicating pumps for nuclear use is part of their current practice. All vendors contacted are interested in supporting new U.S. plant construction.

One domestic vendor indicated that they currently have several years of backlog primarily due to demand from plant construction in China. However, this backlog is expected to diminish significantly by 2009, which would leave vendors open to meeting U.S. demand. U.S. foundry casting capabilities will need to be expanded to support U.S. GEN III+ construction and nuclear plant construction in Asia.

4.3 VALVES

Nuclear grade valves generally fall into three categories; on/off valves (including manual, air operated, and motor operated types), control valves, and pressure relief/safety valves. Valve vendors representing all three categories were contacted during the survey. The quantity of valves required is listed in Table 4-3.

Table 4-3. Quantity of Valves Required

Requirement	Motor and Air Operated	Large Manual Valves (3 inch & >3 inch)	Small Manual Valves (<3 inch)
Total required between 2010 and 2015	8000	48,000	96,000
Maximum per year between 2010 and 2015	2250	6750	27,000

Approximately 70% of the motor and air operated valves are 3 inch or larger and 30% of the motor and air operated valves are 2.5 inch or smaller.

Control Components Inc.

The Control Components, Inc. product line includes on-off valves, control valves, and pressure relief/safety valves. They are commonly known as being a major supplier of control valves, however they claim there is no dominant product in their product line (i.e., they claim their market share is as strong in the on/off and pressure relief/safety valves categories as it is for control valves).

Control Component's headquarters is located in Rancho Santa Margarita, California, which is where the majority of their nuclear grade valves are manufactured. That facility and another located in Switzerland both have an ASME N-stamp certificate. Control Components is owned by parent company IMI, which is British-owned.

Control Components is currently focused on exporting valves for new power plants overseas. They are providing valve packages to the Lungmen project in Taiwan. In addition, they are currently pursuing contracts to support four new plants in Korea.

Control Components claims they would be able to increase their production to support NP2010 goals. They estimate it would take approximately one year to increase production to the necessary level and that doing so would involve adding shifts, with minimal change to their facilities. They stated they are watching the domestic nuclear market carefully and would independently ramp-up production if necessary.

Control Components expressed concerns regarding availability of castings from U.S. foundries. They have experienced an increase in lead time for high alloy steel castings from six to ten weeks over the past year.

Flowserve Valve Division Inc.

Flowserve manufactures on/off valves for the fossil and nuclear power industry including safety-related nuclear valves. They are an ASME N-stamp holder and 50% of their valve business is for nuclear power plants. Their $35 to $40 million annual revenue is roughly split between small and large sized valves. Flowserve's valve manufacturing facility is located in Raleigh, North Carolina.

Flowserve reports they are currently operating at between half to two thirds of their nuclear valve manufacturing capacity so it is expected that they could increase production significantly. Increased production for new U.S. plants could initially be achieved by ramping production using existing facilities, but additional facilities would be required in later years to meet peak demand. Flowserve estimates it would take six to 12 months advanced notice to initiate a significant near-term production increase mainly due to the need to increase staffing.

Flowserve expressed concerns regarding availability of castings from U.S. foundries. In addition, they expressed concerns about the capability of the overall industry to perform nondestructive examinations (NDE) due to potential labor shortages. This issue is addressed in Section 6 of this report.

Velan, Inc.
Velan manufactures nuclear grade on/off type valves including motor operated and air operated valves (MOV and AOV). Velan is a Swiss company and their U.S. headquarters is in Williston, Vermont.

Velan stated that they could increase their rate of production to support the increased demand associated with new U.S. GEN III+ units without building new facilities. Velan indicated they currently have several years of backlog primarily due to demand from plant construction in China. However, they expect to be available for additional projects by approximately 2009, which is consistent with the expected NP2010 schedule.

They stated that they expect near-term price increases and shortages of steel products from foundries and mills due to the high demand of raw materials for construction in China. They predict that prices will begin to decrease six to 12 months from now and that supply shortages would not necessarily be a major issue by 2009.

Other Nuclear Valve Manufacturers
Crane Nuclear, Inc. of Bolingbrook, Illinois and Fisher Controls International, Inc. of Marshalltown, Iowa are major nuclear valve manufacturers.

Conclusions
Based on the response to our surveys it is expected there will be a sufficient supply of nuclear-grade valves to meet NP2010 goals. Most participating vendors did not provide quantitative information concerning their production capacity. However, all vendors contacted communicated that they do not consider NP2010 requirements to be prohibitive for the industry on the whole. Several vendors are currently serving international projects involving production rates exceeding those that would be required to support new GEN III+ units in the U.S. All vendors indicated they are watching the domestic market closely and have a strong desire to maintain or increase their market share in the event of domestic construction.

Lead times involved with ramping production appear to be reasonable. One vendor estimated a lead time of 6 to 12 months to increase the capacity of their facilities by 50% to 100%. Another vendor indicated that they currently have several years of backlog primarily due to demand from plant construction in China. Even this vendor expected to be available to support additional projects by approximately 2009, which is consistent with the expected NP2010 requirements.

Several vendors are concerned they would not have adequate supply of castings from foundries if they increased production. Several vendors have noted that lead times for valve manufacture have increased recently due to the longer lead times associated with obtaining castings.

4.4 CLASS 1E ELECTRICAL EQUIPMENT

Class 1E is the designation for nuclear safety-related electrical equipment. A typical GEN III+ unit is expected to have the following Class 1E components:

- Up to three 6.9kV switchgear panels,
- Nine 480V motor control centers,

- Four 125VDC uninterruptible power supply systems,
- Three 120VAC uninterruptible power supply systems, and
- Three 5MW emergency diesel generators (Emergency diesel generators are not required for designs that use passive safety features).

4.4.1 Switchgear and Motor Control Centers

Switchgear allows connection of power to critical systems during an accident. A variety of different components is included in this category including circuit-breakers, switches, switch fuses, isolators, and contactors.

Motor control centers provide power for critical electric motors such as those that drive safety-related pumps. Although there are few producers of Class 1E motor control centers, several test labs have an established practice of qualifying and dedicating commercial-grade units.

Eaton Cutler-Hammer
Eaton Cutler-Hammer manufactures commercial-grade low-voltage and medium voltage MCC and switchgear products. Eaton Corp., the parent company of Cutler-Hammer, is headquartered in Cleveland, Ohio and has manufacturing facilities in various international locations. Their circuit breakers are manufactured in Puerto Rico. Their switchgear assemblies are built in Asheville, North Carolina and Greenwood, South Carolina. Their MCCs are built in Fayetteville, North Carolina.

Eaton Cutler-Hammer has indicated that, barring unforeseen circumstances, they expect to be able to support new U.S. nuclear plants with their electrical products. They claim they can increase their production by approximately 50% using existing facilities and that they would require 12 to 18 months to significantly increase their production. They estimate that the process of dedicating a new MCC or switchgear to meet Class 1E requirements would initially take four to six months and would take less time once production and order systems are in place. They are anticipating some supplier issues with all basic metals.

ABB
ABB manufactures commercial and nuclear grade medium voltage MCCs and switchgear. ABB is a Swiss company with facilities located in many international locations. Their nuclear-grade components are manufactured in Florence, South Carolina.

ABB states that they could meet the demand for medium voltage MCCs and switchgear resulting from domestic construction. In addition, they claim they could increase production provided they had six months advanced notice. ABB estimates their Florence facility is operating at approximately 30% capacity.

United Controls International
United Controls is a testing laboratory that procures, dedicates, and qualifies commercial-grade electrical equipment for nuclear-grade use. They operate out of Tucker, Georgia.

United Controls claims unlimited capacity based on the fact they have the ability to use several different subcontractors. They are currently supporting domestic nuclear power plants. Their annual sales are $3 to 4 million, out of which 30% is for medium voltage MCCs and switchgear.

Nuclear Logistics, Inc.

Nuclear Logistics, Inc. is a testing laboratory that procures, dedicates, and qualifies commercial-grade equipment for nuclear-grade use. Nuclear Logistics' product line includes batteries for UPS systems, MCCs, and switchgear. For providing station batteries to domestic plants they estimate their market share is approximately 50%. For providing MCC's and switchgear, they estimate their market share is approximately 60 to 70%. A significant amount of Nuclear Logistics' business is supporting operating U.S. nuclear plants. Their U.S. facility is located in Fort Worth, Texas and they have branch offices in Canada, Mexico, Taiwan, and Korea.

Nuclear Logistics expects they could handle the entire workload within their area of business associated with NP2010 requirements since they are not currently operating at maximum capacity. Lead times for providing electrical equipment are approximately one-half year.

Conclusions

Based on the survey responses, each of the three switchgear manufactures contacted is currently capable of providing at least two to three Class1E switchgear panels per year. Production at this rate would satisfy the estimated requirement of six to nine panels per year. The reported production rates also indicate that there would be sufficient supply for the first two units to begin construction. In addition, the production rate could increase over time if necessary since several vendors stated they are currently not operating at maximum capacity.

Both testing laboratories contacted stated that they could independently meet the expected demand for dedicating motor control centers resulting from domestic nuclear construction. Both labs can operate by subcontracting to commercial-grade test laboratories that work under the principal lab’s 10CFR50, Appendix B quality assurance program. This flexibility would allow a more rapid increase in production since construction of new facilities would not be required.

4.4.2 Uninterruptible Power Supply Systems

Uninterruptible power supply (UPS) systems provide a continuous power supply to critical electrical components when the primary power supply is unstable or unavailable. In a nuclear power plant an uninterruptible power supply is provided by means of a safety-related battery and inverter system.

AMETEK Solidstate Controls

AMETEK Solidstate Controls, Inc. manufactures nuclear grade UPS systems for nuclear power plants. Their headquarters and U.S. manufacturing facility are located in Columbus, Ohio.

AMETEK Solidstate Controls reports they have a production capacity sufficient to meet the expected domestic nuclear plant construction requirements and their current demand using existing facilities. The majority of their nuclear work is for domestic plants and most of their current work in the existing plants involves replacing obsolete equipment. The batteries for UPS systems would be purchased from Exide Technologies. They do not expect problems with obtaining batteries from Exide.

Nuclear Logistics, Inc.
Nuclear Logistics, Inc. is a testing laboratory that procures, dedicates, and qualifies commercial grade equipment for nuclear grade use. Nuclear Logistics' product line includes battery chargers and batteries (manufactured by GNB, Type NCN) for UPS systems, MCCs, and switchgear. For providing station batteries to domestic plants they estimate their market share is approximately 50%. See Section 4.4.2 for more information on Nuclear Logistics.

4.4.3 Emergency Diesel Generators

Three 5 MW nuclear qualified emergency diesel generators are required for each ABWR unit. Assuming a given GEN III+ design will have up to half of the near-term deployment market, we estimate a maximum of 12 diesel generator sets will be required. The ESBWR and AP1000 designs do not require nuclear-qualified emergency diesel generators.

Fairbanks Morse Engine
Currently, there is one domestic manufacturer of 5 MW nuclear-qualified emergency diesel generators, namely Fairbanks Morse Engine of Beloit, Wisconsin. They can still make an old design Colt Pielstick engine that was qualified per the original IEEE 387 standard over 20 years ago. Fairbanks Morse Engine has maintained their Appendix B QA/QC program to support their current nuclear replacement parts business that serves 20 Colt Pielstick gensets, 30 Alco gensets, and 51 Fairbanks Morse OP gensets. They have the capacity to build up to 72 emergency diesel generator sets per year. This is considerably more manufacturing capacity than is necessary to support GEN III+ plant requirements of a maximum of three per year and an estimated 12 total. Fairbanks Morse Engine estimates it would take six to 12 month for the engineering associated with the first "duplicate" of the old design with improvements made to satisfy the most recent NRC Regulatory Guide 1.9 and IEEE 387 standard. Vibration qualification and EMI/RFI qualification work would be required. Manufacturing the first old design nuclear-qualified emergency diesel generator in over 20 years would take 12 months. It would take approximately two years to engineer, build, and qualify the first nuclear-qualified "old design" emergency diesel generator. Additional nuclear-qualified emergency diesel generators could be built in nine months.

The Colt Pielstick engine and control system designs have evolved over the years. These new designs for engines and PLC-based control systems are not nuclear-qualified. Documentation, testing, time, and money would be required to qualify the new design. It would take extra time to qualify the new design engine and controls to meet current requirements. It would take approximately two to two and one-half years to engineer, build, and qualify a new design. Qualifying a new design may or may not be economically or technically justified. The old Colt Pielstick design has proved itself in service (20 units operating over twenty years) and U.S. nuclear industry's shared experience operating and maintaining the old design engines is considered to be of real value. A decision would have to be made regarding use of the old or the new design.

Foreign Manufacturers
Japanese (Niigata), Korean, and European (SACM) companies could also qualify and manufacture nuclear-qualified emergency diesel generators.

Conclusions
The available supply of nuclear-qualified emergency diesel generators is significantly larger than the NP2010 requirement. Twelve to 18 months of extra time will be required to do additional qualification work on the first "old design" emergency diesel generators to bring them into compliance with current requirements or to qualify new design emergency diesel generators. Future sets of emergency diesel generators would be available in nine to 12 months after an order. A decision has to be made regarding the use of old or new engine, generator, and control system designs.

4.5 CONTROL SYSTEMS AND SIMULATORS

GEN III+ units are designed to use digital plant control systems and simulators. Although some digital upgrades have been done at operating U.S. plants, the majority of the existing domestic plant control systems are analog. Digital plant control systems have introduced significant regulatory and design challenges to recent nuclear construction projects. This reports Section 9 provides more information on these challenges. Each GEN III+ plant will require one or two complete control systems and one simulator. The control system is comprised of several different sections including both safety- and non-safety-related systems.

General Electric
Both GE Nuclear Energy's ABWR and ESBWR plant designs use digital plant control systems and simulators. GE was responsible for the design of the digital plant control system and simulator installed at their ABWR Lungmen Project. The digital plant control system and the plant's simulator are being procured from hardware and software suppliers located in the U.S. and Europe. GE has stated that they would use these same suppliers or a combination of the same suppliers and some alternative suppliers on future projects. GE does not expect hardware procurement problems for their digital plant control systems or simulators based on their experience with obtaining these components for Lungmen. GE acknowledges that detailed engineering and human factors evaluations need to be done early in the design process if the plant simulator is to be available for operator training two years before fuel load as requested by their utility clients. GE noted that less engineering rework would be required if the simulator was provided one year before fuel load.

Westinghouse
The Westinghouse AP1000 plant design uses a digital plant control system and simulator. Westinghouse manufactures digital plant control systems for safety grade and non-safety grade applications. They have supplied digital upgrades for safety grade process controls at operating plants in the U.S. and at the Sizewell B plant in the United Kingdom.

Toshiba
Toshiba has constructed ABWRs that have digital plant control systems and plant simulators. They have stated that control panels and computers for their ABWR plant would be manufactured by Toshiba, equivalent global suppliers, or a combination of both.

Conclusions and Recommendations
Availability of hardware for digital plant control systems and simulators for GEN III+ units is not expected to be a problem. Designing and manufacturing digital plant control systems and

plant simulators for the first U.S. GEN III+ units is expected to require extra schedule time. We recommend that these designs include a plan for obsolescence and provide an upgrade path.

We recommend that the simulators for the first U.S. GEN III+ units be provided two years before fuel load. This will provide extra time for developing and performing operator training and licensing operators on what will be a new control technology for the U.S. nuclear industry. One way to mitigate the added cost and risk associated with the long lead time associated with plant simulators would be for the owner of the first simulator to lease their simulator to future plant owners for staff training.

We recommend that the design and human factors evaluations for the digital plant control systems and simulators for the first U.S. GEN III+ units be started two or three years before the start of site preparation.

4.6 STRUCTURAL EQUIPMENT

4.6.1 Seismic Snubbers and Prefabricated Supports

Anvil International
Anvil International (formerly Grinnell) manufactures pipe supports (including snubbers) for nuclear power plant service and commercial applications. They are located in Portsmouth, NH. They are ASME N-stamp certified. Their current nuclear business consists of supporting the operating plants with repairs or retrofits. Overall, Anvil sells mostly to U.S. domestic customers. The portion of their sales related to serving nuclear industry customers is approximately 20% of their business and is $1.5 to $2 million per year.

According to Anvil, this amount of production is a small fraction of what they produced when nuclear construction was at its peak. During peak production Anvil employed 100 engineers, whereas they now employ four to five. A ramp-up in production is reportedly easy to accomplish if the market was to require it. The first step would be to begin working multiple shifts for manufacturing, followed by an increase in hiring in engineering, manufacturing and QA. Anvil reported that there are only three suppliers in the U.S. market for nuclear pipe supports today: Anvil, Bergen-Power, and Lisega. Anvil claims Lisega is a relatively new entrant (received their ASME N-stamp certificate in 1998) and has a relatively small fraction of the current market. They claim Anvil and Bergen split the majority of the current market approximately equally.

Bergen-Power Pipe Supports, Inc.
Bergen-Power Pipe Supports provides pipe hangers and supports (including snubbers) for fossil-fired and nuclear power plants. They are located in Donora, PA. They currently have an ASME N-stamp certificate. Their nuclear sales are approximately 20% of their business and approximately $3 million / year. Their nuclear sales represent an even smaller percentage when based on the number of units produced since nuclear-qualified units are significantly more expensive than commercial units. Bergen-Power noted they had contracts to support Browns Ferry Unit 1 restart construction.

Bergen-Power's business is a small fraction of what it was during the height of U.S. nuclear plant construction. They named Bergen-Power, Anvil, and Lisega as the three primary producers in their market.

LISEGA Inc.
LISAGE Inc. is located in Newport, Tennessee and is a subsidiary of the German company, LISAGE AG. LISAGE was not contacted as part of this assessment.

Conclusions
There is expected to be a sufficient supply of snubbers and prefabricated supports available. Multiple vendors have maintained their nuclear certification and are actively producing nuclear-grade products for operating plants. If these vendors are not capable of ramping production to meet demand, additional supply will be available by dedicating commercial products for nuclear service. Snubbers and prefabricated supports used for nuclear applications are not significantly different than those used for commercial applications. There is a large supply of commercial components. One test lab surveyed indicated that dedicating snubbers for nuclear use is a significant portion of their business.

4.7 BULK MATERIALS, NUCLEAR

4.7.1 Electrical Bulk Materials

Under the conservative assumption that two plants' worth of material would be required per year, the required quantities of bulk materials described in Section 3 can be expressed as the annual requirements as shown in Table 4-4.

Table 4-4. Quantities Required per Year

Material	Quantity Required per Year, Maximum
Cable Tray	440,000 feet
Conduit	2,400,000 feet
Power Cable	2,800,000 feet
Control Wire	10,800,000 feet

Anamet Electrical, Inc.
Anamet Electrical manufactures commercial and nuclear-grade conduit. Both grades are required in a nuclear power plant. Anamet's manufacturing facility is located in Mattoon, Illinois. Anamet stated that a typical production rate for them is 100,000 feet per day of conduit. Based on this production rate, the NP2010 requirement for a single year could be met in approximately two and one-half months. Anamet also stated that some additional capacity could be achieved by adding shifts. They are currently operating at between 80 to 90% of maximum capacity.

Okonite Company
Okonite's product line includes power cable and control cable. They have several manufacturing plants, all located in the United States, including facilities in North Carolina, California, Rhode Island, Kentucky, and New Jersey.

Okonite stated that currently only Okonite and Rockbestos offer nuclear-qualified cable. Specifically, they stated that Okonite is currently the only producer of nuclear-qualified power cable and that Rockbestos offers the only nuclear-qualified control cable. However, Okonite is reentering the nuclear market for control cable to meet the demand for replacement cable at operating U.S. plants.

As an example of the production rate for a typical control cable they offered 300V three conductor #12 control cable. They produce this wire at a rate of 150-feet per minute per production line. Okonite also stated that the NP2010 requirement for power cable is relatively small compared to their production capacity. They estimated that the annual NP2010 requirement could be met with approximately two weeks of production. Power cable is a main component of their business. In conclusion, the supply of nuclear-grade power cable is not a problem.

Cooper B-Line, Inc.
Cooper B-Line, Inc. manufactures cable tray and related components. They manufacture cable tray in Illinois, Georgia, and Nevada.

Cooper B-Line stated that they are supplying new Chinese power plants with cable tray and that it takes them about one month to provide all the cable tray required for one plant. Considering Cooper B-Line’s capabilities and the capabilities of other cable tray producers, like The Wiremold Company and MP Husky Corporation, no problems are expected producing the cable tray required for GEN III+ units.

4.7.2 Piping and Metals

Global Demand for Piping Materials
Concerns were raised regarding availability of piping materials by every pipe supplier contacted. Specifically, there are two factors cited as causing significant and prolonged shortages. These factors are:

1. China’s strong demand for pipe, spurred by their strong industrial growth, coupled with;
2. A previously limited domestic investment in pipe production infrastructure throughout the supply chain.

The piping materials predominately used in the construction of the GEN III+ units are 304 and 316 stainless steel, and Inconel 690 alloy piping. Each alloy contains a significant quantity of nickel. Recent nickel shortages have made these high-nickel alloys difficult to purchase. Nickel shortages are expected to continue until the second half of 2006. At this time, Inco, which currently supplies one-fifth of world demand, is scheduled to open their Voisey's Bay project in Labrador. The operation of the Voisey’s Bay project will reportedly increase the supply to 6% above the current global supply of nickel.

However, if the situation is viewed over a time span longer larger than two years, these imbalances in supply and demand of pipe are common. Metal markets, which drive the pipe market supply, are historically volatile. This is due to the demand for metal being highly sensitive to demands for consumer goods made by the automotive, beverage, housing, and other industries that have revenues based on the traditional four year global economic cycle.

Therefore, it can be concluded piping availability and pricing should follow the global economic cycle, and will fluctuate throughout the construction periods of the plants. The current concerns of piping shortages are indicative of normal economic cycles, although they may be somewhat exacerbated by China's recent economic growth. It is likely that the current supply problems will subside once market forces bring supply into closer equilibrium with demand.

Production of Nuclear Grade Metals

To produce nuclear grade metals for U.S. consumption requires appropriate Quality Assurance (QA)/ Quality Control (QC) programs, and an active ASME N-stamp certificate. There are concerns that due to the low demand for nuclear grade metals these programs and stamps are no longer active. This investigation found that the companies contacted, which cumulatively supply a major portion of the total domestic supply of the required metals, already have nuclear QA/QC programs, and in many cases have an active N-stamp. These companies stated that to expand and or resurrect these programs would not be problematic. Further, for those companies who do not have an active N-stamp, they believe that it would take less than a year to obtain this certification. Again, these companies indicated that varying demand in other industries would be the limiting factor in availability and pricing. Therefore, there are few additional constraints in producing nuclear grade vs. non-nuclear grade metals. A list of nuclear-audited metal suppliers published by the Nuclear Industry Acceptance Committee (NIAC) includes over 40 suppliers, which further indicates an active industry.

Conclusions

The supply of raw metals is difficult to predict since the market is volatile. The cost and lead time for certain metals is currently above average. However, the market conditions will likely change before U.S. construction of GEN III+ units. A supply chain in the U.S. for nuclear-grade metals exists today to support operating plants and overseas demand. Component manufacturers have reported supply problems from certain portions of the nuclear metal supply chain. For example, valve and pump manufacturers have reported long lead times for castings from U.S. foundries. GE Nuclear Energy has stated that the longest lead time item for their plant is large forged rings for their reactor pressure vessel. There is only one supplier - located in Japan - capable of providing those nuclear grade forgings. To mitigate risk associated with these localized supply problems, the associated components should be ordered early enough to support construction schedules. Items with long lead times will need to be ordered well before the site work begins on the unit.

4.8 Equipment Testing Facilities

Several nuclear-grade component manufacturers outsource their dedication and qualification activities to external equipment testing facilities. These companies perform the necessary testing and analysis to confirm the design of commercial-grade components is suitable for nuclear applications (qualification) and to confirm that components are correctly made to specification

(dedication). Many manufacturers have exclusive partner agreements with an equipment testing company such that they are dependent on the testing company to support their production rate.

There are currently several equipment testing companies operating in the United States. Their business includes supporting construction of new plants overseas and providing existing domestic plants with replacement components.

Relevant information collected during the survey is provided below for the vendors contacted.

Nuclear Logistics, Inc.

Nuclear Logistics, Inc. is a testing laboratory that procures, dedicates, and qualifies commercial-grade equipment for nuclear-grade use. More information on Nuclear Logistics is provided under Section 4.4.1.   Nuclear Logistics performs testing on both electrical and mechanical equipment.

Wyle Laboratories

Wyle Laboratories is a privately-held domestic company with headquarters in El Segundo, California. Wyle Labs has 3,500 employees and 28 facilities. Wyle Labs provides nuclear utility services from their facility located in Hunstville, Alabama. Their testing services for electronic components include thermal aging, seismic, electromagnetic interference (EMI), and radiofrequency interference (RFI) testing. They also conduct flow testing of pumps and valves. They have an active 10 CFR 50, Appendix B QA program. Wyle's business includes support of domestic nuclear plants and support of new nuclear plant construction overseas. They have supported construction of four new plants in Korea and the Lungmen Project in Taiwan. Overall, Wyle estimates their market share for nuclear-grade equipment in their product line is 30%. They estimate their market share for environmental qualification and seismic testing is approximately 50% and their market share for seismic snubber services and pressure relief valve services is 60 to 70% and 70 to 80%, respectively.

Wyle expects that they could handle the entire demand associated with building the eight new plants in the U.S. Their existing facilities were established to meet the demand in the early 1980s to bring operating units in the U.S. into compliance with newly established seismic limits. Their facilities have since grown and they have excess capacity. They do not expect to need any significant advance notice to increase production to maximum capacity.

National Technical Systems

National Technical Systems (NTS) was contacted but did not participate in our survey.

Conclusions

It is expected that the domestic equipment testing companies would be capable of supporting NP2010 requirements. The majority of required testing would be for electrical components and the capacity to handle these items was identified to be adequate as described in Section 4.4. Several companies have indicated that they could adapt to the increased demand using their existing facilities.

5

Fabrication

This Section provides the results and analysis of interviews with potential construction module fabricators. The types of modules investigated were mechanical, structural, piping, and electrical. Extended discussion of each of these types of modules is provided in the following sections. A summary of the current industry preparedness for fabricating each type of module is provided in Table 5-1.

Table 5-1. Module Fabrication Resource Analysis

Requirement	Capabilities	Shortfall	Lead Time (Years)
Mechanical Modules 140 modules/unit Peak 315 modules/year Total: 1120 modules	Existing qualified fabricators with operating nuclear QA programs are exporting modules for overseas nuclear power plants at rates adequate to support the envisioned domestic demand. Other vendors with suspended or greatly reduced nuclear QA programs are interested in entering or expanding in this market. In addition, other vendors are available that a currently involved in non-power related nuclear activities.	No	
Structural Modules 60 modules/unit Peak 135 modules/year Total: 480 modules	All needed physical infrastructure is available at existing fabrication facilities and domestic shipyards. However, since the shipyards' QA program is based on the military system, some revisions to the QA procedures may be necessary to meet commercial qualifications. Furthermore, shipyards will need to be reconfigured from their current shipbuilding configuration to one that supports nuclear plant structural module fabrication.	No	1-2
Piping Modules 130 modules/unit Peak 292 modules/year Total: 1040 modules	All vendors capable of producing mechanical and structural modules are available to produce piping modules and piping spools.	No	
Electrical Modules 20 modules/unit Peak 45 modules/year Total: 160 modules	There is adequate U. S. infrastructure for electric module fabrication. Electric modules that include Class1E switchgear would require additional time for nuclear-grade dedication activities.	No	

Background

Modular fabrication is a common construction technique used in many industries. A module is formed by a series of assembly operations that involve prefabrication and preassembly. Modules can be fabricated remotely or constructed at the work site. This approach has long been a method used in the construction of offshore oil platforms and has been proposed for nuclear plant construction since the 1970s. However, not until recently has this modular approach been adopted by a large number of onshore construction sectors.

The central principle of this approach is to take advantage of the benefits of fabricating modules in a shop as opposed to the field. The advantages of shop fabrication are the following:

- Higher Productivity – Labor productivities in shops are nearly always greater than in the field. This stems from better working environments, well organized supply chains, higher levels of supervision, indoor working environment, etc.

- Lower Labor Costs – Field labor costs are higher than shop labor costs. Many projects must pay a premium to labor to work in remote locations.

- Lower Impacts from Site Space Limitations – Installing nearly completed modules decreases the number of workers required in congested areas. This can result in significant schedule reductions and the ability to work many critical path activities in parallel.

- Improved Quality Control – Quality control standards can be adhered to more tightly in a shop environment than in the field. This is due to ease of inspection and testing.

The disadvantages of this approach are the increased complexity of design for ease of field assembly and shipping, additional costs associated with structural frames and structural supports, and the additional cost of shipping larger units to site. The costs associated with these disadvantages must be weighed against the advantages to determine what sections of the plant should be modularized.

The four types of modules planned are:

- Mechanical Modules – mechanical equipment on a common structural frame along with interconnecting piping, valves, instruments, wiring, etc.

- Structural Modules – liner, wall, floor, heat sink floor, turbine pedestal form, stair, platform, structural steel and space frame modules. Some structural modules would include leave-in-place formwork for concrete.

- Piping Modules – pipe, valves, and associated instrumentation and wiring on a common structural frame.

- Electrical Modules – electrical equipment on a common structural frame.

Supply and Demand

To evaluate the domestic and international infrastructure preparedness to fabricate construction modules, an estimate of the existing module fabricators' supply and the demand placed on this market by the construction of new nuclear power plants is needed. The supply, demand, and module parameter assumptions were estimated as described in the following paragraphs.

Supply

To evaluate current infrastructure and to identify bottlenecks in the supply of prefabricated modules, multiple vendors have been contacted throughout many industries. The industries contacted are:

- EPC (Engineer, Procure and Construct) Contractors
- NSSS (Nuclear Steam Supply System) Vendors
- Equipment Manufacturers and Piping Fabricators
- Shipyards

The EPC contractors and NSSS vendors will design the modules, but are not be responsible for off-site fabrication. The EPC contractors will be responsible for on-site module fabrication. The remaining industries – equipment manufacturers, piping fabricators and shipyards – will have the responsibility to fabricate the modules off-site. Due to the large size of structural modules, shipyards and similar fabrication facilities have adequate infrastructure (space, crane lift capacity, etc.) to support structural module fabrication.

Demand

The GEN III+ design that has the largest degree of modularization out of the approved designs has been used as a conservative estimate of the impact of building Gen III+ plants on market demand for prefabricated modules. 350 modules are required per unit for the most modularized design. Table 5-2 provides details.

Table 5-2. GEN III+ Market Demand for Construction Modules

Module Type - Number	2010	2011	2012	2013	2014	2015	Total
Mechanical – 140/unit	70	175	315	315	175	70	1120
Piping – 130/unit	65	163	292	292	163	65	1040
Structural – 60/unit	30	75	135	135	75	30	480
Electrical – 20/unit	10	25	45	45	25	10	160
Total							2800

Module Parameter Assumptions

Since modules can vary significantly in size, weight and complexity, an estimated average set of module parameters were developed to allow a quantitative comparison between supply and demand. For the supply and demand study, a module has been standardized as the largest unit transportable by truck. A module as per the definition of this study is defined by the following parameters:

- Dimensions: 12' x 12' x 40'
- Weight: 40 tons
- Complexity: Equal to modules supplied to the petrochemical industry for refineries and offshore oil platforms.

5.1 MECHANICAL EQUIPMENT MODULES

Mechanical equipment modules contain equipment such as heat exchangers, pumps, and vessels on a common structural frame. The equipment will be supplied along with associated piping, valves, instruments, wiring, conduit, cable-tray and other such ancillary items.

Table 5-3 provides a list of the industries and suppliers contacted to assess module fabrication infrastructure. The companies listed are considered representative of the companies that can provide mechanical equipment modules. Inclusion on Table 5-3 is not intended to imply we are making a recommendation or listing preferred suppliers.

Table 5-3. Mechanical Equipment Module Suppliers

Industry	Potential Module Suppliers
EPC Contractors	Bechtel The Shaw Group (Stone and Webster)
NSSS Vendors	General Electric (GE) Nuclear Energy Toshiba Westinghouse
Equipment Manufacturers and Piping Fabricators	Anderson Water System GE Water Joseph Oat Corporation Taylor Forge Engineering Turner International J. Ray McDermott, BWX Technologies

EPC CONTRACTORS

The EPC (Engineer, Procure, and Construct) contractors may or may not fabricate modules at remote locations, but they will oversee subcontractors that prefabricate modules away from the construction site. EPC contractors will be responsible for on-site "out-of- the hole" module fabrication and on-site assembly of "super modules".

Bechtel Power Corporation

Bechtel Power Corporation has designed and/or built more than half of the nuclear power plants in the United States. Currently, Bechtel provides services such as plant recovery support, plant license renewal, steam generator replacement, and construction of new nuclear generation. Bechtel Power Corporation is headquartered in Frederick, Maryland.

Presently, Bechtel is bidding to construct four Westinghouse AP1000 units in China. These units are to be constructed at the Sanmen Nuclear Power Station, in Zhejiang Province southwest of Shanghai, and the Yangjiang Nuclear Power Station in Guangdong Province southwest of Hong Kong. This is part of China's effort to increase their current nuclear capacity of nine units four-fold by 2020. A 5 billion dollar loan for this work has preliminary approval from the U.S. Export-Import Bank (see Reference 7).

Bechtel is a strong supporter of the modular construction approach and is currently using this method in preparing to build the AP1000 units in China. Bechtel envisions that by using modular techniques, nuclear power plants can be built in a 42 to 48 month schedule from first concrete to fuel loading. They envision that 30% to 50% of the plant will be built with modular construction techniques. They say the following benefits of this technique justify their support:

Parallel Completion of Critical Path Tasks – Critical path components could be constructed remotely and then assembled in locations with space limitations.

Proximity of Workforce - Recent years have seen a drastic reduction in the number of people entering the craft workforce. As a result of this labor scarcity, craft laborers must be paid a higher premium to work in remote locations. By using the modular design, modules can be constructed in locations near the workforce and then transported to site.

In addition to their support of modular construction techniques, Bechtel offers the following pieces of important information:

- Bechtel mentioned that they have been in contact with shipyards. Bechtel is interested in using the shipyards to build prefabricated modules. This is well timed for the shipyards, as they are anticipating a decline in the level of activity in their current business lines.

- Bechtel views the number of companies that can provide pipe bending as potentially being insufficient to support construction needs and thereby extending procurement or construction schedules. Please see Section 7.2 for further details.

- Bechtel prefers to use multiple prefabricated module vendors to mitigate shop performance and schedule risks.

Shaw / Stone and Webster, Inc.

The Shaw Group (Shaw), which has in recent years purchased the EPC contractor Stone and Webster, is an engineering, construction and fabrication firm. They are currently responsible for the construction and commissioning efforts to reactivate TVA's Brown's Ferry Unit 1. Shaw, unlike the other EPC contractors, has EPC capabilities coupled with in-house fabricating facilities. They are headquartered in Baton Rouge, Louisiana.

Shaw has seven domestic and four international pipe fabricating facilities with an aggregate production of 35,000 pipe spools (10,000 tons of production) per month. They are capable of producing prefabricated modules and nuclear certified products. They are currently running at approximately 50% capacity, and recently sold two fabrication facilities due to the reduction in workload. Shaw has 300-350 highly-qualified welders in the U.S. They use semi-automated welding techniques on 70% of their production.

Shaw has the largest induction pipe bending capacity in the world. Domestically, they have nine induction-heated pipe bending machines and 13 cold bend machines. The induction heated pipe bending machines have the ability to bend pipe from 2" to 66" in diameter and wall thickness up to 4". The cold pipe bending machines are capable of bending pipe from ½" to 8" in diameter.

Shaw owns and operates the largest ASME Certified Nuclear Parts (NPT Stamp) pipe fabrication facility in the United States. This facility is located in South Carolina and can produce 4,000 pipe spools per month. Shaw also has a smaller nuclear-qualified facility in Utah that is capable of producing 2,500 pipe spools per month. The South Carolina facility has the NPT stamp and complies with the ASME Nuclear Quality Assurance Standard (NQA-1), while the Utah facility only complies with NQA-1. Shaw is currently bidding to supply piping and mechanical modules for the Westinghouse AP1000 nuclear power plants to be built by Bechtel in China.

Shaw has three plants that produce prefabricated modules, one of which is their nuclear certified South Carolina facility. The other two facilities that produce prefabricated modules are located in Delcambre and Addis, Louisiana. The Addis location specializes in structural steel modules. Shaw's prefabricated modules vary in size from a maximum of 2,000 tons to an average of between 300 to 800 tons. For larger modules, rigging is limited to hydraulic jacks and rollers, and heavy lift cranes are brought to the facility on an as needed basis. Recently, these fabrication facilities produced approximately 11 modules (12' x 12' x 40') per month to support the construction of a combined cycle power project in Marcus Hook, Pennsylvania.

Shaw is concerned that the current supply shortage of piping materials may impact the construction of new nuclear power plants. They specifically cited 50 to 80 week lead-times for P91 pipe (pipe manufactured per ASME/ASTM A335 and containing 9% chromium and 1% molybdenum), coupled with the increased quality assurance requirements in providing nuclear-grade material as potential bottlenecks. This concern is investigated further in Section 7.2.

NSSS VENDORS

NSSS vendors are the entities responsible of the GEN III+ nuclear plant designs. They will have designs certified by the NRC. These designs will serve as the starting point for site-specific engineering and plant construction. They will use subcontractors to fabricate construction modules.

General Electric Nuclear Energy (GE)

One GE Nuclear Energy GEN III+ design is the Advanced Boiling Water Reactor (ABWR). The ABWR design has been certified in three countries, including the United States, Japan, and Taiwan. In addition, GE is in the process of obtaining NRC design certification for their Economic Simplified Boiling Water Reactor (ESBWR) design. ABWR construction work in Japan has been executed by Toshiba (see next section) and Hitachi. GE is responsible for the construction of the two ABWR units at Lungmen in Taiwan. GE Nuclear Energy is currently headquartered in San Jose, California.

For their GEN III+ designs, GE intends to fabricate 100% of the structural steel modules off-site at a fabricator's facility and ship these modules to the construction site by truck or rail for final assembly and installation. All rebar modules would be assembled on-site. GE intends to vary the amount of modularization depending on the site location. They note that several shipyards already do a significant amount of modularization and could be utilized for this effort. GE is not anticipating any supply problems for prefabricated modules. Further, GE believes that all the large bore piping can be fabricated off-site by defining modules or pipe spools based upon the pipe vendor facility limitations and the construction techniques adopted by the plant constructor. All small bore piping and tubing (i.e., 2" diameter and below) is planned to be field routed. GE plans further work with Japanese contractors to evaluate the optimum level of modularization for their ESBWR design. GE notes that the Shika 2 ABWR currently under construction in Japan is utilizing 70 to 80 modules.

Toshiba

Toshiba Industrial and Power Systems has been the prime contractor for building 17 nuclear units and was subcontractor on five more. They have built three ABWRs in Japan using modular construction techniques. Their first was the Kashiwazaki-Kariwa Unit 6 that has been in service since 1996. Toshiba is headquartered in Tokyo, Japan.

According to their sales literature, Toshiba has relied heavily on modular construction techniques to compress their construction schedule. Kashiwazaki-Kariwa Unit 6 was built in a 39 months from first concrete to commercial operation. However, Toshiba management does not attribute this success solely to the use of modularization. Toshiba expressed concerns that the industry is overly optimistic regarding the impact of modular construction techniques on project schedule. They emphasized that the optimal degree of modularization is dependent on plant location. Specifically, if the plant is located with barge access, a higher degree of modularization is appropriate. If the plant is located near a large labor-force, then a smaller degree of modularization is appropriate. They believe that the decision to modularize certain systems should be made on a per plant basis.

Westinghouse

Approximately 50% of the operating nuclear power plants in the world, and 60% in the United States, are based on Westinghouse technology. Westinghouse's GEN III+ design is the AP1000. The AP1000 is a two-loop PWR with passive safety features closely related to the earlier AP600 design. The AP1000 design was granted a Final Design Approval (FDA) in September of 2004 by the NRC which expects to issue the AP1000 design certification by December 2005. Westinghouse is part of British Nuclear Fuels Limited. Westinghouse is headquartered in Monroeville, Pennsylvania.

Westinghouse has made extensive uses of modular design techniques to estimate the AP1000's 42 month construction (first concrete to commercial operation) schedule. The Westinghouse design relies more heavily on modularization than any other NSSS vendor. It is estimated that modular construction techniques reduce the total plant cost by 1.5 to 3%.

Westinghouse has worked with Bechtel and Mitsubishi to prepare a bid to construct two twin Westinghouse AP1000 units in China. Details of this work are provided under the Bechtel discussion included earlier in this section.

EQUIPMENT MANUFACTURERS AND PIPING FABRICATORS

The companies that will be responsible for physically fabricating the modules are the equipment manufactures and pipe fabricators. These companies may or may not have an ASME Nuclear Component Stamp (N Stamp); however, all of these companies have provided equipment and or piping to nuclear plants.

Anderson Water Systems

Anderson Water Systems designs, engineers, manufactures, and commissions industrial water treatment systems. Water treatment equipment is needed for nuclear plant. Unfortunately, no water treatment company currently holds nuclear credentials. However, this can be overcome in most case by these companies purchasing their pressure vessels and piping from nuclear certified shops and assembling the equipment on their premises. The last time Anderson Water Systems supplied equipment to nuclear power plants was in the early 1980's. They are not sure whether this equipment required nuclear certification. Anderson Water Systems is headquartered in Dundas, Ontario, Canada.

Anderson Water Systems currently has 18,000 ft^2 of production space and has access to 20,000 ft^2 of rental shop space for overflow capacity. They are limited in the size of modules that they can construct by their 20 ton lift crane capacity. They have approximately 25 people who work in their shop and an engineering department of seven. They are willing to expand production capacity and seek qualifications as necessary to meet the demands of the nuclear industry.

GE Water

GE Water is a water treatment company similar to Anderson Water Systems and has become larger and more diversified in their product offering due to recent acquisitions. They do not have nuclear qualifications, but are willing to pursue them if required.

GE Water has several thousand of employees, primarily in North America with the rest in Europe. They anticipate that the demand for water treatment systems in support of the construction of nuclear power plants would represent a minimal impact on their overall workload. GE Water may be the water treatment equipment supplier for the AP1000 units being proposed by Westinghouse for China. GE Water is headquartered in Guelph, Ontario, Canada.

Joseph Oat Corporation

Joseph Oat Corporation is a designer and fabricator of pressure vessels, chemical reactors, distillation columns, heat exchangers, and other specialty items for the chemical and petrochemical, nuclear power, and other commercial industries. Joseph Oat is located in Camden, New Jersey. They are capable of producing mechanical and piping modules. They are

also capable of manufacturing nuclear rated pressure vessels that can be used by non-nuclear rated fabricators to build modules.

Recently, Joseph Oat supplied pressure vessels for the GE ABWR Lungmen Project in Taiwan. Additionally, they have proposed supplying pressure vessels to Bechtel for the four AP1000 units that Westinghouse has proposed to build in China.

Joseph Oat has the capacity to build mechanical and piping modules and is willing to work with NSSS vendor and EPC contractor designs. They have 120,000 ft^2 of shop floor space and 20,000 ft^2 of environmentally isolated clean rooms for the construction of reactive metal equipment including titanium, zirconium and tantalum. Joseph Oat has the capacity to perform complete vibration, seismic, and structural analysis of equipment and modules.

Taylor Forge Engineering

Taylor Forge Engineering supplies mechanical and piping modules primarily for the petrochemical industry, but also to a lesser extent for the nuclear industry. They have rail and road access, but they do not have barge access. They can produce between 50 to 100 modules per year with the average parameters estimated for this assessment.

Taylor Forge plants are currently operating at 75% capacity and will be increasing production in the near future. Their three facilities are located in Kansas in the towns of Paola, Greenly, and Garnett. They employ between 230 to 240 employees, with 55 to 60 office employees and 190 welders and fabricators.

Only $1 million of their approximately $40 million in annual revenue comes from nuclear work. They stated they would need to be confident that the nuclear industry expansion is going to occur to invest money in expansion of their nuclear capabilities. They currently have 25 nuclear-qualified welders on staff. They use an arc-welder that has been modified to complete automatic welds. Taylor Forge uses an off-site subcontractor for pipe bending.

Turner International Piping Systems

Turner International Piping Systems is part of the Turner Industrial Group, LLC, a privately-owned maintenance and construction company and pipe fabricator. They provide services in the petrochemical, chemical, refining, energy, power generation, pulp & paper, and other related industries. Turner Industrial Group is headquartered in Baton Rouge, Louisiana.

Turner International is capable of producing both mechanical and piping modules. For the first half of 2005, they will be producing 37 modules ranging in size from a maximum of 60' x 20' x 20' at 95 tons to 12' x 14' x 50' at 20 tons. Forty percent of these modules will be shipped by barge and the remainder by truck.

Turner International has two main pipe fabricating plants; one in Paris, Texas, and the other in Port Allen, Louisiana. The Paris plant is located on 150 acres of land with 350,000 ft^2 of shop floor space. They have four fabrication bays and the largest stress relieving furnace in the country. This plant does not have barge access, so all modules must be transported by rail or truck. The Port Allen plant, including a small satellite plant in North Port Allen, has 200,000 ft^2 of shop floor space. This plant has barge, rail and truck access. Both plants have induction

bending machines and can bend pipe up to 24" in diameter. Turner International uses automated welding for 50 to 60% of their work.

Neither plant has nuclear certification, but Turner International is currently investigating becoming nuclear certified. Turner International has held nuclear certification in the past, and is certain that they have the needed skills and qualifications to produce nuclear grade products. Turner International currently uses in-house quality control and assurance procedures.

Presently, Turner International is concerned with the increasing average age of their welders and the shrinking workforce. There are few young people entering the crafts, and the older craftsmen are retiring. Currently, only 50% of their welders have the required skills to weld alloyed steels. Turner International is also concerned with the lack of supervisory skills in the workforce. They indicated they are having troubles recruiting sufficient numbers of schedulers and project managers.

J. Ray McDermott/BWX Technologies

J. Ray McDermott (McDermott) operates numerous fabrication and construction companies. Specifically, McDermott owns BWX Technologies (BWXT) that provides nuclear manufacturing services for both commercial and government clients. BWXT states they are capable of producing all of the prefabricated modules needed for the NP2010 effort. They say that all of the manufacturing facilities they used to build multiple nuclear power plants during the 1970's are still available and have been refurbished with the latest in manufacturing technology. Currently, these manufacturing facilities are used on classified projects, but BWXT has made assurances that the demands of simultaneously building three nuclear power plants, our envisioned maximum demand, would be insignificant when compared to their current workload. However, due to their involvement with classified projects, the details of their capacity cannot be made public. BWXT is headquartered in Lynchburg, Virginia, and their parent company J. Ray McDermott is headquartered in Houston, Texas.

The information that can be made public is limited; however, some important facts are publicly available. BWXT has hundreds of thousands of square footage in shop floor space. They have been recently supplying replacement steam generators for nuclear operating assets. BWXT has nuclear qualified facilities in Mt Vernon, Illinois; Barbarton, Ohio; and Cambridge, Ontartio, Canada. The Mt. Vernon facility has 1,000 ton crane capacity with barge access.

BWXT noted that steam generator tubes can no longer be purchased domestically; only three suppliers are available in Europe and one in Japan. McDermott has been in contacted by Bechtel to serve as a potential subcontractor for the prefabricated modules for the AP1000 units that Westinghouse has proposed to build in China.

Conclusions

Existing qualified fabricators with operating nuclear QA programs are exporting modules for overseas nuclear power plants and have the capacity to support the envisioned domestic demand. Other vendors with suspended or reduced nuclear QA programs are interested in entering or expanding into the nuclear market. In addition, other fabricators are available with ample excess capacity and are currently involved in non-power related nuclear activities. Therefore, adequate resources were found for the fabrication of mechanical modules. No lead time problems are anticipated.

5.2 STRUCTURAL MODULES

Structural modules are used to speed concrete and structural steel installations. These modules are constructed of steel plate that can serve as leave-in-place concrete forms and structural steel. The steel plate will be reinforced as needed to contain and reinforce the concrete poured into these modules on-site. Internal bracing between steel plates is provided as required to allow for transportation and setting the structural modules in place. These modules may be outfitted with pipe, duct, and cable tray.

Table 5-4 provides a list of the shipyards contacted to assess structural module fabrication infrastructure. As noted in Section 5.1, there are other companies that can provide structural modules. Inclusion on Table 5-4 is not intended to imply we are making a recommendation or listing preferred suppliers.

Table 5-4. Structural Module Suppliers

Industry	Potential Supplier
Shipyards	Electric Boat General Dynamics
	Northrup Grumman Newport News Shipbuilding

SHIPYARDS

Structural modules are the largest of the modules, and shipyards have the required crane capacity (greater than 200 tons) and the required 100' clearance for sub-module fit-up and match marking. These shipyards are currently producing ships and submarines for the United States Navy. These shipyards have been contacted and they are interested in becoming involved in fabricating structural modules, mechanical modules, and piping modules for nuclear plants.

Electric Boat General Dynamics

Current capabilities include fabrication of modules for submarines. These modules include submarine nuclear power plant piping assemblies. Electric Boat's Quonset Point fabrication facility is located in North Kingstown, Rhode Island. There are 2100 employees at Quonset Point. Quonset Point has the capacity to produce approximately 44 (12' x 12' x 40', 40 ton) modules per year, depending on the degree of complexity.

The Quonset Point facility has ample space to increase production in the 2009-2014 timeframe. They have the ability to hire both skilled and unskilled workers and have facilities to train personnel on-site. Currently, it takes approximately four months to train a new employee to meet the facility's military QA/QC specifications and standards.

Presently, Quonset Point has 58 pipe welders with 11 nuclear-qualified welders and 17 non-nuclear qualified welders. There are 449 structural welders with 54 non-nuclear qualified welders. All structural welders are available for nuclear training upon demand. Quonset Point has 50 submarine trained and qualified electricians with 14 nuclear-qualified. None of the electricians are licensed. There are approximately 90 additional people in varying phases of training toward becoming fully trained and qualified electricians.

Quonset Point uses automatic welding machines. These include: five orbital welding machines, four horizontal roll welding stations, and one horizontal roll submerged arc welding station. Quonset Point has pipe bending machines. These include: four pipe bending machines capable of bending ¼" to 10" pipe, and three manual pipe bending machines.

In the spring of 2005 Quonset Point is operating at an approximately 50% utilization rate. They are expanding their light metal fabrication shop capacity, and are expecting full operability by year end 2005. Depending on requirements, it would require approximately 12 to 36 months to expand their fabricating capacity. Quonset Point does not anticipate problems increasing their engineering staff since they have access to a large staff at their Groton facility and access to outside resources.

Quonset Point has extensive experience in purchasing nuclear-grade material; however, they are concerned that due to the lack of new commercial nuclear power plant projects over the past few decades, nuclear-grade material may be difficult to obtain at a reasonable price.

QA/QC programs are currently in compliance with the Department of Defense Military Specifications and Standards. These standards include NAVSEA specifications and standards for nuclear and non-nuclear submarine applications. A specification comparison review to ensure compliance with commercial nuclear QA/QC requirements would be required. Quonset Point would need to acquire an ASME N Stamp to fabricate modules for the commercial nuclear sector. The Quonset Point facility is qualified under these programs; ISO 9001 – Quality Control, ISO 14001 – Environmental Compliance, and OHSA 19001 – Safety.

Northrup Grumman Newport News Shipbuilding

Northrop Grumman Newport News (Newport News) is the only domestic company that designs, builds and refuels both nuclear-powered aircraft carriers and submarines. They extensively use modular construction techniques in building ships and could use their existing infrastructure to build prefabricated modules for the next generation of nuclear power plants. Newport News is capable of building all types of prefabricated modules including structural. Northrup Grumman Newport News is headquartered in Newport News, Virginia.

Newport News has a very large throughput capacity. Their shop can build all of the modules required for an aircraft carrier within three and a half years. It is estimated by Newport News that building the modules required for a nuclear power plant is approximately one-tenth the effort of building an aircraft carrier; therefore, this equates to an equivalent 100% capacity of approximately three nuclear power plants per year.

Newport News is expecting a slowdown in their workload from 2007 to 2009, and is currently running at a reduced capacity. This future slowdown correlates with the anticipated commencement of construction of the new nuclear plants. Therefore, it is unlikely that the shipyard will need to increase capacity. In addition, Newport News has access to additional facilities at Electric Boat General Dynamics, Ingalls, and Avondale Shipyards for overflow capacity.

Currently, Newport News is limited in the size of the modules they can construct by the lifting capacity of their crane. The exiting crane is able to lift 900 tons and they plan to install a new crane with a lifting capacity of 1,050 tons shortly.

Newport News has approximately 500 welders on staff. Approximately 20% are pipe welders, including alloyed welding, and the remaining 80% are structural welders. They have robotic assembly lines that include automatic welding machines. They are capable of bending pipe from ½" to 24" in diameter. Their facility covers 45 city blocks, and they are planning to expand shop floor space by 600,000 to 700,000 ft^2.

Newport News emphasized that a standard design approach to building nuclear power plants is essential to rapid and cost effective module production. Their experience has shown that modules can be built more efficiently when carbon-copy modules are built in parallel.

Currently, Newport News is in compliance with military quality control and quality assurance specifications and standards. These specifications are similar to the quality assurance measures taken within the nuclear commercial power sector. Therefore, Newport News should be able to implement a commercial nuclear quality assurance programs.

Newport News noted that for the shipyard to commence building a new ship design takes three to four years of engineering and shop reorganization to begin manufacturing. Although the design for the new nuclear plant modules will be mostly complete prior to the shipyards involvement, extensive redesign of the yards manufacturing facilities will be required to build the envisioned modules. Therefore, it is reasonable to expect a three to four years lag between awarding the contract to the shipyard and the production of the first structural modules if module design is required and one to two years lead time to fabricate an existing design.

Conclusions

All needed physical infrastructure required to build structural modules and other modules is currently available at U.S. shipyards. However, since the shipyards' QA program is based on the military system, some revisions to the QA procedures would be necessary to meet commercial nuclear qualifications. Furthermore, shipyards will need to be reconfigured from their current shipbuilding configuration to one that supports nuclear plant module fabrication. While fabrication resources are available to produce structural modules, a one to two year lead time would be required to reconfigure the shipyard fabricating facilities and systems to support nuclear unit structural module fabrication. NSSS vendors and EPC contractors should carefully consider using the available U.S. infrastructure that is currently supporting the U.S. Navy's nuclear program for the fabrication of structural modules, mechanical modules, and piping modules.

5.3 Piping Modules and Pipe Spools

Piping modules contain pipe and valve assemblies and their ancillary instrumentation. These modules may also contain sections of electrical raceway and HVAC ducts. Piping modules may contain several pipe runs and their supports mounted on a surrounding structure. All of the vendors who produce mechanical and structural modules are capable of producing the piping modules and the pipe spools that would be used to construct a GEN III+ unit. Please see Sections 5.1 and 5.2 for supplier information and conclusions that are also applicable to piping modules and pipe spools.

5.4 ELECTRICAL EQUIPMENT MODULES

The electrical equipment modules for GEN III+ units would include prefabricated power distribution centers and indoor substations. The modules will be constructed on skids. As self-contained units, these modules can be completely coordinated, assembled, and tested in a controlled factory environment. If integral transformers are close-coupled to switchgear or with bus duct connections, these modules can serve as a complete unit substation. The electrical module requirements for GEN III+ units indicated in Table 5-2 include a combination of Class 1E qualified modules for safety-related applications and commercial grade modules for balance of plant applications.

Table 5-5 provides a list of the suppliers contacted to assess electrical module fabrication infrastructure. The companies listed are considered representative of the companies that can provide electrical modules. Inclusion on Table 5-5 is not intended to imply we are making a recommendation or listing preferred suppliers.

Table 5-5. Electrical Module Suppliers

Industry	Potential Suppliers
Electric Equipment Manufactures	Eaton Cutler-Hammer Powell ABB

Eaton Cutler-Hammer

Eaton Cutler-Hammer's prefabricated electrical systems are marketed as 'Integrated Power Assemblies, or Electro/Centers'. Although they are not nuclear-safety qualified, Eaton Cutler-Hammer electrical distribution equipment is seismically tested, seismically qualified, and exceeds requirements of both the Uniform Building Code and California Building Code. The 'Electro/Centers' can contain medium voltage, low voltage switchgear, and dry-type distribution transformers.

Eaton Cutler-Hammer currently has the ability to build commercial MCC and switchgear products for any industry. The major industries served by Eaton Cutler-Hammer are power generation, petrochemical, chemical, cement, pharmaceutical, transportation, and waste water treatment.

While Eaton Cutler-Hammer does not presently manufacture Class 1E components for nuclear plants, some of Eaton Cutler-Hammer's component offerings in low voltage and medium voltage breakers are purchased as commercial items and qualified for nuclear service. Eaton Cutler-Hammer has teamed up with EPC contractors to supply equipment for many overseas fossil power plant construction projects.

Eaton Cutler-Hammer uses multiple companies to support Electro/Center manufacturing such as Protect Controls, Inc., Houston, Texas and Metal Systems, Chattanooga, Tennessee. The electrical switchgear in the Electro/Centers is manufactured in Eaton Cutler-Hammer's plants in Asheville, North Carolina, Greenwood, South Carolina, and Fayetteville, North Carolina. There are a total of 1,500 employees in these three plant locations. The estimated capacity for

producing Electro-Centers is 45 total units per year, if 18 months advanced notice is provided to plan for the work load. This estimated capacity is based on the current annual capacity of 30 units and considering a 50% increase in the capacities of these facilities. Overall, an electrical module will typically take a total of 44 to 50 weeks to fabricate, excluding nuclear qualification.

Powell

Powell Industries (Powell) is a major U.S. manufacturer in the electric power product segment. Powell manufactures custom engineered electrical modules, power control rooms, secondary unit substations and low voltage/medium voltage MCCs, and switchgear for various onshore applications at the Powell Electrical Manufacturing Plant in Houston, Texas. This plant has around 700 employees. Powell also has another module fabrication plant in Jacintoport, Texas. This plant manufactures electric modules for offshore applications mainly focusing on petrochemical industry. The electric module construction business is around 30% of Powell's total business revenue of $174 million (FY2004) in the electric power products segment.

Powell currently manufactures around 200 electric modules per year and indicated that they can meet the requirements of 45 modules per year for U.S. GEN III+ plants with the existing plant infrastructure at Houston. The delivery time for electrical modules would be 20 to24 weeks from of receipt of purchase order, excluding nuclear qualification.

Powell has a current ISO9001/2000 QA certification. Powell has a discontinued 10CFR50 Appendix B program and indicated that they can reactivate this QA program if there is sufficient demand for Class 1E electrical equipment.

ABB

ABB is one of the leading global manufacturers of electrical equipment. ABB currently manufactures low voltage and medium voltage switchgear components for the nuclear industry. ABB's plant in Lake Mary, Florida manufacturers Power Distribution Centers and ANSI primary unit and secondary unit substations rated up to 2500kVA. The Lake Mary plant currently has about 300 workers. ABB has indicated that they have the ability to find skilled workers, expand their facilities, and provide components that are compliant with NRC requirements.

ABB currently manufactures 1,200 vertical sections of low and medium voltage switchgear, around 12 power distribution centers, and 100 to150 units of primary and secondary unit substations per year. This is approximately 90% of the work done in the Lake Mary plant. The manufacturing time for the modules would be around 4 weeks and the delivery time is around 20-24 weeks from date of receipt of purchase order. ABB indicated that they can meet the requirements of 45 modules per year for U.S. GEN III+ units. ABB does not manufacture low voltage motor control centers. Accordingly for modules where MCCs are required, ABB would buy the MCCs from other vendors.

Conclusions

There is adequate U.S. infrastructure for electric module fabrication. Electrical modules for GEN III+ plants involve a combination of Class 1E switchgear for safety-related applications and commercial grade switchgear for balance of plant. The delivery time for the modules with commercial grade switchgear is approximately 24 weeks. For the electric modules with Class 1E switchgear, electrical manufacturers indicated that the actual delivery schedule depends on the type of switchgear required and the time required for nuclear grade dedication.

6 Labor

This Section provides information on the projected availability of labor required to build the next generation nuclear power plants beginning in the 2010 timeframe. The labor necessary to support nuclear plant construction includes construction craft labor, craft supervision, and the staffs required by the EPC contractor, the NSSS vendor, equipment suppliers, quality control/inspection technicians, NRC inspectors, and the plant owner's personnel for plant operations & maintenance.

The availability of labor in each of these areas is evaluated by comparing labor employment projections with nuclear plant construction labor requirements on both a national and state level. These comparisons are used to determine any challenges related to labor availability and recruiting for each of the specific labor categories and occupations. In addition, issues affecting labor productivity on nuclear power plant construction sites based on historical experience and issues related to utilizing union vs. non-union labor are also discussed at the end of this section.

Table 6-1 follows to provide a labor resource analysis summary. Resource requirements are compared with available resources and any shortfalls are noted.

Table 6-1. Labor Resource Analysis

Item	Labor Requirement	Labor Resources [1]	Shortfall	Lead Time (Years)
1	800 Construction Laborers	765,000 / 90,200	No	
2	300 Boilermakers	17,800 / 1,300	Yes	0.25
3	1,450 Electricians and I&C Technicians	547,000 / 5,600	Yes	0.25
4	1,450 Ironworkers	30,000 / 700	Yes	0.25
5	250 Millwrights	30,000 / 1,200	No	
6	650 Operating Engineers	233,000 / 40,800	No	
7	800 Carpenters	781,000 / 9,300	No	
8	1,350 Pipefitters	424,000 / 13,000	Yes	0.25
9	150 Insulators	51,000 / 600	No	
10	150 Painters	215,000 / 800	No	
11	250 Sheetmetal Workers	164,000 / 400	No	
12	250 Teamsters	111,000 / 11,000	No	
13	150 Concrete Masons	199,000 / 3,800	No	
14	200 QC Inspectors		Possible	1
15	400 Construction Supervisors		No	
16	500 Construction Engineers and Schedulers		No	
17	1,000 Owner's O&M Staff		Possible	2
18	100 NRC Inspectors	1,100	Possible	1-2

Note

1. 2012 Projected Total Construction Industry Employment / 2012 Projected Utility System Construction Employment.

6.1 Construction Craft Labor Availability

The majority of the labor required to construct a new nuclear power plant is construction craft labor. The craft labor required to support nuclear power plant construction accounts for over 60% of the total on-site labor during plant construction based on the labor requirements estimated in Section 3.3.

The maximum labor requirements are provided in Section 3, Resource Requirements, and are estimated based on a maximum of eight nuclear units under construction at any given time. A five year construction schedule from site preparations to commercial operations is assumed for each plant with 12 to 18 months for site preparation, 36 to 42 months for construction (first concrete to fuel load), and 6 to 12 months for testing and commissioning activities.

The start dates are assumed to be staggered over a four year period as described in Table 3-1 with the first 12 to 18 months required for site preparation. Single unit labor requirements peak during months 19 to 36. Single unit labor requirements lessen as the heavy construction period ends and the final construction activities, fuel loading, commissioning, and testing period begins. This staggering of the site labor requirement curves yields a national labor requirement curve as shown in Figure 6-1.

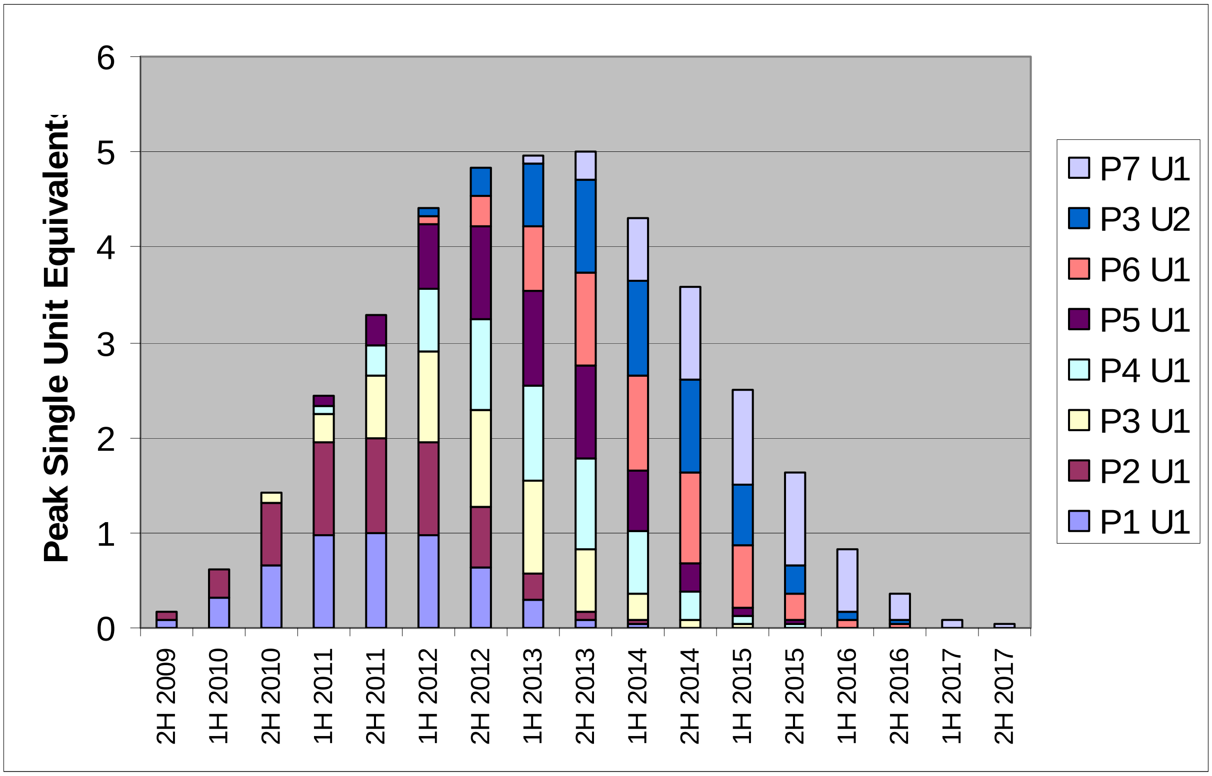

Figure 6-1. Peak Labor Requirements to Build Eight Units

The maximum labor requirement is shown to peak at five times the single plant peak labor requirement. Maximum labor is required in the second half of 2013 just after site preparation is started on the eighth unit.

For each state considered as a potential location for new nuclear units it is assumed that no more than two nuclear units will be under construction at any given time. Using the two-unit example shown in Figure 6-1 (Plant 3 Unit 1 and Plant 3 Unit 2) which has the construction start staggered by 18 months, this yields a peak labor requirement in any state that is 1.6 times the peak labor required to build a single unit.

Note that only same state labor is considered in this report for state labor availability. This may slightly under or overestimate availability as prospective plant sites may be close to state borders or far from state industrial centers. Detailed local labor market analyses would be required for EPC firms and owners to develop a better picture of labor availability on a site by site basis as site decisions are made.

Table 6-2 lists specific trades and the estimated peak number of workers from each trade required for single unit and nationwide multiple unit construction (8 units under construction simultaneously across the country).

Table 6-2. Peak Construction Craft Labor Requirements

Craft Description	Craft Percent	Peak Personnel - Average Single Unit	Peak Personnel - 2 Units in a Single State	Peak Personnel - 8 Units Nationally
Boilermakers	4	60	96	300
Carpenters	10	160	256	800
Electricians/Instrument Fitters	18	290	464	1450
Iron Workers	18	290	464	1450
Insulators	2	30	48	150
Laborers	10	160	256	800
Concrete Masons	2	30	48	150
Millwrights	3	50	80	250
Operating Engineers	8	130	208	650
Painters	2	30	48	150
Pipefitters	17	270	432	1350
Sheetmetal Workers	3	50	80	250
Teamsters	3	50	80	250
Total Construction Labor	**100**	**1600**	**2560**	**8000**

These estimated labor requirements for individual crafts are compared to craft employment statistics and projections in the following sections. The results of these comparisons are then used to determine the key challenges relating to labor availability for new nuclear plant construction and to provide insight into possible actions to mitigate labor availability challenges.

6.1.1 National Construction Employment

According to the U.S. Bureau of Labor Statistics, construction is one of the nation's largest industries, employing 6,700,000 wage and salary workers in 2002. The construction industry is expected to grow by 15.1% and add about 1,000,000 new jobs between 2002 and 2012 (Reference 11). This 15.1% growth is similar to the 14.8% growth expected for all industries over this period. The size and growth rate of the construction industry makes it one of the top 10 sources of new job growth in the economy during this time period.

In addition, the combined effects of job growth, retirement, and attrition will require that 240,000 workers enter the construction industry each year to replace those leaving the construction workforce or retiring. Over a 10 year period, this requirement equates to a total of 2.4 million new workers or 36% of the total current labor force (Reference12).

Table 6-3 describes the employment and predicted growth in the key construction craft categories required for nuclear plant construction based on employment projections for 2012 (Reference 12). The center columns show employment projections for 2012 in increasingly specific industry descriptions (e.g., utility system construction is a subset of heavy and civil engineering construction, which is a subset of general construction). The values for projected employment increases are taken from data on the Utility System Construction Industry.

Table 6-3. National Construction Craft Employment Predictions for 2012

Craft Description	**Total Employment (All Industries), 2012**	**Construction Industry Employment, 2012**	**Heavy and Civil Engineering Construction Employment, 2012**	**Utility System Construction Employment, 2012**	**% Change for Utility System Construction, 2002-2012**
Boilermakers	24,994	17,783	1,685	1,322	1.1
Carpenters	1,331,047	781,681	32,825	9,343	12.4
Electricians	813,908	547,468	7,829	5,568	23.6
Structural Iron Workers	90,443	73,537	5,309	1,865	12.4
Reinforcing Iron Workers	33,445	30,474	3,120	685	12.4
Insulation Workers	61,938	51,135	1,564	639	11.5
Construction Laborers	1,070,466	764,705	206,306	90,239	12.4
Concrete Masons	229,047	199,098	18,408	3,809	21.7
Millwrights	73,151	29,649	2,252	1,242	4.5
Operating Engineers	389,439	232,878	111,987	40,798	10.0
Painters	499,570	215,447	5,710	814	12.4
Pipefitters/Steamfitters	584,068	423,807	16,793	13,094	12.4
Sheetmetal Workers	245,604	164,109	557	357	12.4
Teamsters	2,103,667	110,648	42,882	11,468	17.9
All Occupations	**165,318,670**	**7,745,400**	**991,700**	**421,400**	**10.7**

Note: For reference, the U.S. Census Bureau estimates that the total population of the United States was 281 million in the 2000 census and will be 309 million in the year 2010. This represents a 10% increase over 10 years (Reference 13).

Table 6-3 shows the differences in craft employment as the industry is specified in more and more detail. For example, heavy and civil engineering construction will employ about 13% of the overall construction industry while the more specific utility system construction industry will employ about 5.4% of all workers in the construction industry.

However, specific occupations differ significantly in their representation in these industry subsets. For example, a large fraction of equipment operating engineers in the overall construction industry (17.5%) will work in utility system construction, while a very small number of sheet metal workers in the construction industry will work in utility system construction (0.2%). These fractions are evaluated on a craft by craft basis in Section 6.1.5 to

determine the effect of these industry breakdowns on the availability of experienced labor to support nuclear plant construction.

Looking at this issue in another way, Table 6-4 describes the percentage of the total projected workforce from each of the industry subsets that will be required to support the construction of eight nuclear units simultaneously nationwide.

Table 6-4. Percentage of Workers from Industry Required for Multiple Nuclear Power Plant Construction

Craft Description	% of Construction Workers Req'd	% of Heavy & Civil Engineering Construction Workers Req'd	% of Utility System Construction Workers Req'd
Boilermakers	1.7%	17.8%	22.7%
Carpenters	0.1%	2.4%	8.6%
Electricians	0.3%	18.5%	26.0%
Structural Iron Workers	1.4%	17.2%	56.9%
Insulation Workers	0.3%	9.6%	23.5%
Laborers	0.1%	0.4%	0.9%
Concrete Masons	0.1%	0.8%	3.9%
Millwrights	0.8%	11.1%	20.1%
Operating Engineers	0.3%	0.6%	1.6%
Painters	0.1%	2.6%	18.4%
Pipefitters and Steamfitters	0.3%	8.0%	10.3%
Sheetmetal Workers	0.2%	44.9%	70.0%
Teamsters	0.2%	0.6%	2.2%

These statistics demonstrate that, while there may be plenty of workers in the construction industry as a whole to support new nuclear construction, the population of workers with power plant or other heavy industrial construction experience is much smaller. Conclusions for overall national craft labor availability can be found in Section 6.1.5.

6.1.2 State Construction Employment

There are currently four existing nuclear power plant sites that are likely candidates for the site of the construction of a new nuclear power plant in the United States. The NRC is currently reviewing early site permits (ESPs) from three applicants: Dominion Nuclear North Anna, LLC for the North Anna site in Virginia; Exelon Generating Company, LLC for the Clinton site in Illinois; and System Energy Resources, Inc. for the Grand Gulf site in Mississippi. In addition, of the three proposals to participate in a combined operating license (COL) demonstration project, the TVA is considering building a twin unit plant at the Bellefonte site in Alabama.

The availability of craft labor to support construction of new nuclear power plants in these states is evaluated in this section. Occupational employment data for each state and more specific industry classifications are examined and compared to the craft labor requirements for the construction of two nuclear units in each state.

Table 6-5 provides a summary of the employment projections for the 2010 timeframe for each state. Total population statistics for July 2004 are also included to give a baseline for the total size of each state. Note that employment projections for selected trades are for total employment, not the construction industry specifically. For example, since total employment statistics are used, the number of electricians with power plant construction experience is likely significantly less than the number listed. However, these numbers are useful in comparing the relative sizes of the workforces in each state.

Table 6-5. State Construction Employment Summary

	Total Population (2004)	**Total Employment (2012)**	**Boiler-makers**	**Electricians**	**Concrete Masons**	**Millwrights**	**Pipefitters**
Required Craft	--	--	96	464	48	80	432
Alabama	4,530,182	2,402,150	470	14,260	3,050	1,870	7,730
Illinois	12,713,634	6,928,400	1,766	37,725	9,470	2,369	24,870
Mississippi[1]	2,902,966	1,516,777*	690*	5,710*	1,160*	1,740*	5,420*
Virginia	7,459,827	4,097,672	364	22,306	6,327	1,428	15,956

Notes:

1. Employment values for Mississippi are for 2010, not 2012.

Tables 6-6 through 6-9 describe the occupational employment projections for the 2010 timeframe for each of these four states. Note that some states gave projections for 2010 while others use projections for 2012. In addition, the available industry breakdowns (i.e., general building contractor employment, heavy and civil engineering construction employment, etc.) varied between the four states.

Table 6-6. Alabama Construction Craft Employment Predictions

Craft Description	Total Employment (All Industries), 2012	Heavy Construction, Except Highway Employment, 2010[1]	% Change for Heavy and Civil Engineering Construction, 2000-2010
Boilermakers	470[2]	--[4]	0%[3]
Carpenters	19,990	300	0%
Electricians	14,260	18	20%
Structural Iron Workers	1,630	100	0%
Reinforcing Iron Workers	590	16	7%
Insulation Workers	1,640	31	3%
Construction Laborers	16,560	2,100	5%
Concrete Masons	3,050	200	0%
Millwrights	1,870	27	-7%
Operating Engineers	8,190	1,000	11%
Painters	9,700	16	7%
Pipefitters and Steamfitters	7,730	100	0%
Sheetmetal Workers	4,380	--[4]	24%[3]
Teamsters	46,290	400	0%
All Occupations	**2,402,150**	**10,428**	**4%**

Notes:

1. Occupational breakdowns and total employment statistics for utility system construction were not available.
2. The projected total employment for boilermakers is for 2010 instead of 2012.
3. The % Change for employment of boilermakers and sheet metal workers is for total employment, not any specific industry.
4. Sheetmetal Workers and Boilermakers were not listed as an occupation employed by the Heavy and Civil Engineering Construction Industry.
5. Employment statistics are based on information from Alabama's ACLMIS System (Reference 14) and information on the Alabama Department of Industrial Relations website (Reference 15).

Table 6-7. Illinois Construction Craft Employment Predictions

Craft Description	Total Employment (All Industries), 2012[1]	% Change for Total Employment, 2002-2012
Boilermakers	1,766	3.5%
Carpenters	64,067	13.3%
Electricians	37,725	21.9%
Structural Iron Workers	3,614	15.9%
Reinforcing Iron Workers	669	14.4%
Insulation Workers	1,282	13.6%
Construction Laborers	43,352	16.2%
Concrete Masons	9,470	24.8%
Millwrights	2,369	1.2%
Operating Engineers	10,423	9.9%
Painters	16,183	10.1%
Pipefitters and Steamfitters	24,870	18.1%
Sheetmetal Workers	7,925	18.6%
Teamsters	88,674	15.2%
All Occupations	**6,928,400**	**9.8%[2]**

Notes:

1. Statistics on employment broken down by industry were not available for the state of Illinois.
2. The average growth for construction occupations between 2002 and 2012 is projected to be 14.6%.
3. Employment statistics are based on information from Illinois' Labor Market Information website (Reference 16).

Table 6-8. Mississippi Construction Craft Employment Predictions

Craft Description	Projected Employment (All Industries), 2010	General Building Contractor Employment, 2010[1]	% Change for Total Occupation, 2002-2010
Boilermakers	690	142	11.3%
Carpenters	11,910	3,794	16.2%
Electricians	5,710	68	26.3%
Structural Iron Workers	950	412	28.4%
Reinforcing Iron Workers	590	18	25.5%
Insulation Workers	930	11	18.3%
Construction Laborers	9,320	3,050	25.3%
Concrete Masons	1,160	217	9.4%
Millwrights	1,740	508	10.8%
Operating Engineers	3,340	250	11.4%
Painters	4,410	219	13.4%
Pipefitters and Steamfitters	5,420	128	18.1%
Sheetmetal Workers	2,860	55	30.6%
Teamsters	27,260	58	17.1%
All Occupations	**1,516,777**	**17,316**	**16.3%**

Notes:

1. Statistics on employment in utility system construction or power/communication system construction are not available. These industries are a subset of general building contractors.
2. Employment statistics are based on information from Mississippi's labor market information system (Reference 17) and the Mississippi Department of Employment Security website (Reference 18).

Table 6-9. Virginia Construction Craft Employment Predictions

Craft Description	Projected Employment (All Industries), 2012	Heavy and Civil Engineering Construction Employment, 2002[2]	% Change for Total Employment, 2002-2012
Boilermakers	364	--[3]	3%
Carpenters	29,396	1,350	14%
Electricians	22,306	--	23%
Structural Iron Workers	2,790	57	16%
Reinforcing Iron Workers	506	137	15%
Insulation Workers[1]	--	--[3]	--
Construction Laborers	23,764	7,661	14%
Concrete Masons	6,327	801	24%
Millwrights	1,428	--[3]	0%
Operating Engineers	8,921	3,049	11%
Painters	10,169	165	15%
Pipefitters/Steamfitters	15,956	--[3]	19%
Sheetmetal Workers	7,866	--[3]	17%
Teamsters	41,128	1,651	19%
All Occupations	4,097,672	34,930	17%

Notes:

1. Statistics for Insulation Workers as an occupation were not available.
2. Occupational breakdowns for the utility system construction industry were not available. However, the total employment for this industry in 2004 is 13,789 or about 42% of heavy and civil engineering construction.
3. Occupational employment projections for boilermakers, electricians, millwrights, pipefitters/steamfitters, and sheet metal workers in employed in Heavy and Civil Engineering Construction were not available.
4. Employment statistics are based on information from Virginia's electronic labor market access system (Reference 19).

6.1.3 Construction Craft Union Membership

The EPC firms contacted for information for this report indicated that they prefer to use union craft labor for new nuclear power plant construction. However, the EPC firms indicated that they would move to a merit shop (using both union and non-union labor) if sufficient union labor is not available. This section compares union membership in the states where new nuclear power plants will likely be built to determine the likely availability of union labor in these states.

According to the Bureau of Labor Statistics, 12.5% of all wage and salary workers across the United States were union members in 2004. The construction industry had higher union membership rates with union members making up 14.7% of construction industry workers. However, certain craft trades have higher union membership rates, such as boilermakers.

The AFL-CIO Building and Construction Trades Department was contacted to determine the membership numbers for various craft unions in the four states evaluated in this report. Table 6-10 describes the union membership information for these states with the number of journeymen followed by the number of apprentices in each field if any. The last row on the table describes the total union membership of the state along with the union membership rate (percentage) for the state according to the U.S. Bureau of Labor Statistics.

Table 6-10. Construction Craft Union Membership by State

Craft	In-state Requirement	Alabama	Illinois	Mississippi	Virginia
Boilermakers	96	1,140 / 240	1,173 / 215	200 / 25	654 / 117
Carpenters	256	1,104 / 165	39,060 / 2,034	728 / 125	3,285 / 561
Electricians	464	2,744	11,643 / 2,191	1,638	3,158 / 484
Iron Workers	464	859 / 114	5,092 / 724	449 / 5	2,166 / 244
Laborers	256	975	6,509	330	2,170
Operating Engineers	208	662 / 29	9,415 / 380	500 / 4	2,806 / 104
Sheetmetal Workers	80	325 / 50	3,172 / 282	307 / 48	1,119 / 159
Pipefitters and Steamfitters	432	2,125 / 194	11,087 / 1,703	1,579 / 214	2,374 / 317
Insulation Workers	48	325 / 50	3,172 / 282	280 / 35	980 / 103
Total Union Membership		**181,000 (9.7%)**	**908,000 (16.8%)**	**53,000 (4.8%)**	**176,000 (5.3%)**

The union membership information above indicates that, like the information for state employment, the states with smaller populations (Mississippi and Alabama) also have lower numbers of workers employed in construction craft occupations.

Comparing the union membership numbers to the in-state peak labor requirements for two units (1.6 times the single unit peak), Illinois has the largest margin between labor availability and the requirements for nuclear unit construction while Mississippi has the smallest margin. In fact, the requirement for iron workers is above the total union membership for this craft in Mississippi. Mississippi also had one of the lowest union membership rates in 2004 at 4.8 % of wage and salary workers.

These numbers indicate that, while adequate numbers of unionized workers may be present in Illinois and Virginia, it may be very challenging or impossible to recruit all of the necessary craft labor from in-state unions in Mississippi and Alabama. To maintain a union shop it would be necessary, in these cases, to recruit travelers from out of state unions or to move to a merit shop where both union and non-union craft are employed on the project. The implications of using union and non-union labor are discussed in Section 6.7 below.

6.1.4 Construction Craft Training Programs

Apprenticeships are one of the primary means of training new skilled craft workers for the construction industry. The primary source of apprenticeship data is the Department of Labor's Office of Apprenticeship Training, Employer and Labor Services (OATELS). The OATELS' Registered Apprenticeship Information System (RAIS) is used to provide information on the number of apprenticeships by industry, occupation, and program type. However, only 31 states participate in RAIS so this database does not represent the entire registered apprenticeship system, nor does it provide a nationally representative sample.

According to OATELS, in 2003 there were 488,927 apprentices enrolled in registered programs with 171,031 of these apprentices in the construction industry (Reference 8). Table 6-11 lists some of the top 25 apprenticeship occupations ranked by total as of September 30, 2003 (Reference 9).

Since training programs last several years, the number of annual completed apprenticeships is significantly lower than the values in Table 6-11. According to the AFL-CIO B&CTD, Building and Construction Trades Union sponsored programs generally take three to five years to complete.

The numbers provided by OATELS generally show a strong apprenticeship program in the construction industry with apprenticeship enrollment equal to about 5 to 10% of the total industry employment. However, due to the limited participation by states in the RAIS, it is not possible to make any judgments on the adequacy of these programs to support construction industry needs.

Table 6-11. RAIS Apprenticeship Occupations Enrollment and Programs

Rank	Occupation	Total Active Enrolled	Number of Active Programs	Average Enrollment per Program
1	Electrician	46,519	3,496	13.3
2	Carpenter	26,019	658	39.5
4	Pipe Fitter (construction)	15,127	957	15.8
6	Sheetmetal Worker	9,492	746	12.7
8	Structural Steel Worker	6,322	171	37
9	Construction Craft Laborer	5,475	67	81.7
12	Painter (construction)	4,144	353	11.7
14	Operating Engineer	3,914	154	25.4
16	Boilermaker	3,787	57	66.4
20	Millwright	2,963	574	5.2

6.1.5 Construction Craft Labor Assessment

National Labor Availability Conclusions

The U.S. Department of Labor projects total U.S. employment of 165,000,000 in 2012 with 7,700,000 employed in all construction industries and 420,000 employed providing utility services construction. A portion of the utility service construction subset is involved building new power plants. We have estimated a peak labor requirement of 8,000 construction worker to construct eight GEN III+ nuclear units with a total labor requirement of 12,000. Hiring the highly skilled and highly valued construction worker needed to build nuclear units is expected to be a challenge. Only a portion of construction workers normally used to build fossil power plants would have the skills necessary to build nuclear power plants.

The total number of construction workers in the U.S. is expected to grow by 15% from 6,700,000 in 2002 to 7,700,000 in 2012. When the combined effects of industry growth, worker attrition, and retirements are considered, new construction workers equivalent to 36% of the current construction labor workforce must be recruited, trained, and retained during this ten year period to increase the total number of construction workers and to replace workers that find new jobs or retire. This challenge is the same challenge faced by other industries and organizations as the current generation of workers retire. Recruiting highly skilled and highly valued construction workers needed to build and maintain nuclear power plants is currently a challenge and will likely remain a challenge.

According to a Construction Users Round Table in 2001, "the most critical issue facing the construction industry today is the growing gap between supply of and demand for skilled construction laborers" (Reference 11). Recruiting skilled and highly educated workers for positions in the construction industry is a national challenge that has been identified by many industry groups and will affect the ability to recruit skilled craft for nuclear power plant construction.

Due to the large scale and specialized nature of certain aspects of nuclear power plant construction, attracting and retaining the top craft labor will be very important and a key challenge for the firms involved in these construction projects. However, the relatively long duration of nuclear power plant construction projects and their high profile should make attracting the top craft somewhat less challenging. The conclusions for national labor availability are addressed on a craft by craft basis later in this section.

State Labor Availability Conclusions

Based on the state employment projections for the various craft categories, the availability of construction craft labor will be highly dependent on the location of the power plant construction. It is expected that all GEN III+ unit sites will require some travelers to support construction.

The total size of the workforce and the employment numbers in each craft category for the four states considered show that construction in Mississippi, being the smallest state in population by a large margin, will likely present the most challenges in terms of craft labor availability. Illinois is the largest state by population, also by a large margin, and generally has the largest number of craft employed.

However, local craft labor availability will be heavily influenced by other construction projects in the area. If large highway or building projects are present at the same time as the nuclear power plant construction, competition with other projects may result in labor shortages. Unfortunately, the likelihood of these other large construction projects being present during nuclear plant construction (especially during the time of peak labor requirements) is impossible to determine this far in advance.

Due to the relatively long duration of nuclear plant construction, it is likely that there will be at least some competition with other large construction projects at some point during plant construction. However, the long duration of nuclear plant construction is also a benefit to the builders because this long duration will attract higher quality craft that desire long term projects and the prestige of working on high profile projects.

Certain craft categories that are used extensively by operating power plants in the area may also present labor availability challenges during the spring and fall seasons when existing power plants generally schedule outages to repair and replace components during periods of low electrical demand. Boilermakers and pipefitters are two of the crafts that are used extensively for power plant outages and their availability may be affected by these power plant outages.

In addition, some of the craft laborers involved in the initial power plant builds will be interested in traveling to other nuclear power plant sites to apply the specialized skills developed during the first plant builds if proper incentives are used. This effect may make labor availability less challenging as more plants are built and also increase the productivity of the craft labor force if a significant portion of the craft has experience in similar nuclear plant construction projects. EPC contractors and other industry representatives should develop programs to encourage experienced craft labor to participate in other nuclear power plant construction projects to realize productivity gains as more plants are constructed. The conclusions for state labor availability are addressed on a craft by craft basis later in this section.

Boilermakers

Boilermakers are the smallest of the construction craft trades required for nuclear plant construction. In 2012, there will be about 25,000 boilermakers in the U.S. with 1,322 working in utility system construction. Approximately 300 boilermakers would be needed nationally to support a maximum of eight simultaneous plants under construction, or 1.7% of the total employment and 22.7% of the boilermakers in the utility system construction industry.

Boilermakers employed in new nuclear plant construction would generally be involved in assembling and constructing various heat exchangers, heaters, and tanks. Some of the boilermakers would be certified to weld safety-related equipment including pressure vessels.

Recruiting boilermakers may be challenging in some of the states. For example, Virginia projects that there will be 364 boilermakers employed in the state in 2012. The peak number of boilermakers required for two units under simultaneous construction in a given state is 96 or 26% of the total employment for Virginia. Alabama and Mississippi have higher total numbers of boilermakers, but recruiting in these states may also present significant challenges. Illinois has the highest projected boilermaker employment for 2012 with 1,766, so construction of two nuclear units would only require 5.4% of the available boilermakers.

Many of the required boilermakers would need to be certified to weld safety-related equipment, including ASME code pressure vessels. Boilermaker labor availability may also become tight in the spring and fall months when operating power plants require boilermakers for plant outage repair work. The EPC firms contacted during the course of this study identified qualified welders (including those employed as boilermakers) as one of the most challenging craft trades to recruit in sufficient numbers to support power plant construction.

Carpenters

Carpenters make up one of the largest of the construction craft trades. Nationally there will be about 1.3 million carpenters in the U.S. with 9,343 employed in utility system construction in 2012. Approximately 800 carpenters would be required to support the peak labor demands of 8 plants under construction simultaneously, or 0.1% of the total employment or 8.6% of carpenters in the utility system construction industry.

About 256 carpenters will be required to support two units under simultaneous construction in a given state. The state employment projections range from a high of 64,067 in Illinois to a low of 11,910 in Mississippi. Therefore, recruiting carpenters in any of the identified states is not likely to present major challenges. Carpenters are readily available in large numbers and the only special skills required would be experience with building concrete formwork. While the numbers of carpenters employed in heavy construction is much lower, carpenters from other industries can likely be trained for work on nuclear power plant construction.

Electricians

Electricians are a large craft category with over 800,000 workers projected to be employed nationally in 2012; however, the number of electricians working in heavy construction or utility construction nationally is less than 1% of the total employment. Approximately 1450 electricians would be required to support the peak labor demands of 8 plants under construction simultaneously, or 0.3% of the total employment or 26% of electricians in the utility system construction industry.

EPC firms identified electricians as one of the most challenging craft trades to recruit in sufficient numbers for power plant construction projects. Based on state employment numbers, Mississippi will be the most challenging state in terms of electricians with only 5,710 electricians projected for 2010 in all industries. About 464 electricians will be required to support two units under simultaneous construction in a given state.

In addition, while there may be sufficient numbers of electricians overall, finding electricians experienced in power plant construction and power plant electrical equipment may be significantly more challenging. Recruiting electricians experienced in working with the instrumentation and controls equipment used in power plants may be especially difficult.

Iron Workers

Iron workers can be broken down into two craft labor trades: structural iron workers and reinforcing iron workers. Both of these trades are amongst the smaller trades with 90,443 and 33,445 workers projected to be employed nationally for structural and reinforcing iron workers, respectively. This report estimates that a total of 1,450 iron workers will be necessary to support the peak labor demands of eight plants under construction simultaneously, or 1.2% of the total employment or 5.7% of iron workers in the utility system construction industry.

The state employment for iron workers may present significant challenges, especially in Mississippi and Alabama, where the combined employment for these two trades are 1,540 and 2,220, respectively. With the peak in-state requirement of 464 iron workers, recruiting in these states may be challenging, especially if there is any significant competition from other heavy construction projects, which would also likely require iron workers.

Insulation Workers

Insulation workers are a relatively small craft category with 61,938 workers projected to be employed in 2012. This report estimates that 150 insulation workers will be necessary to support the peak labor demands of eight plants under construction simultaneously, or 0.3% of the total employment or 26% of insulation workers in the utility system construction industry.

About 48 insulation workers will be required to support two units under simultaneous construction in a given state. While the numbers of insulation workers in heavy construction are small, it appears that the states will be able to provide enough insulation workers to support nuclear power plant construction; however, employment figures for insulation workers as an occupation were not available for the state of Virginia. The total employment numbers for this field range from a low of 930 workers in Mississippi to a high of 1,640 workers in Alabama. This yields a state nuclear plant construction requirement of 5.2% to 2.9% of the total state workforces, respectively.

Construction Laborers

Construction laborers are one of the largest craft trades with 1,070,466 workers projected to be employed nationally in 2012 with 90,200 working on utility system construction. This report estimates that 800 construction laborers will be necessary to support the peak labor demands of eight plants under construction simultaneously, or 0.1% of the total laborer employment or 0.9% of construction laborers employed in the utility system construction industry.

About 256 construction laborers will be required to support two units under simultaneous construction in a given state. The supply of construction laborers is sufficiently large in each of the four states examined in this report to make it unlikely that there will be a labor shortage from this trade group. Mississippi lists the smallest number of laborers at 9,320 which would require 2.7% of the workforce to support construction of a two unit plant in Mississippi. Construction laborers are available to support nuclear construction projects.

Concrete Masons

The U.S. Bureau of Labor Statistics projects that there will be 229,000 concrete masons employed nationally in 2012 with 3,800 working on utility system construction. This report estimates that 150 concrete masons will be required to support the peak labor demands of 8 plants under construction simultaneously, or 0.1% of the total employment or 3.9% of the concrete masons in the utility system construction industry.

About 48 concrete masons will be required to support two units under simultaneous construction in a given state. The projected state employment for concrete masons ranges from a high of 9,470 in Illinois to a low of 1,160 in Mississippi. This yields a state nuclear plant construction requirement of 0.5% and 4.1% of the total employment for these states, respectively. These are sufficient numbers to ensure that labor availability of concrete masons will not likely become significant challenge.

Millwrights

Millwrights are one of the smaller craft trades with 73,000 workers projected to be employed nationally in 2012 with 1,200 working on utility system construction. This report estimates that 250 millwrights will be necessary to support the peak labor demands of eight plants under construction simultaneously, or 0.3% of the total employment or 20.1% of millwrights in the utility system construction industry.

About 80 millwrights will be required to support two units under simultaneous construction in a given state. The total state employment projections for millwrights range from a high of 2,369 in Illinois to a low of 1,428 in Virginia. This yields a state nuclear plant construction requirement of 3.4% to 5.6% of the total employment of millwrights for these states, respectively. This is a sufficient number to support new plant construction; however, shortages could become a problem during the spring and summer months when operating power plants are in outages.

Operating Engineers

Operating engineers are projected to be the largest craft trades in utility system construction with 40,800 workers in this industry in 2012 and a total of 389,000 employed in all industries nationally. This report estimates that 650 operating engineers will be necessary to support the peak labor demands of eight plants under construction simultaneously, or 0.2% of the total employment or 1.6% of operating engineers in the utility system construction industry.

About 208 operating engineers will be required to support two units under simultaneous construction in a given state. The total employment projections for operating engineers range from a high of 10,423 in Illinois to a low of 3,340 in Mississippi. This yields a state nuclear plant construction requirement of 2.0% to 6.2% the total employment of operating engineers in these states, respectively. With the large numbers of operating engineers in the utility system construction industry, labor availability of this craft should not be problematic.

Painters

The U.S. Bureau of Labor Statistics projects that there will be 499,570 painters employed nationwide in 2012. However, the number of painters employed in the utility system construction industry is only 0.2% of the total or 814 workers. This report estimates that 150 painters will be required to support the peak labor demands of eight plants under construction simultaneously, or 0.03% of the total employment or 18% of painters in the utility system construction industry.

About 48 painters will be required to support two units under simultaneous construction in a given state. The projected state employment for painters ranges from a high of 16,183 in Illinois to a low of 4,410 in Mississippi. This yields a nuclear plant construction requirement of 0.3% and 1.1% of the total employment for these states, respectively. These are sufficient numbers to ensure that labor availability of painters will not likely become significant challenge.

Pipefitters and Steamfitters

The U.S. Bureau of Labor Statistics projects that there will be 584,000 pipefitters and steamfitters employed nationally in 2012 with 13,100 or 2.2% of these workers in utility system construction. This report estimates that 1,350 pipefitters and steamfitters will be required to support the peak labor demands of eight plants under construction simultaneously, or 0.2% of the total employment or 10.3% of pipefitters and steamfitters in the utility system construction industry.

About 432 pipefitters and steamfitters will be required to support two units under simultaneous construction in a given state. The projected state employment for pipefitters and steamfitters ranges from a high of 24,870 in Illinois to a low of 5,420 in Mississippi. This yields a nuclear plant construction requirement of 1.7% and 8.0% of the total employment for these states, respectively.

One of the challenges in recruiting pipefitters and steamfitters will be hiring workers with welding qualifications needed for work on high energy steam piping and safety-related piping. This may be especially challenging in states with lower total numbers of pipefitters and steamfitters, such as Mississippi. In these states, extensive use of travelers may be required to meet the demand for this craft.

Sheetmetal Workers

The U.S. Bureau of Labor Statistics projects that there will be 246,000 sheet metal workers employed nationwide in 2012. However, very few sheet metal workers are employed in the utility system construction industry; only 0.1% of the total employment for this craft or 357 workers. This report estimates that 250 sheet metal workers will be required to support the peak labor demands of eight plants under construction simultaneously, or 0.01% of the total employment or 70% of sheet metal workers in the utility system construction industry.

About 80 sheet metal workers will be required to support two units under simultaneous construction in a given state. The projected state employment for sheet metal workers ranges from a high of 7,925 in Illinois to a low of 2,860 in Mississippi. This yields a nuclear plant construction requirement of 1.0% and 2.8% of the total sheet metal worker employment for these states, respectively. These are relatively low percentages of the total workforce compared to

other crafts and should be sufficient numbers to ensure that labor availability of sheet metal workers will not likely become significant challenge.

Recruiting sheet metal workers experienced in power plant construction projects may be difficult given the low number of workers employed in the utility system construction industry; however, sheet metal workers from other industries can likely be brought into the construction project without major training requirements. Therefore, sheet metal workers labor availability is not considered to be significantly challenging.

Teamsters

Teamsters or heavy truck drivers are the largest of the craft trades considered in this report with a projected 2,103,667 teamsters employed nationally in 2012. However, the number of teamsters employed in the utility system construction industry is only 0.5% of the total or 11,468 workers. This report estimates that 250 drivers will be required to support the peak labor demands of eight plants under construction simultaneously, or 0.01% of the total employment or 2.2% of teamsters in the utility system construction industry.

About 80 teamsters will be required to support two units under simultaneous construction in a given state. The projected state employment for teamsters ranges from a high of 88,674 in Illinois to a low of 27,260 in Mississippi. This yields a nuclear plant construction requirement of 0.1% and 0.3% of the total employment for these states, respectively. These are the lowest percentages of any craft category and should be more than sufficient to ensure that the labor availability of teamsters will not likely become significant challenge.

6.2 NSSS Vendor & Subcontractor Staff Issues

6.2.1 NSSS Vendors & Subcontractors

NSSS vendors and subcontractors are expected to have approximately 140 personnel on-site during the peak construction period to support the equipment installation and construction management activities. Due to the relatively small number of NSSS vendor and subcontractor personnel required and the anticipated availability of qualified personnel from the NSSS and subcontractor organizations, the availability of NSSS vendor and subcontractor personnel was not analyzed in detail and the availability of NSSS vendor and subcontractor personnel is not considered a labor staffing issue.

6.2.2 Start-up Personnel

According to one EPC firm, approximately 30 start-up personnel would be required for each unit. Additional start-up personnel would be provided by the NSSS vendor and other equipment suppliers. For this assessment a total requirement of 60 start-up personnel was used. This total requirement does not include any of the craft labor that would be required to support start-up and testing activities.

Since there have not been any new nuclear power plants commissioned in the United States since Watts Bar in 1996 and the Brown's Ferry Unit 1 commissioning activities that are just about to occur, there are only a small number of experienced nuclear plant start-up personnel available. Also, the GEN III+ units will have significant differences from older designs and will have

unique start-up issues related to the new NRC nuclear power plant licensing structure. For these reasons it is likely that start-up testing personnel, who are familiar with the plant design and functional requirements, will be drawn from the EPC and NSSS organizations, much like the first plants in the last generation of nuclear plants. Due to the relatively small number of nuclear plant start-up personnel required and the anticipated availability of qualified personnel from the EPC and NSSS organizations, the availability of start-up personnel was not analyzed in detail and the availability of startup personnel is not considered a labor staffing issue.

6.3 EPC Contractor Staffing Issues

The EPC firms will supply their own construction engineers and schedulers to supervise the progress of the construction on-site. According to one EPC firm surveyed for this report, about 100 EPC personnel would be expected to be working on site during nuclear power plant construction. These personnel would likely be drawn from existing EPC firm employees and would not create any labor availability issues. The size and high profile nature of nuclear plant construction should ensure that adequate personnel are available for these projects given the current build out plans.

6.4 Owner's Operating & Maintenance Staff Issues

6.4.1 Health Physicists

Health physics personnel will not be required for the construction period of new nuclear power plants; however, these workers will need to be available immediately before fuel arrives on-site and throughout the testing of plant systems once fuel has been loaded. Health physicists will also have to be retained by the plant owners to participate in the commercial operation of the plant. According to the Health Physics Society's report, the average nuclear power plant employs 28 full time and eight temporary health physicists (Reference 20).

According a 2001 study conducted by the Health Physics Society, the demand for health physics personnel in all industries will outstrip supply by about 160% for the period between 2001 and 2006 (Reference 20). A more recent study conducted in 2004 concluded that, "even if it is assumed that an equal percentage of individuals will retire each year over a forty year working lifetime, the number of existing health physics program graduates, i.e., 122 per year does not meet or exceed the demand based on a retirement rate of 167 per year" (Reference 21).
As with other occupations, a significant number of experienced health physicists are approaching retirement age and young workers to fill these positions are difficult to recruit. According to a General Accounting Office report issued in 2001, it was anticipated that 35% of the fiscal year 1998 workforce will be eligible for regular retirement by 2006 (Reference 29).

This shortage of health physicists affects not only existing nuclear power plants, but also government agencies (e.g., DOE, DOD, NRC, etc.), national labs, universities, and medical employers of radiation protection personnel. Therefore, new nuclear power plants coming online will have to compete for health physicists with existing plants and other industries that use radioisotopes.

Conclusions

Due to the retirement of current workers and the lack of new recruits, hiring an adequate number of trained health physicists may be very challenging for new nuclear power plants. The Health Physics Society has been working with DOE and other federal agencies to secure funding for health physics academic programs and to promote health physics as an occupation to increase the number of people entering the field to meet this high demand. These efforts should be continued and closely monitored to ensure that adequately trained health physics personnel are available to support new nuclear plant construction.

6.4.2 Nuclear Plant Operators

The NRC licenses reactor operators (ROs) and senior reactor operators (SROs) to operate commercial nuclear power plants in the United States. According to information provided by the NRC, there are currently 1,760 licensed reactor operators and 2,592 senior reactor operators in the U.S. With 103 operating commercial nuclear power plants, this averages to 17 ROs and 25 SROs for a total of 42 operators per unit (Reference 23).

Over the past three years the NRC has licensed about 300 to 400 operators per year. Note that this includes a mix of ROs and SROs, with some of the SRO applicants being upgrades from ROs, which do not increase the total number of licensed operators. This licensing rate corresponds to about 8% of the current total per year.

It should be noted that each facility licensee runs its own operator training program, often with a combination of in-house and contractor training staff. Therefore, some larger facilities have a reactor operator training class every year with as many as a dozen or more applicants a year. Smaller facilities with lower turnover may only hold a class every couple of years with smaller classes. The information provided by the NRC noted that many facilities have begun stepping up their operator training programs to prepare for a wave of retirements that are on the horizon as their operating staff ages. The NRC solicits information regarding the licensing needs for the next four years from each facility annually and adjusts examiner staff accordingly.

From the assumptions made in Section 3 regarding the commercial operation dates for new reactors, 2015 is the year that the greatest number of new plants will come online with three. Assuming these plants will require the average number of operators, this represents 126 operators, or about a 3% increase over the current number of licensed reactor operators. Eight new GEN III+ units will require a total of 336 new ROs and SROs.

Conclusions

Due to the flexible nature of the operator training program and the NRC's close involvement with new plant licensing, it appears that the facility and NRC licensing programs will be able to adapt to train and license these additional new operators for the next generation nuclear power plants. Reactor operators for the next generation of nuclear power plants will require special training off-site and on the site simulator; however, these requirements are normal for reactor operators and should not impact labor availability. Simulator availability early enough to support operator training is discussed in Section 4.5.

New operator applicants will likely come from current nuclear power plant O&M employees and retired U.S. Navy nuclear plant operators who are interested in the prestige and benefits of becoming a licensed reactor operator.

6.4.3 Operations & Maintenance Technicians

After each new nuclear power plant is constructed, the owner will need to develop a workforce of operations & maintenance technicians to perform upkeep over the life of the plant. This workforce will likely come partly from craft that were involved in the construction, new hires, and possibly transfers from other nuclear units to provide O&M expertise.

According to a 2003 NEI workforce survey, the nuclear industry will need to recruit 1,167 new technicians a year between 2003 and 2008 to meet the needs of technician retirement, attrition, and promotion to other jobs within the industry (Reference 28). This number does not include the O&M technicians that will be required to support new nuclear power plant construction.

This survey also lists the training requirements for the various types of O&M technicians. The category with the longest training requirements is instrumentation and controls technicians. These technicians may need two years of training and on-the-job experience to attain the status of journeyman and another five years of experience to complete an apprenticeship (seven years total). An electrical technician's training period is slightly shorter at one and one-half years for journeyman and three to four years to complete and apprenticeship (four and one-half to five and one-half years total). Mechanical technicians generally require a shorter training with one year for journeymen and another three years to complete an apprenticeship program (four years total).

Conclusions

The NEI workforce study notes that many trade schools may not teach students about certain nuclear specific requirements or technologies. This may increase the training times and increase the need to transfer knowledge from experienced nuclear craft workers. Unfortunately, the workforce of experienced craft labor is very lean and many of these technicians are approaching retirement age. Therefore, recruiting these skilled technicians may be especially challenging at a time when the need for experienced technicians is high.

6.5 QUALITY CONTROL & NDE INSPECTION STAFF ISSUES

This report estimates that a peak of 40 quality control inspectors and NDE technicians will be required at each power plant site during construction, or 200 personnel for the assumed initial build out of 8 plants (See Section 3.3). The majority of these inspectors will be trained non-destructive evaluation (NDE) technicians who will be responsible for inspecting craft work after completion to ensure that this work meets all specifications and quality requirements.

American Society for Nondestructive Testing (ASNT)

The American Society for Nondestructive Testing was contacted to determine the labor availability of NDE technicians to support new nuclear power plant construction. ASNT is the world's largest technical society for nondestructive testing (NDT) professionals and has an individual membership of nearly 10,000 people with approximately half of these individuals in the U.S.

We note that ASNT membership information does not include NDE personnel that have been independently certified by their employers. According to ASNT, this population is substantial, but there is no reliable way to determine its size since employers do not report the number of certified employees to ASNT. Therefore, the number of ASNT certificate holders shows only a

portion of the total population of certified NDE technicians and is a conservative metric for gauging NDE technician labor availability.

The ASNT indicated that there are over 10,000 individuals working worldwide that hold ASNT certificates. Additionally, individuals are usually certified in more than one NDT method. As a result, there are more than 23,000 ASNT certificates that are valid at the time of this report. On average, ASNT administers 3,000 exams a year to more than 2,000 individuals. Additional information on the number of ASNT certificate holders for the four states examined in this report and U.S. are listed in Table 6-12 (Reference 25).

Table 6-12. American Society for Nondestructive Testing Certificate Holders

State	Total	ACCP Level II[1]	ASNT NDT Level III[2]	ACCP Professional Level III[3]
Alabama	104	48	42	14
Illinois	110	38	55	18
Mississippi	27	13	9	5
Virginia	106	26	61	19
Total U.S.	4605	1674	2250	681

Notes:

1. ASNT Central Certification Program (ACCP) Level II is given in five NDT methods (MT, PT, RT, UT, and VT) and is the lowest of the certification levels offered by ASNT.
2. ASNT Level III is available in 11 NDT methods and is the most widely accepted NDT certification.
3. ACCP Professional Level III expands Level III certification to cover practical and procedure preparation (PP) examinations in five NDT methods (MT, PT, RT, UT, and VT). This is the highest level of NDT certification offered by ASNT.

Electric Power Research Institute (EPRI)

NDE workforce availability has been the subject of several reports produced by the EPRI. While these reports were not reviewed in detail for this report, the publicly available abstracts provided several key conclusions of these studies regarding NDE personnel requirements for the nuclear industry and labor trends among NDE personnel.

According to a November 2004 report (Reference 27), inspections at commercial nuclear power plants currently require an estimated 820 NDE personnel each year. In addition, the required NDE workforce for the nuclear industry is projected to increase by about 10% to 901 by 2013 (Reference 27). However, steady attrition of the current NDE workforce is expected to reduce the current workforce of about 769 in the nuclear industry to 303 by 2013. This will result in a supply versus demand gap of about 600 NDE personnel by 2013.

An earlier December 2000 report (Reference 26) estimated that 240 individuals available to enter the NDE industry are enrolled each year in entry-level training conducted by academic and industrial organizations. While these numbers would be more than sufficient to replace the number of personnel leaving the industry, the report concluded that further study is required to determine what fraction of those enrolled are likely to go on to attain the qualifications required by the nuclear industry.

EPRI and ASNT have been working closely to address the projected NDE labor availability gap. These continuing efforts are aimed at encouraging new entrants into the workforce and reducing attrition rates. Over the past four years these efforts have achieved some success. For example, between the publishing of the December 2000 and November 2004 EPRI reports on NDE labor availability, EPRI raised their projected retention rate for the current workforce from 24% of the workforce remaining in 2013 to 37% of the workforce remaining in 2013. However, continuing efforts will be required to address the significant labor availability gap identified by EPRI.

Conclusions

The requirement for 200 NDE and quality control inspectors adds about 22% to the total projected nuclear NDE workforce requirement for 2013 (901 personnel) and is over 66% of the projected remaining NDE workforce for the nuclear industry in 2013 (303 personnel after retirement and attrition without additional NDE personnel joining the nuclear industry). The number of NDE and quality control inspectors required for new nuclear power plant construction is very significant compared to the 2013 projections for the available workforce and will likely result in significant challenges if the situation is not substantially improved by 2013. Like many of the other craft labor categories, staffing problems could become more acute during the spring and fall, when many existing power plants are conducting maintenance requiring NDE during outages scheduled to take advantage of low electricity prices during these seasons.

In conclusion, DOE should work with and support EPRI and ASNT to 1) ensure that the requirements for new nuclear power plant construction are considered in NDE workforce requirement estimates and 2) to continue to work to address the future shortfall in the availability of qualified NDE personnel. Overall the availability of NDE personnel will likely be a significant challenge in new nuclear power plant construction.

NRC Inspectors

The NRC is expected to have a Resident Inspector for each GEN III+ unit. The Resident Inspector would be supported by other NRC inspectors for monitoring equipment manufacturing activities, module fabrication activities, and construction activities. While NRC inspection staffing plans are still being developed, we expect a NRC inspection staff of 10 to 20 inspectors based on the number of NRC inspectors working on the TVA’s Brown’s Ferry Unit 1 restart and the number of NRC inspectors used during nuclear plant construction during the 1980’s and 1990’s. This Report’s Section 8 contains more detailed information on NRC staffing.

6.6 Nuclear Power Plant Project Labor Productivity Issues

Labor productivity is a critical component of the successful nuclear power plant project. The NRC investigated this issue as part of their assessment of quality assurance associated with nuclear plants built during the 1970s and early 1980s (Reference 30, NUREG-1055 Improving Quality and the Assurance of Quality in the Design and Construction of Nuclear Power Plants).

NUREG-1055 reported on the lessons learned from the construction of St. Lucie 2. This unit was constructed in approximately half the time of the industry average and at a cost of less than half the cost of comparable plants that were subjected to the same regulatory process. The start of St. Lucie 2 construction was delayed nine months. A very complete design and project planning and scheduling were done during the delay period and were found to significantly

contribute to the short construction period (Reference 30, page 3-21). It was noted that a very complete design is a necessary prerequisite for doing the detailed project planning necessary to have a successful project.

NUREG-1055 references a 1979 study by the University of Texas that evaluated ten single and multiple unit plants and reported on lost time for six reasons. Productivity can be cut by more than half in large construction projects that are poorly planned and managed. Table 6-13 provides information on the major reasons associated with reduced productivity at large construction projects.

Table 6-13. Lost Time per Week of Large Construction Projects

Reason for Lost Time	Average Time Losses in Hours Per Craftsman Per Week
Material Availability	6.27
Redoing Work	5.70
Overcrowded Work Areas	5.00
Total Availability	3.80
Crew Interfacing	3.29
Inspection Delays	2.66
Total Lost Time	26.72

The St. Lucie 2 management team identified the following reason the unit was completed essentially on schedule, within cost, and without any major quality-related problems:

- Management commitment
- A realistic and firm schedule
- Clear decision-making authority
- Flexible project control tools
- Team work
- Maintaining engineering ahead of construction
- Early startup involvement
- Organizational flexibility
- Ongoing critique of the project and
- Close coordination with the NRC

NUREG-1055 stated in Appendix A.4 “The single most important factor in assuring quality in nuclear plant construction is prior nuclear experience (i.e. licensee experience in having constructed previous nuclear power plants, personnel who have learned how to construct them,

experienced architects-engineers, experienced constructors, and experienced NRC inspectors)." This was true in the 1970s and we believe this will also be true in the 2010s. Having the right craft, supervision, and management available to build nuclear units is as important as having the right number of personnel.

Based on lessons learned from NUREG-1055 and our experience, NSSS vendors and EPC contractors should complete the plant design (including the routing of small bore piping, tubing, and conduit) prior to starting construction, prepare a detailed construction schedule and work breakdown structure, and plan for sufficient staffing for rapid response teams at the point of work for problem resolution. To the maximum extent possible, personnel with experience designing and building nuclear units should be used to design and construct the first GEN III+ units. These steps will be needed to sustain the high labor productivity rates necessary for achieving the desired construction schedules and construction costs.

Prior experience, detailed in NUREG-1055, shows that QA and QC problems caused major difficulties in earlier nuclear plant construction projects. NUREG-1055 found that during the 1970s the orientation of the NRC inspection program was focused "heavily on programmatic matter and paperwork at the expense of examining actual work in progress and program implementation." This approach did not identify or address the quality assurance, quality control, and quality-related problems that affected nuclear construction projects during the 1970s. The NRC inspection program approach was changed during the 1980s and further changes are expected to better inspect GEN III+ unit construction. The NRC, utilities, NSSS vendors, component suppliers, and EPC contractors should ensure that appropriate Quality Assurance (QA) and Quality Control (QC) programs are in place for the design, fabrication, and construction of GEN III+ units. These actions will help ensure the construction of new GEN III+ units is accomplished on schedule and on budget.

Considering that the future construction of nuclear unit in the U.S. depends on the successful completion of the first few units, it is essential that the first GEN III+ unit construction projects to meet the project schedule and budget requirements. With millions of craft labor manhours required to build a GEN III+ unit, one factor critical to achieving this success is maintaining craft labor productivity rates at acceptable levels. This assessment has assumed that the labor productivity problems of the past will not be repeated during the construction of GEN III+ units. Labor manhour requirements for this assessment have been based on a productive work force. A discussion of labor productivity issues follows.

Discussion

Initial ingredients essential for good craft labor productivity are:

- The right personnel (craft).
- The right tools and equipment.
- The right material.

These three functions must come together simultaneously at the point of work for positive productivity results. In addition, personnel and processes must be in place to support the work once it begins.

The success enjoyed by completing the engineering, procurement and planning necessary to bring these three functions together at the proper time can be thwarted quickly. Experience with nuclear power plant construction in the 1970's and 1980's taught us that a number of conditions contributed to poor productivity at the point of work. The following conditions were among the most significant:

- Interference with existing embedded reinforcing steel.
- Interference with previously installed commodities.

Interference with existing embedded reinforcing steel

Conventional practice was to prefabricate large bore pipe supports with attached predrilled base plates. This practice dictated the location of anchor bolts to be drilled in the concrete. With little or no flexibility for anchor bolt location, the installing craft would drill anchor holes and hit existing reinforcing steel. This would set off a mired series of activities resulting in an enormous amount of nonproductive hours being charged to that particular large bore pipe support. A typical scenario would involve the craft at the point of work, contacting the foreman, who would contact a field engineer, who would start the resolution process. On average, it would take between two to five days to get an engineered resolution back to the point of work. This meant that usually the craft would be assigned to another project that would require support such as scaffolding to be built, material staged, welding leads and air hose run to the point of work. This situation created strain on the foreman who is tasked with planning the work and keep the craft working. Often times the resolution to the initial problem would be delivered to the point of work and craft unfamiliar with this particular large bore pipe support would be assigned, resulting in a loss of continuity. The stacking of inefficiencies associated with the initial circumstances becomes overwhelming and soon spirals out of control. It becomes easier to understand that if this scenario were applied to the large volume of work going on at a nuclear power plant construction site, productivity at the point of work would be impacted negatively.

Interference with previously installed commodities

Small bore piping was typically designed and fabricated on site during the construction of nuclear power plants in the 1970's and 1980's. The routing portion of the design was accomplished by taking field measurements at the point of installation. A considerable amount of time would pass before the material was ready for installation. During this time other field run commodities would be installed creating interferences with the small bore piping that had recently been designed. Often these interferences would be resolved by redesigning the small bore piping. The new routing would generally require a new dynamic analysis which would frequently result in different manufactured pipe support specialty items such as snubbers. The long lead time for these new specialty items would further delay completion and negatively impact productivity.

Wait time at "Hold" points

During the mechanical installation phase of the project several hold points were included in the design. These hold points would require either quality control or field engineering personnel interface. The personnel required to witness hold points were the same personnel required to resolve and implement solutions to the aforementioned interference problems. Upon reaching a hold point during the installation of particular commodity the craft would call for a witness. This request would be put on a priority board and in some cases the craft would wait for two days

before getting a hold point witnessed. Additional trained personnel were not added since the immediate interference issues were viewed as an aberration.

Conclusions

Mitigating measures available for new generating facilities to improve construction labor productivity are:

- Complete the plant design prior to starting construction.
- Provide sufficient staffing for rapid response teams at the point of work for problem resolution.

The majority of the interferences encountered previously were a direct result of an incomplete design. The facility designs in the 1970's and 1980's were completed during the construction period. Completing the design prior to beginning construction including those commodities that are field run such as small bore pipe with the 3D modeling technology available today can eliminate a large majority of the interference problems encountered in the past.

Even using the 3D modeling capabilities today there will still be a need to resolve installation problems during construction. It is paramount that a rapid response team concept be employed and staffed adequately to keep the craft working.

6.7 Nuclear Power Plant Union versus Non-Union Labor Issues

EPC firms and NSSS vendors have indicated that union labor is preferred for the required construction labor force to build new nuclear units. However, these companies have also reserved the option to move to a merit shop with a combination of union and nonunion labor should certain crafts have shortages of qualified union labor. The skilled non-union workforce is expected to be an important resource in states with small labor pools and limited numbers of union labor.

The AFL-CIO's Building and Construction Trades Department (B&CTD) has indicated that they would do everything in their power to supply the necessary union labor. Should qualified union labor not be available, however, the project manager has the option to contract to nonunion contractors in project labor agreements.

As in the past when nuclear power plant projects were ongoing across the country, it would be advantageous for the EPC contractors and the AFL-CIO's B&CTD to set up a national labor agreement to provide a universal labor basis for all nuclear power projects. This would provide continuity from worksite to worksite and provide EPC contractors with some cost and availability certainty for planning of these construction projects. Therefore, we recommend that EPC contractors and AFL-CIO's B&CTD representatives should negotiate a national labor agreement to cover new nuclear power plant construction.

7 Construction Equipment

This Section provides the results and analysis of interviews with suppliers of the specialty construction equipment that would be used for constructing GEN III+ units. The equipment of interest include: Very Heavy Lift (VHL) cranes, pipe bending machines, automatic welding machines, and automated rebar assembly machines. Discussion of each of these technologies is provided. Table 7-1 follows to provide a construction equipment resource analysis summary. Resource requirements are compared with available resources and any shortfalls are noted.

Table 7-1. Construction Equipment Resource Analysis

Item	Requirement	Capabilities	Shortfall	Lead Time (Years)
1	Seven Very Heavy Lift Cranes	More than 6 VHL Cranes are available for lease. VHL cranes can be manufactured as needed in 9 to 18 months.	No	0.75 - 1.5
2	Pipe Bending Machines	Cold bending machines are readily available off-the-shelf. The survey identified at least 11 heat induction machines for off-site bending of larger bore pipe.	No	
3	Automatic Welding Machines	There are many suppliers that provide these technologies with equipment that is generally available off-the-shelf or with reasonably short lead times.	No	
4	Seven Automatic Rebar Assembly Machines	This technology was developed by the Japanese civil contractors to support nuclear plant construction. Each machine is custom built. This technology should be considered and if economical, purchased or leased from Japanese civil contractors that developed the technology.	No	1

7.1 VERY HEAVY LIFT CRANES

Very Heavy Lift (VHL) cranes are needed to support "open top" construction of GEN III+ units. Open top construction accelerates construction schedules but requires heavy equipment and large prefabricated modules to be put in place using a VHL crane. The use of VHL cranes has generally increased as equipment sizes and the use of prefabricated modules has grown in popularity. VHL cranes are used to construct bridges, stadiums, and large buildings.

Since the last generation of nuclear plants built in the U.S., the load capacity and reach of cranes has been increased, leading to cranes known as Very Heavy Lift (VHL) Cranes. These cranes are capable of lifting and moving modules weighing more than 1,000 tons and reaching several hundred feet. The advent of these cranes permits very heavy loads to be placed. This has extended the feasibility of open-top construction and allows large-scale use of techniques such as modularization.

GEN III+ plant construction requires a VHL crane with the capacity to lift and place up to 1,200 ton modules and components at a 130-foot radius and a height of 200-feet. GEN III+ plants require a main boom capacity of up to 1,500 tons and an auxiliary boom capacity of up to 250 tons. In some instances, plant construction requires the VHL cranes to pick up and travel with large modules.

Although there are many U.S. manufacturers of crane equipment, there are relatively few manufacturers of VHL cranes with capacities of more than 1,000 tons. A summary of very heavy lift crane suppliers and their reported fleet size is provided in Table 7-2.

Table 7-2. VHL Cranes Suppliers and Models

Vendor	Crane Models and Lift Capability	Comments
Lampson	Models LTL-900 through LTL-2600 capabilities between 900 and 2,600 tons	Fleet size of 16
Manitowoc	Models 18000 and 21000 capabilities of 825 and 1,100 tons respectively	
Liebherr	Models LR 1800 through LR 11200 capabilities between 826 and 1,100 tons, respectively	Fleet size of two
Demag	Models CC8800 and CC12600 capabilities of 1,375 and 1,750 tons, respectively	

Lampson International, Kennewick, Washington

Lampson International manufactures, sells and leases VHL cranes. Lampson has a patented lattice boom design and counter weight design called Transi-Lift that is constructed on Manitowoc crawlers. In addition to their VHL cranes, Lampson leases other heavy construction equipment (e.g., hydraulic platform trailers, and crawler trailers).

VHL cranes can be disassembled into transportable sections and reassembled on project sites.

There are 16 cranes in Lampson's fleet in the 1,000 ton capacity range. The Lampson staff estimated that the lead time to manufacture a new crane would be approximately nine months.

Lampson is currently in discussions with Bechtel and Westinghouse to potentially support the construction of AP1000 units in China. In addition, a Lampson VHL crane had recent service in construction of the Shika NN2 ABWR Power Plant in Japan. The Lampson VHL crane was used to place a 913 ton reactor vessel at a reach of 184 ft.

Liebherr Cranes Incorporated, Newport News, Virginia

Liebherr is a German company that manufactures construction machinery including VHL crawler cranes. In the U.S., the large-sized crawler cranes are distributed by Liebherr Cranes Inc. located in Newport News, Virginia. Liebherr did not provide an exact estimate of their fleet size of VHL cranes. They stated informally that there were "one or two" LR 11200 models, and did not provide an estimate of the LR 1800 fleet. The U.S. representative estimated that the lead time to manufacture a new VHL crane would be 18 months.

Manitowoc Crane Group, Manitowoc, Wisconsin

Manitowoc is a major crane and VHL crane manufacturer that sells VHL cranes. Manitowoc does not lease their VHL cranes. Manitowoc provides the crawlers to Lampson International that Lampson uses as a base for constructing their VHL cranes. Manitowoc VHL cranes have been sold to major rigging contractors, like Burkhalter Rigging.

Conclusions

It is anticipated that the availability of VHL cranes is sufficient to support new nuclear plant construction in the United States. Lampson International reported that their fleet has 16 cranes that are of sufficient capacity to support the GEN III+ unit construction.

The lead time for construction of new VHL cranes is estimated to be between 9 and 18 months based on vendor responses. It is estimated that the schedule for new plant construction can reasonably support these lead times if additional VHL cranes were required.

7.2 PIPE BENDING MACHINES

In the past, domestic nuclear power plants were constructed extensively using welded pipe fittings, such as elbows, in piping systems throughout the plant. Significant construction materials and labor are required at the construction site to support this type of piping system construction. This method contributes to the long construction period typical of large-scale field constructed projects. Pipe bending is an alternative construction technique that can speed up piping system construction and reduce the number of workers required at the construction site.

Pipe bending technology was available 20 to 30 years ago when the existing domestic nuclear power plants were constructed. However, at that time, welded-in fittings were a more cost-effective construction method. At present, pipe bending can be performed at a lower cost than welding. Furthermore, the development of portable bending machines allows on-site bending of some smaller sizes of pipe.

Pipe bending is a proven and commonly used technology. Applications of pipe bending on large construction projects include piping systems at fossil plants, process piping at refineries, replacement pipe in U.S. nuclear power plants, and various piping systems in nuclear power plants in South America and Asia. Several types of pipe bending techniques are currently available. The most common are cold bending and induction bending.

Cold bending techniques do not apply heat to the pipe and are applicable to smaller bore pipe (approximately less than 8 inches). Cold bend equipment is readily available from manufacturers and brokers with reasonably short lead times. The cold bends of piping approximately 2 inches or less can be performed by machines located on the construction site.

Heat induction bending is a technique that uses localized heating in the location of the desired bend. This bending technique is used for larger bore pipe (up to 66 inch outside diameter (OD) and wall thickness up to 4 inches). The pipe is pushed through a set of rollers, and then through an induction ring, which is ring shaped to match the contour of the pipe. The induction ring uses electricity to heat the pipe from room temperature up to 800°F to 1,200°F. After passing through the induction ring, the pipe is bent and then quenched using water or oil. Heat induction machines are not mobile. They require a dedicated permanent facility to provide the required large amounts of electrical energy and heavy foundations.

Table 7-3 provides information on North American manufacturing facilities which have induction bending machines for bending large diameter pipe.

Table 7-3. North American Shops with Induction Pipe-Bending Machines

Shop	Location	Maximum Pipe Bend Size	Comments
Bend-tec	Duluth, MN	66 inch OD	Owns two induction bending machines.
Tulsa Tube Bending	Tulsa, OK	28 inch OD	Owns one Cojafex induction bending machine.
Shaw Group	Baton Rouge, LA	66 inch OD	Seven domestic and two overseas. Owns Cojafex of Rotterdam, Netherlands, a manufacturer of induction bending machines.
Houston Pipe Benders	Houston, TX	36 inch OD	http://www.hpbenders.com
BendCo	Pasadena, TX	36 inch OD	http://www.bendco.com
Triple DDD Bending	Calgary, Alberta Canada	36 inch OD	

Tulsa Tube Bending, Tulsa, Oklahoma

Tulsa Tube Bending claims to be the largest American pipe bending company. They have both cold bending and heat induction bending capabilities. Tulsa owns a Cojafex heat induction pipe bending machine, with capabilities to bend up to 28 inch OD pipe. The 28 inch induction machine was the first Cojefex induction pipe bending machine installed in North America. This machine was installed in 1970. They also have a machine capable of making cold tube bends up to 16 inch OD. Tulsa Tube Bending has 76,000 square feet of work space in five buildings with a covered storage are of about five acres. The staff estimated that it would take three to six months to construct a new induction bending machine.

BendTec, Duluth, Minnesota
BendTec specializes in the production of pipe bends for pipelines and electric power plants. They have both cold and heat induction bending technology. BendTec owns four cold bending machines with capabilities up to 12 inch OD. BendTec owns two induction bending machines. One has a capability up to 66 inch OD pipe. This machine was constructed in 1973. The second has a capability to bend 27 inch OD pipe. This machine was constructed in 1975.

The technical staff stressed the importance of annealing of pressurized piping after the pipe bend is created. In the technical staff's experience, cold bends of approximately 2 inch OD pipe or less can be performed by mobile equipment located at a construction site. The used equipment market is a good place to find many of these kinds of machines.

BendTec has approximately 165 employees. The manufacturing facilities total about 160,000 square feet of shop floor space with an outside storage area of about five acres. The staff estimated that it would take six months to construct a new induction bending machine.

Shaw Group / Cojafex, Baton Rouge, Louisiana
Shaw Group is a company with core businesses of Engineer Procure and Construct (EPC) contracting, pipe fabrication, and maintenance contracting. They are a fairly large company of 17,000 employees. Their pipe fabrication facilities are capable of producing an aggregate of 35,000 pipe spools (10,000 tons of pipe spools) per month between seven U.S. facilities and four international facilities.

In 1997, Shaw Group acquired Dutch company Cojafex, a manufacturer of induction pipe bending machines. Shaw reports that Cojefex has a 70% global market share. Cojafex offers 12 standard models for bending pipe between 2 inches to 66 inches OD. All the machines are capable of bending a pipe bend radius equal to 1.5 times the pipes diameter, a bend comparable to a manufactured pipe elbow. Several models offer automated spool bending. These spool bending machines can make up to ten bends in one pipe.

Shaw Group owns eight induction bending machines located at different facilities. The machine count at each facility is:

- Three at the Naptech facility, Clearfield, Utah;
- Two at the Sunland facility, Walker, Louisiana;
- One at the BF Shaw facility, Laurens, South Carolina;
- One at a facility in China; and
- One at a facility in Bahrain.

The staff estimated that it typically takes 12 months to construct a new induction bending machine.

The staff also spoke about recent experience that Shaw Group has had supporting restart work at Browns Ferry 1, where they were N-Stamp providers of pipe material and the required pipe bends.
Shaw can provide a skid mounted induction machine that is somewhat portable (it still requires significant on-site installation of the machine). This portable machine can bend pipe from 3 inch to 16 inch in diameter and up to 2 inches in thickness. The staff reported that a specific job would require about 20,000 spools of pipe for the site installation of the machine to be justified over the off-site shop approach.

Conclusions

The domestic pipe bending capacity is extensive. The cold bending machines, which are suitable for smaller bore pipe sizes, are readily available in fabrication shops nationwide. These machines can be used either in off-site fabrication shops or located at nuclear plant construction sites.

There are several U.S. facilities that also use heat induction bending machines, which are suitable for larger bore pipe. Our survey revealed at least 11 heat induction machines in different facilities. These large machines are used at off-site pipe fabrication facilities, rather than at on-site pipe fabrication facilities.

The suppliers reported estimated construction lead times for new induction machines between six 12 months. If additional large-diameter pipe bending capacity were required, this magnitude of lead time could be supported by the envisioned new plant deployment schedule.

7.3 AUTOMATIC WELDING MACHINES

Different types of automatic welding machines would be utilized for welding piping, large-bore piping, condenser tubes, condenser shells, liners, and tanks at nuclear plant construction sites and at prefabricated module fabrication facilities.

The automatic welding machines used for pipe are called orbital welders. This technology is widely available and used by most pipe spool fabrication facilities. Orbital welding uses the gas-tungsten-arc-welding (GTAW) process. One of the keys to the process is to automatically regulate the weld current with a control system which results in a more reliable method than manual welding.

Robotic welding is a more flexible technology that is used extensively in many U.S. industries (automotive and other assembly-line operations), but is not typically used by the construction industry. In traditional large-scale construction projects, the majority of the welding operations are performed in the field. Field welds are commonly difficult to access with robotic welding systems. In addition, many field weld procedures are repeated only a few times (i.e., small series production). Only processes that require minimal setup time could take advantage of robotic welding systems. It has been reported that robotic welding has been applied in the shop-based construction of nuclear power plant components in Japan.

Both orbital welding and robotic welding suppliers and applications are readily available. Below is feedback from a significant user of orbital welding technology, Shaw Group, and a summary of suppliers of both robotic and orbital welding suppliers.

Shaw Group, Baton Rouge, Louisiana

The Shaw Group has an extensive pipe fabrication business (the pipe bending capabilities are discussed in Section 7.2). In the pipe fabrication processes, they use automated welding technology.

Shaw Group used orbital welding technology extensively in their pipe spool production process. This technology is well-established and commercially available. In addition, Shaw Group is beginning to pioneer the use of more flexible robotic welding technology in the shop environment. The applications for this technology are a little more challenging to identify. One of the technical challenges is that it requires material with low dimensional tolerances for the robot to consistently deal with the material and make a quality weld. Their robotic welding technology is all shop-based (not for field welds or construction site applications) and is reasonably characterized as leading edge in the pipe fabrication industry.

Table 7-4 provides information on automatic welding equipment suppliers.

Table 7-4. Automatic Welding Equipment Suppliers

Vendor	Location	Comments
Magnatech	East Granby, CT	Manufacturers automatic tubesheet welding and automatic orbital welding systems used in a broad spectrum of industries including shipbuilding, power plant construction, and gas pipeline construction.
Arc Machines, Inc.	Pacoima, CA	Arc Machines, Inc. makes orbital welding machines for tube and pipe.
Koiki Aronson, Inc.	Arcade, NY	Manufactures Automatic Girth Welders, Vertical Plate Seam Welders, and Track Welders for tank and containment automatic welding.
Pro-Fusion Technologies	Rexburg, ID	Vendor of orbital welding systems. Products offered include power supplies, precision welding lathes, orbital welding equipment, welding system controls, reverse polarity surface cleaners, welding accessories, and consumable parts. These products are used in the Medical, Aerospace, Semiconductor, Automotive, Pharmaceutical, Construction, Instrumentation, Fitting and Valve Manufacturers, Food and Dairy, Military, Tube Mill, Bellows and many other industries.
Liburdi Dimetrics Corporation	Davidson, NC	Liburdi Dimetrics offers GMAW, GTAW, and hot wire orbital heads and power supplies. In addition, they offer MicroPAW 20 & 100 micro-plasma welding systems, automated welding lathes, seamers, rotary positioners, and turning rolls.

Table 7-5 provides information on robotic welding machine suppliers.

Table 7-5. Robotic Welding Machine Suppliers

Vendor	Location	Comments
ABB Flexible Automation		Has supplied over 16,800 welding robots worldwide. Non-U.S. based.
Motoman	West Carrollton, OH	Motoman, Inc. claims to be the second largest robotics company in the Americas, with more than 20,000 robots installed. Motoman is backed by Yaskawa Electric America, (a manufacturer of numerical control products, AC servo motors and drives, and inverters), and Yaskawa Electric Corporation of Japan (a manufacturer of industrial robots with over 105,000 installed worldwide). Motoman's headquarters covers 182,000 square feet in West Carrollton, Ohio. It also has a manufacturing facility in Troy, Ohio with 165,000 square feet.
FANUC	Rochester Hills, MI	In 1992, the company became a wholly owned subsidiary of FANUC Ltd of Oshino-mura, Japan. FANUC has over 114,000 robotic units installed worldwide and over 55,000 in North and South America. Their staff reports that over 300 robotic systems are designed, engineered and implemented each year, and over 150 robots are on their manufacturing floor at any given time.

Conclusions

Plate, tubesheet, and orbital pipe welding are well established technologies, with many suppliers providing commercial products. New nuclear plant construction would utilize these automatic welding technologies in addition to manual welding. It is not anticipated that the current population of suppliers would be stretched beyond their capacity to provide the required automatic welding equipment. In summary, automatic plate, tubesheet, and orbital pipe welding technologies are available to support new nuclear plant construction in the United States.

Limited robotic welding could be used in off-site fabrication shops. On-site robotic welding is not expected to play a role in the fabrication or construction of new nuclear power plants.

7.4 Automatic Rebar Assembly Machines

Automatic rebar assembly machines are currently used in the construction of the ABWR units in Japan. To MPR's knowledge, this technology was only utilized for ABWR construction, and discussions with U.S.-based constructors and NSSS vendors of competing GEN III+ designs did not reveal any requirement for using this construction technology.

The automatic rebar assembly system consists of a computer aided design (CAD) system and database software that automates rebar design and drawing generation and an automatic rebar assembly machine that is programmed by the software to construct flat mats and wall sections.

The automatic rebar assembly machine consists of two rebar placement vehicles, one that moves along the X-axis and one that moves along the Y axis. Each vehicle places rebar one at a time at intervals specified by the CAD files, after which the rebar is manually tied or welded. This system has been used for the construction of nuclear plants since 1990 and was used for constructing the Kashiwazaki-Kariwa Unit 7 ABWR.

The company who pioneered the technology is Shimizu Corporation, a Japanese civil constructor. They currently own two of these machines. We estimate a lead time of approximately one year to manufacture a new machine. In public domain documents (Prefabrication of Reinforcing Bars Using CAD/CAM, Reference 31), these machines have been are stated to double the productivity of rebar mat assembly for portions nuclear plant structure.

An automatic elevating scaffolding and horizontal rebar feeding machine was used for the construction of Kashiwazaki-Kariwa Unit 6 ABWR according to information provided in the International Atomic Energy Agency report (IAEA TECDOC-1390 "Construction and Commissioning Experience of Evolutionary Water Cooled Nuclear Power Plants, April 2004, Reference 32). This machine was used to place containment structure rebar. We recommend that U.S. EPC contractors consider using the automatic rebar assembly system and the automatic elevating scaffolding and horizontal rebar feeding machine. These systems have the potential to reduce labor costs and construction schedules.

Conclusions

To date this automatic rebar assembly technology has only been applied to the ABWR design offered by Toshiba. The other GEN III+ designs do not explicitly call for the use of this technology. Use of automatic rebar assembly machines may be economically justified based on a reduction in the size of the on-site construction labor force and the time required for assembling rebar mats and panels. The anticipated one-year lead time for manufacturing a new automatic rebar assembly machine can be reasonably supported by the anticipated schedules for new nuclear plant construction. We recommend EPC firms evaluate using these technologies.

8 NRC Support

This Section assesses whether the Nuclear Regulatory Commission (NRC) has the staff resources necessary to support the near-term deployment of GEN III+ reactors. Some codes and standards issues that will require NRC involvement to resolve are discussed separately in Section 9. The NRC is planning to increase their licensing and inspection staffs to support the near-term deployment of GEN III+ units. Exactly when these staff additions will be required is dependent on when Design Certification and COL applications are received and when procurement and construction activities commence.

The following observations are made based on a review of NRC documents available from the www.nrc.gov website and discussions with NRC personnel from the Office of Nuclear Reactor Regulation's Division of Inspection Program Management and Division of Regulatory Improvement Programs.

Current NRC Staff

The NRC has a staff of approximately 3,100 full time equivalents (FTEs) with about 1,100 FTEs working on nuclear reactor licensing and 1,000 working on nuclear reactor inspection (Reference 33, NUREG-1100 Volume 21 Performance Budget Fiscal Year 2006). The remainder of the NRC staff works on the following major programs: fuel facility licensing and inspection, nuclear materials users licensing and inspection, high-level waste repository, decommissioning and low-level waste, spent fuel storage and transportation licensing and inspection, and the Inspector General. By location, approximately 75% work at headquarters and 25% work in regional offices in Pennsylvania, Georgia, Illinois, and Texas, several other offices, and nuclear sites.

NRC Perspectives and Preparations for Inspections and COL Applications

The NRC expects a large ramp-up of staff levels in the future to support the licensing and inspection requirements associated with the near-term deployment of GEN III+ units. Licensing examiners and inspectors will be needed to supplement the existing NRC staff that monitors 103 operating nuclear units, activities associated with the restart of Brown's Ferry Unit 1, 35 test reactors, license modifications, license renewal applications, and power uprate applications. The NRC Fiscal Year (FY) 2006 budget request includes additional funds and staff to review two standard reactor design certification applications. The NRC reports that the FY 2006 and FY 2007 budgets each include an additional $20 million to hire and train new staff to meet current and anticipated needs. The NRC has not provided estimates for the number of additional licensing and inspection personnel required to support GEN III+ unit construction. When additional NRC personnel will be needed is also an open issue that is affected by when Design Certification and COL applications are received and when procurement and construction activities commence.

The NRC works within the federal budgeting system with fiscal years starting October 1st each year. Planning is in progress to determine the level of increased funding and staff authorizations required to support GEN III+ unit licensing and inspection activities when the first COL

application is expected in FY 2008 (late in calendar year 2007). It is noteworthy that inspection activities start at the beginning of the ESP process and continue through the COL process and unit construction. Details on the NRC's plans for supporting near-term deployment of GEN III+ units should be available during the second half of 2005 as part of the NRC's Reactor Status Update and Planning Report. This report was produced annually until now and will be issued quarterly beginning in July 2005.

While the number of inspectors required for each GEN III+ unit is not known at this time, the NRC staff is preparing a plan for inspecting new construction as part of their Construction Inspection Program. The NRC notes that SECY-01-0188 "Future Licensing and Inspection Readiness Assessment" dated October 21, 2001 (Reference 38) and NUREG-1055 "Improving Quality and the Assurance of Quality in the Design and Construction of Nuclear Power Plants" published in May 1984 (Reference 30) provide some of the input for establishing inspection requirements and NRC staffing. SECY-01-0188 provides estimated time frames for completing licensing activities and inspection staffing requirements, i.e., 19 full time equivalents for monitoring the reactivation of Brown's Ferry Unit 1. The NRC notes that they are incorporating lessons learned from previous NRC experience including the experience related to the importance of quality assurance. While past NRC inspections focused on programmatic matters and paperwork, the NRC notes future inspections will be focused on the work to ensure that the ITAAC have been successfully completed and the NRC has the information needed to support a 10 CFR 50.103(g) finding by the Commission.

The Brown's Ferry Unit 1 reactivation is being monitored by a NRC Resident Inspector supported by additional NRC inspectors. A NRC Resident Inspector is expected at each GEN III+ unit construction site along with an on-site multi-disciplinary team of NRC inspectors and additional NRC inspectors to monitor off-site organizational, design, manufacturing, and fabrication activities. The NRC is working to take advantage of the Brown's Ferry Unit 1 reactivation by rotating headquarters and regional personnel to the site to familiarize their inspectors with the inspection of construction activities.

The NRC is in the process of issuing NRC Inspection Manual Chapters (IMC) to define the inspection requirements associated with new nuclear units. The first, IMC-2501, addresses inspections associated with ESP applications. IMC-2501 was issued on May 29, 2003. IMC-2502 is in preparation and will address the COL application process and required NRC inspections. IMC-2503 is in preparation and will address Inspection, Test, Analysis, and Acceptance Criteria (ITAAC) associated with the construction and start-up of new nuclear units. IMC-2504 is in preparation and addresses the review of non-ITAAC programs associated with new plant construction. The NRC plans to issue IMC-2502 in July 2005. The NRC plans to issue IMC-2503 and IMC-2504 by the end of 2005.

The amount of NRC time and staff effort required for reviewing a COL application is dependent on the quality of the information provided, the complexity and completeness of the application, and the applicant's level of commitment to support the application. Specific requests are reported to be easier to review than non-specific requests. A COL application for a design certified GEN III+ unit at an existing nuclear plant site will require significantly less NRC time than a COL application for a non-design certified GEN III+ unit at a new site. Possible COL application variability and uncertainty regarding the number and timing of COL applications make it difficult for the NRC to plan for staff additions.

The NRC estimates that they would require three months to train mid-career hires to support licensing activities and twelve months to train mid-career hires to support inspection activities. The NRC estimates that they would require twelve months to train new college graduates to support licensing activities and twenty-four months to train new college graduates to support inspection activities. They require two years to train NRC Resident Inspectors. The NRC expects to hire permanent staff and contract workers to support licensing and inspection activities. The NRC expects the pool of nuclear licensing professionals and construction inspectors they would consider hiring to be in high demand because of the utility and NSSS vendor demand for these professionals and the expected high level of non-nuclear construction activity during the period when GEN III+ units would be built. The NRC plans to hire a mix of experienced staff and new college graduates.

One NRC Commissioner previously said “There is a crisis looming in government” because an entire generation of employees is going to retire or will be eligible to retire in the near future (Reference 35, GAO “Major Management Challenges and Performance Risks – Nuclear Regulatory Commission, page 20). In FY 2001, about 16% of NRC staff is eligible to retire and by the end of FY 2005 33% will be eligible. While all eligible NRC employees are not expected to retire when they become eligible, replacement of a generation of NRC employees, training new employees, and retaining the new employees will be a challenge that could impact NRC performance.

Budget Analysis

NUREG-1100 Volume 21 Performance Budget FY 2006 and NUREG-1100 Volume 20 Performance Budget FY 2005 (Reference 34) contain information on enacted and requested NRC budgets. The FY 2005 budget includes useful information on the costs and FTEs currently working on reactor license renewals and new reactor licensing. This same “by program” breakdown was not provided in the FY 2006 budget. Table 8-1 provides information about the total NRC budget and a breakdown of the Nuclear Reactor Safety portion of the NRC budget. “Full cost” budget numbers are provided with “full cost” dollars and FTE estimated for FY 2003.

Table 8-1. NRC Budget Information, FY 2003 to FY 2006

Item / Fiscal Year	2003	2004	2005	2006
Total NRC Budget Authority, $ million	585	626	670	702
Offsetting Licensee Fees, $ million	-526	-546	-541	-560
Total Net Appropriated, $ million	59	80	129	142
Total Full Time Equivalents (FTE)	2919	3058	3130	3154
Nuclear Reactor Safety, $ million	381	423	435	469
Nuclear Reactor Safety, FTE	1974	2086	2102	2174
Reactor Licensing, $ million	97	94	100	275
Reactor Licensing, FTE	573	559	569	1140
Reactor License Renewal, $ million	21	30	30	NA
Reactor License Renewal, FTE	111	133	135	NA
New Reactor Licensing, $ million	24	36	40	NA
New Reactor Licensing, FTE	103	139	147	NA
Other Programs, $ million	92	116	108	NA
Other Programs, FTE	287	350	347	NA
Reactor Inspection, $ million	147	147	157	194
Reactor Inspection, FTE	900	905	904	1034

In accordance with the amended Omnibus Budget Reconciliation Act of 1990, the NRC budgets are based on a 90% fee recovery from Licensees. The entire NRC budget is subject to fees except for the High-Level Waste program. Net appropriated funds are paid from the General Fund and the Nuclear Waste Fund in approximately equal shares.

Based on recent NRC budgets for license renewals and new reactor licensing, we estimate that an additional $30 million to $40 million per fiscal year and approximately 150 FTEs will be needed to support licensing activities associated with issuing COLs for GEN III+ units starting in FY 2008. The NRC is using Federal employees and contract personnel to license new reactors. Based on the NRC’s ramp-up for new reactor licensing work currently in progress, we estimate that half of the new personnel would be Federal employees and half would be contract personnel.

We reviewed NRC inspection staffing in the late 1980s and early 1990s and estimated NRC inspection requirements associated with monitoring new GEN III+ plant design, manufacturing, and construction activities. We estimate that starting in 2009 the NRC will have to ramp-up to an additional $30 million to $40 million per fiscal year and approximately 150 more FTEs to support inspection activities associated with new GEN III+ units with the ramp-up complete in 2012. This estimate is based on building an initial eight GEN III+ units and continuing to complete two units per year after the initial building period. We estimate that half of the new inspectors would be Federal employees and half would be contract personnel.

Additional NRC budget authorizations would be required after each unit goes into commercial operation to support ongoing inspection and licensing activities. Two Resident Inspectors would be expected at each new plant site with support from NRC inspectors from the Regional Offices. When GEN III+ units are added at an existing nuclear plant site it may be appropriate to add just one Resident Inspector or no additional Resident Inspectors to supplement the two Resident Inspectors already at the existing site.

Conclusions

The NRC will need to ramp-up their licensing and inspection staffs by several hundred personnel to support the licensing and inspection associated with the near-term deployment of eight new GEN III+ units and future GEN III+ units. While ramping up staff levels, assigning staff with prior nuclear plant construction experience to support GEN III+ activities, replacing of a generation of retiring NRC employees, training new employees, and retaining employees will be a challenge, the NRC Management believes they have an adequate plan to address this challenge.

9

Codes, Standards, and Regulations

There is one major concern associated with U.S. codes and standards and NRC regulations, namely, the NRC licensing and design reviews associated with digital plant control system designs that need to be made using evolving codes and standards. This Section documents an evaluation of codes, standards, and regulations issues associated with GEN III+ units. A detailed evaluation of applicable codes, standards, and regulations has not been made. Design, construction, future inspection, and NRC regulatory issues are considered.

Impact on GEN III+ Designs

In general, the GEN III+ units are designed to comply with U.S. Codes and Standards. The GE/Toshiba ABWR unit was designed to meet U.S. Codes and Standards and received NRC Design Certification on this basis. Components for the two GE ABWR units at Lungmen, Taiwan have been designed and manufactured based on U.S. Codes and Standards. The Westinghouse AP1000 unit has been designed to comply with U.S. Codes and Standards. The AP1000 has received Final Design Approval and is scheduled to receive Design Certification in December 2005. GE is designing the ESBWR to meet U.S. Codes and Standards.

There is one area that requires special attention. Fully integrated digital instrumentation and control (I&C) systems for the GEN III+ units represent a technology that changes and improves very rapidly. These control systems have a "generation time" that is much shorter than the plant lifetime and can even be shorter than the time for the design and construction of a new plant. Reference the National Research Council Study on Digital I&C (Reference 36). NSSS vendors and the NRC recognized this during the design certification process. The digital I&C system descriptions in designs submitted for NRC Design Certification are generally at a high level and the ITAAC include the NRC reviewing the design of these systems in more detail at the time of the final plant design and through the COL process. As a result, the final designs for digital plant control systems have not been completed for any U.S. GEN III+ units at this time. Useful experience has been gained on this process based on the experience associated with the Lungmen digital plant control system design and review. This experience shows there are a number of licensing and codes and standards issues that require attention to facilitate the digital control system design and the NRC review processes. These include:

1. NRC guidance endorses old IEEE standards that have been replaced by the IEEE after the NRC had reviewed and endorsed the old standard. For example USNRC Regulatory Guide 1.168 endorses IEEE 1012-1986 (reaffirmed 1992) that has been replaced by IEEE 1012-1998 and Regulatory Guide 1.169 endorses IEEE 1042-1987 that has been deleted and in part replaced by a combination of IEEE 730-2002, IEEE 828-1998, and IEEE 1028-1997. Designing new units to old standards present a number of practical problems. NRC review and endorsement of the new standards would facilitate the ease of design and manufacture of GEN III+ digital plant control systems.

2. NRC guidance in NUREG-0800 (Reference 37) concerning Software Safety Analysis (SSA) is quite general in nature and does not support the efficient design and the NRC review of plant control system software. Improved and detailed NRC guidance is needed to provide a standardized, efficient process that provides practical guidance to the designers and the regulators as to what constitutes an acceptable approach and acceptable documentation.

3. Agreement is needed regarding cyber security issues. Many industry groups have been investigating this issue and their reports could serve as a basis for an NRC and Industry consensus guidance document. This guidance is needed as cyber security issues affect the design and the NRC review of digital plant control systems.

4. Agreement is needed for an appropriate method for the NSSS vendor to revise and the NRC to review the digital plant control system design information contained in the NSSS vendor's approved Standard Safety Analysis Report or Design Certification. Lungmen is regulated by the ROC-AEC rather than the NRC, although there is a close working relationship between both organizations. Relatively minor differences between the design of the certified Digital Control and Instrumentation Systems (DCIS) and as-designed DCIS are being handled by ROC-AEC under a "10 CFR 50.59-like" process. This was because the methodology and schedule required to change the U.S. certification rule are not well-defined and were projected to take years, a duration incompatible with the scheduled completion of the actual plant.

We recommend that the NRC commit resources to investigate and modify their guidance concerning the design, review, and licensing of digital plant control systems for new GEN III+ plants. This guidance is needed to effectively design and review new digital plant control systems and put this process on a schedule compatible with the actual project schedule. DOE should consider cost-shared efforts with the IEEE and the nuclear industry to revise standards and provide input on revision of applicable Regulatory Guides by the NRC if other resources are not available.

Impact on GEN III+ Plant Construction

GEN III+ plants are expected to be able to be constructed based on current U.S. Codes and Standards. Current U.S. Codes and Standards provide acceptable methods for factory testing, receipt inspection, and on-site testing. The modular construction methods planned for GEN III+ units have the advantage that several types of pre-operational tests can be performed in a factory, instead of in the field. Factory module testing enables the early detection of problems in the factory setting where corrective actions can be taken quickly and in a cost effective manner. Factory module testing reduces construction schedule risks associated with testing plant systems that are built on-site. A potential downside of this practice is redundancy in testing. If systems that are partially contained in several modules are tested up to the boundaries of their modules, it is likely that at least some portions of the entire system would still need to be tested after all modules have been connected.

Impact on Future Inspection of GEN III+ Plants

While a comprehensive review of codes and standards has not been performed, future inspections of GEN III+ units do not appear to be a problem except for one issue. One GEN III+ design uses leave-in-place formwork. Unlike conventional reinforced concrete construction where formwork is removed after concrete placement and some curing time, the leave-in-place

steel plate formwork remains in place after the concrete is poured. The American Concrete Institute's ACI-349.3R (Reference 37) requires periodic evaluations by visual inspection of concrete external surfaces. This is not possible with leave-in-place formwork. Therefore, the ACI guidance needs to be reconsidered for leave-in-place formwork construction. Removable inspection panels or future partial removal of the steel plate may be required for proper concrete inspection. This is a long-term aging management and in-service inspection issue.

NRC Regulations

GEN III+ units are designed to comply with U.S. NRC regulations. GEN III+ units will receive Design Certification and a COL from the NRC prior to the plant construction. While a detailed evaluation of NRC regulations has not been made, changes to NRC regulation are not expected to impact the construction or inspections activities associated with GEN III+ plant construction. Based on a review of the NRC's Update of the Risk-Informed Regulation Implementation Plan (Reference SECY-05-0068), changes associated with risk-informed regulation are not expected to impact the construction or inspections activities associated with GEN III+ plant construction. NRC regulation 10 CFR 52.63 regarding the Finality of Standard Design Certifications states that "the Commission may not modify, rescind, or impose new requirements on the certification, …, unless the Commission determines in a rulemaking that a modification is necessary either to bring the certification or the referencing plants into compliance with the Commission's regulations applicable and in effect at the time the certification was issued, or to assure adequate protection of the public health and safety or the common defense and security." Except for possible changes to regulatory guidance mentioned previously, NRC regulatory changes are not expected to significantly impact the design, construction, or ITAAC inspection associated with GEN III+ plant construction and startup.

Conclusions

The currently completed portions of the two GEN III+ plant designs that have already received or are about to receive their Design Certifications do not need any changes to existing U.S. Codes and Standards for new plant design and construction. The third GEN III+ plant design is also being designed without the need for any changes to existing U.S. Codes and Standards for new plant design and construction.

Based on the preceding discussion, there is one major area where changes to licensing practice and U.S. Codes and Standards are recommended. The NRC should commit resources to investigate and modify their regulatory guidance concerning the design, review, and licensing of digital plant control systems. As a generalization, the NRC, Design Certificate holders, and the owner/operators need to make sure the process for addressing and resolving potential differences between the design certification and the final digital plant control system design is well understood and efficient and the process does not delay the construction and operation of GEN III+ units.

Based on the preceding discussion, there is one minor area where changes to licensing practice and U.S. Codes and Standards are recommended. The applicability of the American Concrete Institute's ACI-349.3R and licensing requirements associated with ACI-349.3R's in-service inspection requirements for reinforced concrete with leave-in-place steel plate formwork should be reviewed and modified where necessary.

10

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A

Glossary of Terms and Acronyms

ABWR	Advanced Boiling Water Reactor
ACI	American Concrete Institute
ACRS	Advisory Committee on Reactor Safeguards; *an independent committee to the NRC that reviews and provides advice on nuclear reactor safety*
A/E	Architect/Engineer
AFL-CIO	American Federation of Labor - Congress of Industrial Organizations
ALWR	Advanced Light Water Reactor
ANSI	American National Standards Institute
AOV	Air Operated Valves
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
AP1000	Advanced PWR 1000
ARC	Advanced Reactor Corporation; *a consortium of operating electric utilities to oversee the development of advanced plant designs*
ASL	Approved Supplier List; *the list of approved nuclear vendors for safety-related purchases and procurements*
BCTD	Building and Construction Trade Department
BEA	Bid Evaluate and Award
BLS	United States Bureau of Labor Statistics
BNFL	British Nuclear Fuels Limited
BOP	Balance of Plant; *all systems, structures, components, and facilities of the plant not a part of or included in the nuclear island*
BWR	Boiling Water Reactor
BWXT	BWX Technologies, part of J. Ray McDermott
CAD	Computer Aided Design
CED	Contract Effective Date
COL	Combined Construction and Operating License; *a phase in the new reactor licensing process as described in 10 CFR Part 52*
CP	Construction Permit

DC	Design Certification; *a phase in the new reactor licensing process as described in 10 CFR Part 52*
DCIS	Digital Control and Instrumentation Systems
DEPSS	Drywell Equipment and Piping Support Structure
DOE	U.S. Department of Energy
EMI	Electromagnetic Interference
EPC	Engineer-Procure-Construct
EPR	European Pressurized Water Reactor
EPRI	Electric Power Research Institute
ESBWR	Economic Simplified Boiling Water Reactor
ESP	Early Site Permit; *a phase in the new reactor licensing process as described in 10 CFR Part 52*
FDA	Final Design Approval
FMCRDs	Fine-Motion Control Rod Drives
FOAK	First-of-a-Kind
FOAKE	First-of-a-Kind Engineering
FTE	Full Time Equivalents
FY	Fiscal Year, October 1st to September 30th
GE	General Electric Nuclear Energy
GEN III+	Generation III +
GTAW	Gas-Tungsten-Arc-Welding
HVAC	Heating, Ventilation, and Air Conditioning
I&C	Instrumentation and Control
IEEE	Institute of Electrical and Engineers
IMC	Inspection Manual Chapter
ITAAC	Inspection, Tests, Analysis, and Acceptance Criteria
K-6/K-7	Kashiwazaki-Kariwa Units 6 & 7
LWA	Limited Work Authorization
LWR	Light Water Reactor
M&E	Mechanical and Electrical
MCR	Main Control Room
MCC	Motor Control Center
MOV	Motor Operated Valves
N	ASME Certification for the manufacture of Nuclear Components, N Stamp

NDE	Nondestructive Evaluation
NDT	Nondestructive Testing
NEI	Nuclear Energy Institute
NIAC	Nuclear Industry Assessment Committee
NOAK	Nth-of-a-Kind
NP2010	Nuclear Power 2010; a program established by DOE to deploy new nuclear power plants in the U.S. by 2010
NPT	ASME Certification for the manufacture of Nuclear Parts, NPT Stamp
NRC	U.S. Nuclear Regulatory Commission
NQA-1	ASME Standard, Nuclear Quality Assurance
NSSS	Nuclear Steam Supply System
NTS	National Technical Systems
NTDG	Near Term Deployment Group; *a group established by DOE to examine prospects for deployment of new nuclear plants in the U. S. in this decade and to identify obstacles to deployment and provide action for resolution*
NUPIC	Nuclear Procurement Issues Committee
NUREG	Nuclear Regulatory Commission Publication
OATEL	U.S. Department of Labor Office of Apprenticeship, Training, Employer and Labor Services
O&M	Operating and Maintenance
OL	Operating License
P&ID	Piping and Instrumentation Diagram
PCS	Passive Containment Cooling System
PHT	Primary Heat Transport
PLC	Programmable Logic Controller
PRA	Probabilistic Risk Assessments
PSAR	Preliminary Safety Analysis Report
PWR	Pressurized Water Reactor
QA	Quality Assurance
QC	Quality Control
RCCV	Reinforced Concrete Containment Vessel
RFC	Release for Construction
RFI	Radiofrequency Interference
RFF	Release for Fabrication
RIP	Reactor Internal Pump

RO	Reactor Operators
ROC-AEC	Republic of China - Atomic Energy Commission
RPV	Reactor Pressure Vessel
SSA	Software Safety Analysis
SSCs	Systems, Structures, and Components
SSLC	Safety System Logic Control
SEAB	Secretary of Energy Advisory Board
SECY	Office of the Secretary of the Commission (NRC)
SENSE	Schools Excelling Through National Skills Education
SRO	Senior Reactor Operators
STG	Steam Turbine Generator
TEPCO	Tokyo Electric Power Company
TMI-2	Three Mile Island – Unit 2
TVA	Tennessee Valley Authority
UPS	Uninterruptible Power Supply
URD	Utility Requirements Document; *a document prepared by the ALWR program team that outlines requirements for future Light Water Reactor designs*
VHL	Very Heavy Lift (crane)
Westinghouse	Westinghouse Electric Company LLC (part of British Nuclear Fuels Limited)
WBS	Work Breakdown Structure

B

ASME Certificate Holders

Table B-1. ASME N Stamp Certificate Holders (U.S. Only)

No.	Company, Location
1	Aerofin Corporation Lynchburg, VA
2	American Industrial Technologies, Inc. Wilmington, DE
3	Anderson Greenwood Crosby Wrentham, MA
4	Black & Veatch Construction, Inc. Overland Park, KS
5	BNL Industries, Inc. Vernon, CT
6	Chempump Warminster, PA
7	Control Components, Inc. (CCI) Rancho Santa Margarita, CA
8	Crane Nuclear, Inc. Bolingbrook, IL
9	Curtiss-Wright Electro-Mechanical Corporation Cheswick, PA
10	David Brown Union Pumps Company Battle Creek, MI
11	Dragon Valves, Inc. Norwalk, CA
12	Dresser Flow Control Alexandria, LA
13	Dresser, Inc. Avon, MA
14	Energy Steel & Supply, Co. Auburn Hills, MI
15	Enertech Brea, CA
16	Fisher Controls International, Inc. Marshalltown, IA
17	Flowserve Corporation Vernon, CA
18	Framatome ANP, Inc. Lynchburg, VA
19	GE Nuclear Energy San Jose, CA
20	Hayward Tyler, Inc. Colchester, VT
21	Henry Pratt Company Dixon, IL
22	IHI Southwest Technologies, Inc. San Antonio, TX

No.	Company, Location
23	Ionics, Incorporated Bridgeville, PA
24	IST Conax Nuclear, Inc. Cheektowaga, NY
25	ITT Engineered Valves Lancaster, PA
26	Johnston Pump Company Chattanooga, TN
27	Joseph Oat Corporation Camden, NJ
28	Major Tool & Machine, Inc. Indianapolis, IN
29	Precision Custom Components, LLC York, PA
30	Senior Operations, Inc. New Braunfels, TX
31	SGT, LTD. Charlotte, NC
32	Southern California Edison San Clemente, CA
33	SPX Valves & Controls McKean, PA
34	Stone & Webster, Inc. Stoughton, MA
35	Sulzer Pumps (US), Inc. Portland, OR
36	Swagelok Company Solon, OH
37	Target Rock E. Farmingdale, NY
38	Teledyne Brown Engineering Huntsville, AL
39	Tetra Tech FW, Inc. Richland, WA
40	The American Tank and Fabricating Company Cleveland, OH
41	Transnuclear, Inc. Hawthorne, NY
42	Trentec Cincinnati, OH
43	U.S. Tool & Die, Inc. Pittsburgh, PA
44	Valcor Engineering Corporation Springfield, NJ
45	Velan Valve Corporation Williston, VT
46	Washington Group International-Power Princeton, NJ
47	Weir Valves & Controls USA, Inc. Salem, MA
48	Westinghouse Electric Company, LLC Monroeville, PA
49	Westinghouse Electric Company, LLC Newington, NH

Table B-2. ASME NPT Stamp Certificate Holders (U. S. Only)

No.	Company, Location
1	Aerofin Corporation Lynchburg, VA
2	American Industrial Technologies, Inc. Wilmington, DE
3	Anderson Greenwood Crosby Wrentham, MA
4	Anvil International Inc. North Kingstown, RI
5	B. F. Shaw, Inc. Laurens, SC
6	Basic-PSA, Inc. Johnstown, PA
7	Bergen Power Pipe Supports Donora, PA
8	Black & Veatch Construction, Inc. Overland Park, KS
9	BNL Industries, Inc. Vernon, CT
10	Bristol Metals, L. P. Bristol, TN
11	Chempump Warminster, PA
12	Control Components, Inc. (CCI) Rancho Santa Margarita, CA
13	Crane Nuclear, Inc. Bolingbrook, IL
14	Curtiss-Wright Electro-Mechanical Corporation Cheswick, PA
15	David Brown Union Pumps Company Battle Creek, MI
16	Dieterich Standard, Inc. Boulder, CO
17	Dresser Flow Control Alexandria, LA
18	Dresser, Inc. Avon, MA
19	Energy Steel & Supply, Co. Auburn Hills, MI
20	Enertech Brea, CA
21	Fisher Controls International, Inc. Marshalltown, IA
22	Flowserve Corporation Raleigh, NC
23	Framatome ANP, Inc. Lynchburg, VA
24	GE Nuclear Energy Wilmington, NC
25	GE Reuter Stokes, Inc. Twinsburg, OH
26	Hayward Tyler, Inc. Colchester, VT

No.	Company, Location
27	Henry Pratt Company Dixon, IL
28	Ionics, Inc. Bridgeville, PA
29	IST Conax Nuclear, Inc. Cheektowaga, NY
30	ITT Engineered Valves Lancaster, PA
31	Johnston Pump Company Chattanooga, TN
32	Joseph Oat Corporation Camden, NJ
33	LISEGA, Inc. Newport, TN
34	Major Tool & Machine, Inc. Indianapolis, IN
35	NOVA Machine Products Middleburg Heights, OH
36	Oregon Iron Works, Inc. Clackamas, OR
37	Penn Iron Works, Inc. Sinking Spring, PA
38	Precision Custom Components, LLC York, PA
39	Ranor, Inc. Westminster, MA
40	Scott Process Systems, Inc. Hartville, OH
41	Senior Operations, Inc. New Braunfels, TX
42	SGT, LTD. Charlotte, NC
43	Southern California Edison San Clemente, CA
44	SPX Valves & Controls McKean, PA
45	Stone & Webster, Inc. Stoughton, MA
46	Sulzer Pumps (US), Inc. Portland, OR
47	Swagelok Company Solon, OH
48	Swepco Tube, LLC Clifton, NJ
49	Target Rock E. Farmingdale, NY
50	Taylor Forge Engineered Systems, Inc. Paola, KS
51	Teledyne Brown Engineering Huntsville, AL
52	The American Tank and Fabricating Company Cleveland, OH
53	Trentec Cincinnati, OH
54	U.S. Tool & Die, Inc. Pittsburgh, PA

No.	Company, Location
55	Valcor Engineering Corporation Springfield, NJ
56	Velan Inc. Montreal, QC, Canada
57	Velan Valve Corporation Williston, VT
58	Washington Group International-Power Princeton, NJ
59	Weir Valves & Controls USA, Inc. Salem, MA
60	Welding Services, Inc. Norcross, GA
61	Westinghouse Electric Company, LLC Monroeville, PA
62	Westinghouse Electric Company, LLC Newington, NH
63	Westinghouse Government Environmental Services Company, LLC Carlsbad, NM

C
Infrastructure Assessment Contact List

Infrastructure Assessment Contact List

Table C-1. Infrastructure Assessment Contact List

No.	Company	Nature of Work	Contact	Phone	Email or Website
1	AFL-CIO: Building Construction Trades	Union	Joe Maloney	202-756-4657	
2	AFL-CIO: Building Construction Trades	Union	George Jones	865-599-6245	gjbctd@aol.com
3	Allegheny-Ludlum	Steel Supplier	Rick Duncan	724-226-6213	
4	American Society of Nondestructive Testing	Trade Group	Betsy Blazar	800-222-2768	
5	Ansaldo Camozzi	Component Manufacturer	David Kitzmiller	214-727-3500	dkitzmiller@camozzi.com
6	Bechtel Power Corp.	EPC Contractor	Scott Close	301-228-6000	sclose@bechtel.com
7	Bechtel Power Corp.	EPC Contractor	Tom Tai	301-228-6000	
8	BendTec	Pipe Bending	Roger Pellet	218-722-0205	
9	BWXT, McDermott International, Inc	Module Fabricator	Randy Howard	434-522-6763	
10	Chicago Bridge and Iron	EPC Contractor	Carl Dube	302-325-8420	
11	Crane Nuclear	Component Manufacturer	Bruce Harry	630-226-4960	
12	Doosan Heavy Industries and Construction	EPC Contractor and Fabricator	H. K. Kang	724-722-5215	
13	Energy Steel	Steel Supplier (Pipe)	Bob Paiten	248-377-4990	
14	EPRI	Trade Group	Harry Stevens	704-547-6128	hstephen@epri.com
15	GE Water	Module Fabricator	Eric Hykamp	519-836-0500	
16	General Dynamics Electric Boat	Shipyard	Bill Michaud	860-433-8681	ebwem@aol.com
17	General Electric Nuclear Energy	NSSS Vendor	Larry Fenner	408-925-1000	
18	Health Physics Society	Trade Group	Kevin Nelson	904-953-8978	
19	Hitachi	NSSS Vendor and EPC Contractor	Hiroyuki Yagi	914-524-6633	hiroyuki.yagi@hal.hitachi.com
20	Japan Steel Works (America, Inc.)	Large Forging Supplier	Tom Noda	212-490-2623	t.noda@jswamerica.com
21	Joseph Oat Corporation	Module Fabricator	Eddy Marinock	856-541-2900	
22	Lampson International	VHL Cranes	Tom Sanders	509-586-0411	
23	Mitsubishi Heavy Industries	NSSS Vendor and EPC Contractor	Terumasa Onaka		terumasa_onaka@mhi.co.jp
24	MPR Associates, Inc.	Consulting Engineers	Robert D'Olier	703-519-0413	rdolier@mpr.com
25	Northrup Grumann Newport News	Shipyard	Bob Donovan	757-380-3115	
26	Nuclear Energy Institute	Trade Group	Carol Berrigan	202-739-8050	
27	Nuclear Energy Institute	Trade Group	Adrian Heymer	202-739-8094	
28	Shaw Group	EPC Contractor and Fabricator	David Morton	225-932-2512	

Table C-1. Infrastructure Assessment Contact List

No.	Company	Nature of Work	Contact	Phone	Email or Website
29	Shaw Group	EPC Contractor and Fabricator	Remi Bonnease	225-932-2500	
30	Special Metals	Steel Supplier (Mill)	Al Szafranski	304-526-5378	
31	Sulzer Pumps	Component Manufacturer	Don Spencer	503-226-5200	
32	Taylor Forge	Module Fabricator	Mike Kilkenny	913-294-5331	
33	Toshiba	NSSS Vendor and EPC Contractor	Hiroshi Sakamoto	212-596-0614	hiroshi6.sakamotot@toshiba.co.jp
34	Tulsa Tube Bending	Pipe Bending	Lloyd Ruley	1-888-88BENDS	
35	Turner International Pipe Systems	Module Fabricator	Lester Barback	225-922-5050	lbarback@turner-industries.com
36	US Dept. of Labor	Government Agency	Thomas Hooper	202-693-3865	hooper.thomas@dol.gov
37	Velan Valve Corporation	Component Manufacturer	Don Bowers	802-864-3350	dbowers@velanvalve.com
38	Westinghouse	NSSS Vendor	Jim Winters	412-374-5290	wintersjw@westinghouse.com