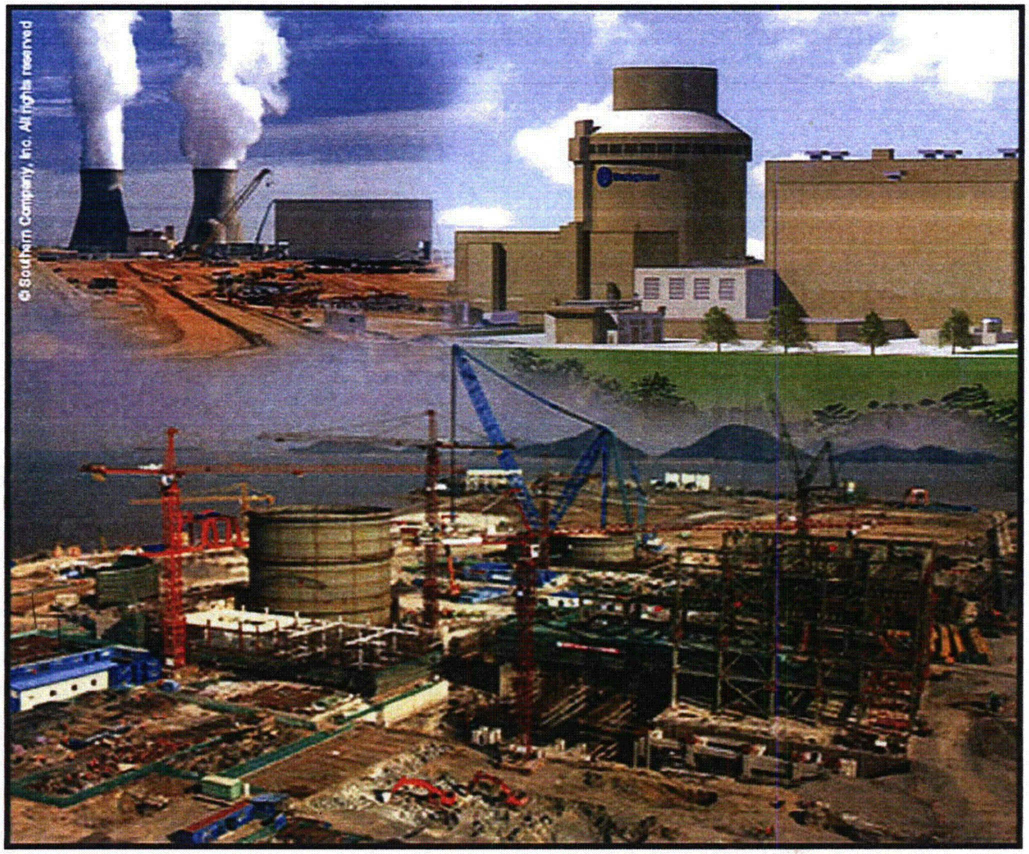
Westinghouse Non-Proprietary Class 3

Department of Energy
Nuclear Power 2010 Program

Report on AP1000® Design Certification And Design Finalization Project With Lessons Learned

Cooperative Agreement: DE-FC07-07ID14779



Westinghouse

Westinghouse Electric Company LLC

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TABLE OF CONTENTS

TABLE OF CONTENTS iii

LIST OF TABLES v

LIST OF FIGURES vii

LIST OF ACRONYMS ix

Executive Summary 1

1 Introduction 7

2 Program Summary 9

3 Design Certification Activities 15

4 Design Finalization 19

5 Plant Cost Estimates 25

6 Project Management 31

7 Lessons Learned 39

8 Appendix 51

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LIST OF TABLES

Table 6-1 Project Milestones 32

Table 6-2 **AP1000** Design Project Participants 35

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LIST OF FIGURES

Figure 1 Vogtle Containment Vessel Fabrication, November 2010 1

Figure 2 Pouring of First Concrete at Sanmen Unit 2, December 2009 3

Figure 3 VC Summer Unit 2 Excavation, October 2010 4

Figure 4 Aerial View of Haiyang Site, November 2010 5

Figure 5 Machining of **AP1000** Core Shroud in Newington, New Hampshire 7

Figure 6 Preparation for Construction at Vogtle Site, March 2010 10

Figure 7 **AP1000** Reactor Coolant Pump Manufactured in Cheswick, Pennsylvania 12

Figure 8 Manufacture of **AP1000** Control Rod Drive Mechanism in Newington, New Hampshire 13

Figure 9 **AP1000** Shield Building 17

Figure 10 **AP1000** Control Room Simulator 21

Figure 11 Shaw Modular Solutions Facility 22

Figure 12 Shaw Modular Fabrication 22

Figure 13 VC Summer Module Assembly Building 23

Figure 14 Vogtle Module Assembly Building Construction, November 2010 23

Figure 15 Preparation for Construction at Vogtle Site, July 2009 26

Figure 16 Manufacture of **AP1000** Core Barrel Assembly in Newington, New Hampshire 27

Figure 17 Setting of Containment Vessel Bottom Head at Sanmen Unit 1, December 2009 29

Figure 18 Cost Estimate Curve, Development through Deployment 30

Figure 19 Cutaway View of **AP1000** Unit 30

Figure 20 Aerial View of Haiyang Site, December 2010 39

Figure 21 Setting of Containment Vessel Ring Number 4 at Sanmen Unit 1, December 2010 39

LIST OF FIGURES (cont.)

Figure 22 Twin Unit **AP1000** Plant 43

Figure 23 Pouring of First Concrete at Sanmen Unit 1, March 2009 49

LIST OF ACRONYMS (cont.)

PCCI	Power Capital Costs Index
PRA	probabilistic risk assessment
PUC	public utility commission
PWR	pressurized water reactor
RAI	request for additional information
R-COLA	reference COLA
S-COLA	subsequent COLA
Shaw	The Shaw Group Inc.
TAG	Technical Assessment Guide
TVA	Tennessee Valley Authority
Westinghouse	Westinghouse Electric Company LLC

Executive Summary

This report summarizes the work performed and the lessons learned by Westinghouse Electric Company LLC as part of the Department of Energy (DOE) Nuclear Power 2010 (NP2010) Program. Westinghouse performed this work under its cooperative agreement with DOE (DE-FC07-07ID14779) from April 2007 through December 2010 and as subcontractor to the NuStart Energy Development LLC (NuStart) cooperative agreement with DOE (DE-FC07-05ID14636) from May 2005 to April 2007. The work scope covers Westinghouse activities in support of designing and licensing the **AP1000**®[1] nuclear power plant standard design.

Under the cooperative agreement, Westinghouse is meeting the following three primary objectives:

- Substantially complete the engineering of the **AP1000** standard design (design finalization [DF])
- Obtain U.S. Nuclear Regulatory Commission (NRC) approval via a rulemaking amendment for the **AP1000** standard design (design certification [DC])
- Support NuStart's efforts to obtain a combined construction and operating license (COL) from the NRC for the first **AP1000** design project

All of these objectives are scheduled to be satisfied by the end of 2011.

More importantly, DOE's overall goal for the NP2010 Program itself – an industry decision to deploy at least one new advanced nuclear power plant – is being satisfied by current activities for **AP1000** units at the Southern Company Vogtle site and the SCANA Corporation V.C. Summer site (a total of four units). Although formal commitments to proceed with the projects are awaiting NRC issuance of the COLs later this year, the current advanced state of licensing and construction preparation at the two sites strongly supports the expectation that the projects will proceed as planned. The deployment of the first new nuclear plants in the United States in more than a generation will make the NP2010 Program a major success for DOE.

Figure 1. Vogtle Containment Vessel Fabrication, November 2010

Expanded Scope of Work

The final results achieved as a result of the NP2010 Program have proven to be substantially greater than were originally envisioned at the start of the NuStart subcontract. Initially, the Westinghouse scope was to complete the DC rulemaking for the **AP1000** standard design (the NRC staff had already completed its review and issued a final design approval prior to the start of the subcontract), complete the engineering of the **AP1000** standard design, and support NuStart's efforts to obtain a COL as a demonstration of the process. NuStart was not chartered to proceed with construction of a plant, and it was not clear at the time whether any other entity

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would make the decision to deploy an **AP1000** plant after the demonstration project's completion.

During implementation of the **AP1000** design DOE project, Westinghouse's activities were impacted by a confluence of external forces: financial incentives in the Energy Policy Act of 2005 (EPACT 2005); adjustments to the NRC regulations, requirements, and review processes; orders for **AP1000** units in China; and plans by several NuStart members to begin safety-related construction immediately following issuance of their COLs. DOE's flexibility in working with Westinghouse to allow adjustments to the schedule for engineering and licensing activities for the **AP1000** standard design to reflect these external forces was an essential aspect of the project's success.

The financial incentives for new nuclear plants in EPACT 2005 led a number of U.S. utilities to pursue COLs for potential new plant projects. Five of the utilities in NuStart submitted COL applications (COLAs) for twin unit **AP1000** plants on six different sites, not including the COLA already being planned by NuStart. This substantially affected Westinghouse's activities on the **AP1000** reactor project related to both regulatory and design issues. To support review of the large number of anticipated COLAs, the NRC requested that COL applicants form Design Centered Working Groups (DCWGs) for each of the standard designs. NuStart formed the DCWG for the seven **AP1000** design COLAs, which is the largest of the DCWGs by far, adding to the complexity of Westinghouse's efforts to support NuStart. Without the head start provided by the NP2010 Program and the formation of NuStart, it is likely that industry and NRC efforts to respond to the incentives in EPACT 2005 would have been delayed by 2 to 3 years.

Nuclear Regulatory Commission Reviews

During the **AP1000** design project, the NRC instituted a number of important adjustments to its regulations, policies, and guidance in preparation for the wave of COLAs that were anticipated. One of the changes to Title 10 Code of Federal Regulations Part 52 (10 CFR 52) provided for amending a DC, an action that was not previously addressed in the regulation.

Since the **AP1000** design had received its DC in 2005 near the beginning of the NuStart project, it was originally planned that essentially all of Westinghouse's licensing effort would be in support of NuStart's COLA. However, after the change to 10 CFR 52, it was agreed by NuStart, Westinghouse, and DOE that Westinghouse would apply for an amendment to the DC that would minimize the number of issues remaining to be addressed in the NuStart COLA, as well as in all subsequent COLAs for **AP1000** plants. This would be more efficient and would reduce licensing risks for all of the COLAs.

The **AP1000** DC amendment was reviewed by the NRC in parallel with the NuStart COLA, which originally was for the Tennessee Valley Authority (TVA) Bellefonte site; however, during the DOE program, NuStart shifted to the COLA for the Southern Vogtle site. Furthermore, the NRC's review occurred just after the NRC had issued a number of revisions to its requirements and guidance for new plants. The NRC had also substantially increased and reorganized its review staff. Much of Westinghouse's work scope under the DOE project that had been categorized as DF was, in fact, needed to support the NRC review. The engineering schedule for the **AP1000** design was accelerated and routinely adjusted to ensure that details needed to support NRC review would be available when required.

The most significant NRC review issue was related to changes that were made in the containment shield building design to address a new NRC regulation requiring assessment of aircraft impacts. Resolution of the issue included further design changes to the shield building and performance of a significant structural test program. The NRC Generic Safety Issue 191 (GSI-191) on pressurized water reactor (PWR) containment sump blockage was another challenging issue that required a new set of Westinghouse test programs to reach closure.

During the latter stages of the NRC review, **AP1000** design changes resulted from Westinghouse DF activities; NRC review; insights from NuStart members concerning operability and maintainability; and feedback from equipment suppliers, construction projects in China, and construction preparation projects in the United States. The NRC, NuStart, and NuStart members all worked diligently with Westinghouse to manage this activity and the NRC review schedule.

Figure 2. Pouring of First Concrete at Sanmen Unit 2, December 2009

Benefits Gained from Deployment Projects

During the **AP1000** design DOE project, a Westinghouse consortium was awarded contracts to provide engineering and procurement services for the nuclear island portion of four **AP1000** units in China on two separate sites, Sanmen and Haiyang. With startup and operation of the first **AP1000** unit scheduled for 2013, the China projects are providing valuable construction experience and lessons learned that will benefit the first **AP1000** units to be deployed in the United States with targeted commercial operation dates 2 to 3 years after the units in China.

Portions of the engineering activities for the **AP1000** standard design were needed to support the projects in China. (Note: Although the China projects used portions of the engineering for the **AP1000** standard plant, none of the project-specific engineering for the China project was performed under the DOE project.)

Several of the NuStart members wanted to begin safety-related construction immediately following issuance of their COLs. It therefore became necessary to accelerate the engineering schedule to facilitate the following efforts: provide sufficient design information to begin procurement of long lead-time materials; support construction planning; support procurement of equipment; support the efforts by NuStart's members to obtain approvals of state regulators for their projects; and support negotiation of engineering, procurement, and construction (EPC) contracts, as well as the supporting subcontracts.

These activities were not performed under the DOE project; however, they did rely on the underlying engineering and licensing work for the **AP1000** standard design and substantially impacted the schedule needs. Very importantly, these activities were necessary to fulfill DOE's overall goal for the NP2010 Program: an industry decision to deploy at least one new advanced nuclear power plant.

Lessons Learned

Following are some of the most significant lessons learned during implementation of the **AP1000** design DOE project:

- The high level of design detail needed to support NRC licensing and to support a commercial decision to deploy a plant creates a very high threshold for introducing a new standard design. An investment of several hundred million dollars is required.
- To deploy a new standard design in less than a decade, the activities for DF, DC, COL, and commercial contracting of the initial units cannot be performed in series. The activities must overlap and there will be considerable interaction between them.
- The engineering schedule for the standard design should be front-end loaded in the deployment schedule in order to support the high level of detail needed for the NRC review and the start of safety-related construction immediately following issuance of the COL.
- Establishment of the NRC requirements, guidelines, and processes needed to support a wave of DC applications and COLAs should be front-end loaded in the deployment schedule and, if possible, completed well in advance of the initial submittals.
- A very strong commitment to standardization within the industry, as well as between industry and the NRC, is necessary to minimize human resource needs, minimize rework, and maintain the schedule for deployment. Communication and cooperation between all parties are also extremely important.
- Initiation of an industry partnership program by DOE (e.g., NP2010), in advance of legislation that provides financial incentives for deployment, can dramatically improve the likelihood that industry will be successful in commercial deployment of an advanced new technology.
- Flexibility in the implementation of the cooperative agreement between DOE and the plant supplier (for DC and DF) is necessary to allow the engineering and licensing activities for the standard design to adapt to external forces in the evolving marketplace.
- Active participation by utilities that are seriously evaluating commercial deployment projects is the best means available for providing input and guidance to the plant supplier and ensuring that the program will meet the needs of the marketplace.

Figure 3. VC Summer Unit 2 Excavation, October 2010

Future Actions

At the end of 2010, the NRC staff was nearing completion of its review of the DC amendment for the **AP1000** standard design and the COLA for Vogtle, the lead **AP1000** reactor project. At the time of this report, the NRC's schedule calls for completion of the rulemaking process and issuance of the amended DC rule for **AP1000** reactor in September 2011. The Vogtle and V.C. Summer COLs are anticipated by the end of the

year. Westinghouse will also be completing DF for the **AP1000** standard design during 2011.

During 2011, Westinghouse and Southern will complete a limited-scope pilot activity with the NRC to demonstrate the process for implementing and closing out the inspections, testing, analyses, and acceptance criteria (ITAAC) that will be included in the COL.

Except for completion of the ITAAC demonstration activity, DOE funding under the cooperative agreement was exhausted during 2010. However, because the NP2010 Program has been successful in leading to deployment of the **AP1000** standard design, Westinghouse is completing the licensing and engineering activities without the DOE cost-share.

In the future, Westinghouse and industry will begin shifting focus toward the remaining aspects of deployment that still must be implemented before the first plants can go into operation, including:

- Support of the NRC construction oversight program
- Closure of all ITAAC before fuel loading
- Development of domestic infrastructure to support fabrication, procurement, and construction
- Implementation of lessons learned from construction, startup, and operation of the **AP1000** units in China

Figure 4. Aerial View of Haiyang Site, November 2010

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1 Introduction

This report summarizes the work performed and the lessons learned by Westinghouse as part of the DOE NP2010 Program. Westinghouse performed this work under the cooperative agreement with DOE (DE-FC07-07ID14779) from April 2007 through 2010 and as subcontractor to NuStart's cooperative agreement with DOE (DE-FC07-05ID14636) from May 2005 to April 2007. The work scope covers Westinghouse activities in support of designing and licensing the **AP1000** nuclear power plant standard design.

Besides describing Westinghouse's activities during the program, this report is intended to address a number of issues, including lessons learned, as requested by DOE.

The report is organized as follows:

- **Section 2, Program Summary**, discusses Westinghouse's activities in the **AP1000** design cooperative agreement in the context of its role in the DOE NP2010 Program and the overall industry effort to deploy new nuclear plants.
- **Section 3, Design Certification Activities**, summarizes the licensing activities related to completing the initial DC of the **AP1000** standard design and amendment of the DC by the NRC in support of seven COLAs submitted by NuStart and its members.
- **Section 4, Design Finalization Activities**, summarizes the engineering activities related to completing the **AP1000** standard design to a level of detail sufficient to support the licensing process and commercial decision-making process for utilities considering deployment of **AP1000** units in the United States.
- **Section 5, Plant Cost Estimates**, discusses considerations in estimating nuclear plant costs over the life of a development program such as NP2010. It does not include cost numbers for the **AP1000** standard design, because this scope was removed from the DOE program.
- **Section 6, Project Management**, covers issues related to the cooperative agreement and interactions with DOE.
- **Section 7, Lessons Learned**, describes experiences that provided significant insights to Westinghouse and the lessons learned from them.

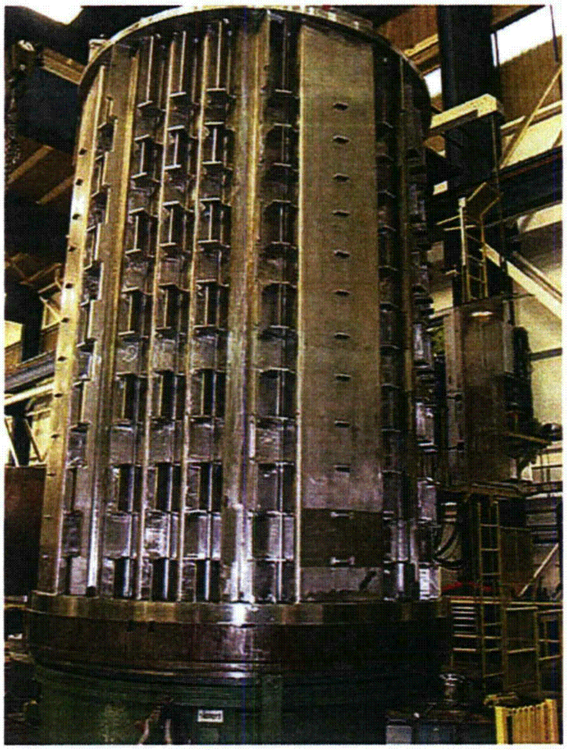

*Figure 5. Machining of **AP1000** Core Shroud in Newington, New Hampshire*

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2 Program Summary

2.1 Background

Westinghouse has played a prominent role in efforts to use nuclear energy for electricity generation since the world's first commercial nuclear plant at Shippingport, Pennsylvania, in 1957. Nearly half of the nuclear plants operating in the world today employ technology originated by Westinghouse.

During the 1980s and 1990s, Westinghouse participated in DOE's Advanced Light Water Reactor (ALWR) Program, a government and industry collaboration to develop new reactor designs that could take advantage of the lessons learned from building and operating the first generations of nuclear plants during the 1960s through the 1980s. Westinghouse's efforts focused upon the development, DC, and first-of-a-kind-engineering (FOAKE) for the AP600 standard design. The AP600 reactor is a 600 MWe nuclear plant design that employs passive safety features to simplify the construction and operation of the plant, reduce costs, and improve safety. The AP600 design also makes use of advanced modular construction technologies to reduce construction schedules and costs.

By the time that the DOE ALWR Program was completed in 1999, the economics of electricity generation had changed substantially because of deregulation of the power industry during the 1990s and the growth of inexpensive natural gas as the predominant fuel source for new power plants. Westinghouse immediately began looking at the feasibility of uprating the AP600 design to a power level above 1000 MWe as a means to restore economic competitiveness.

During 2001, a number of utilities were interested enough in the **AP1000** design to participate in development of a business model to evaluate the economic feasibility of deploying **AP1000** units in a way that could spread first-time costs and risks over a group of plants. By 2002, Westinghouse had developed enough detail for the **AP1000** standard design to enable submittal of a DC application to the NRC. It was not expected that Westinghouse would be able to go beyond the DC phase without some form of government assistance.

Meanwhile, in 2001 DOE organized a team of participants from industry, universities, and national laboratories to prepare a roadmap for the actions necessary to support deployment of new nuclear plants in the United States by the end of the decade. The roadmap served as the basis for the NP2010 Program, which DOE announced in 2002.

In 2003, DOE issued a solicitation for a collaborative government/industry cost-shared project to do the following:

- Demonstrate the NRC's untested COLA process in 10 CFR 52
- Obtain DC for the standard design used in the COLA
- Complete sufficient engineering of the standard design to support commercial decisions by utilities on whether to deploy the design

Westinghouse joined with a group of utilities and another reactor supplier to form the team that would respond to the DOE solicitation.

2.2 Value of the NP2010 Program

The **AP1000** DC/DF project under the NP2010 Program clearly satisfied a need in the nuclear community. Utilities were not prepared to invest the hundreds of millions of dollars that reactor suppliers, such as Westinghouse, needed to develop detailed standard designs and to obtain NRC certification that maximized resolution of licensing issues. Nor were the utilities prepared

to make commitments to place orders for new plants. Although Westinghouse had committed tens of millions of dollars to obtain an uprated DC for the **AP1000** design, without a stronger utility commitment it could not justify expenditures for the much larger program that was needed.

The NP2010 Program prompted a substantial number of utilities to form the NuStart consortium. It also prompted the utilities and reactor suppliers to commit to provide substantial cost-share. Without the NP2010 Program, these detailed design and licensing activities would have been delayed at least 2 years until after EPACT 2005 was passed, which provided financial incentives and support for a first wave of new nuclear plants, such as production tax credits and loan guarantees. Industry activities would likely have been organized differently had the NuStart consortium not been formed to implement the NP2010 Program. Without the formation of NuStart in response to NP2010 planning, the number of COLAs prompted by EPACT 2005 would likely have been much lower.

2.3 Achieving the Goals of the NP2010 Program

The primary objectives of Westinghouse's cooperative agreement are to substantially complete the engineering of the **AP1000** standard design (DF), obtain NRC approval via a rulemaking amendment for the **AP1000** standard design (DC), and support NuStart's efforts to obtain a COL from the NRC for the first **AP1000** reactor project. All of these objectives are scheduled to be satisfied by the end of 2011.

More importantly, DOE's overall goal for the NP2010 Program itself, an industry decision to deploy at least one new advanced nuclear power plant, is being satisfied by current activities for **AP1000** units at the Southern Vogtle site and the SCANA V.C. Summer site (a total of four units). Although formal commitments to proceed with the projects are awaiting NRC issuance of the COLs later this year, the current advanced state of licensing and construction preparation at the two sites strongly supports the expectation that the projects will proceed as planned. The deployment of the first new nuclear plants in the United States in more than a generation will make the NP2010 Program a major success for DOE.

Figure 6. Preparation for Construction at Vogtle Site, March 2010

2.4 The NP2010 Program Role in Addressing Industry Issues

The NP2010 Program gave the industry a head start in addressing the issues needed to deploy new nuclear plants. It provided a basis for the utilities and reactor suppliers to work with industry groups – including the Nuclear Energy Institute (NEI), Institute of Nuclear Power Operations (INPO), American Society of Mechanical Engineers (ASME), and many others – to develop generic industry guidance for licensing and deploying new nuclear plants. The NP2010 Program also prompted NRC action to update and revise its set of regulations on the procedures for licensing new nuclear plants (10 CFR 52), as well as other regulations that would need to be addressed, such as aircraft impact assessment (AIA). The NRC also updated its guidelines for new plants (e.g., regulatory guides and standard review

plans), and even established and staffed a new organization for licensing new plants.

The NP2010 Program allowed industry to begin organizing and staffing the new infrastructure needed to support design, licensing, procurement, construction, and startup of the new nuclear plants. This, in turn, allowed subsuppliers to begin organizing and staffing new organizations that would be needed to design and manufacture equipment for the new nuclear plants, including planning for expanded or new manufacturing facilities.

The NP2010 Program also provided reactor suppliers with sufficiently detailed information to support negotiation of EPC contracts that equitably allocated contractual risks among all parties. (Note: EPC negotiations were separate from, and not part of, the NP2010 scope.)

The NP2010 Program provided utilities with the sufficiently detailed information needed to support their efforts to obtain state public utility commission (PUC) approvals for proceeding with their deployment projects.

2.5 Accelerating Engineering Activities

During the implementation of the NP2010 program, a number of issues resulted in the need to accelerate the schedule for the **AP1000** reactor engineering activities, make numerous changes to the **AP1000** standard design, and increase the level of design detail included in the standard design.

At the beginning of the NP2010 program, the **AP1000** DC/DF activities were intended to support a single demonstration COL for a project that might eventually be deployed by an entity other than NuStart. It was also envisioned that the entity deploying the first project might wait until after the COL was issued before beginning the procurement of long lead-time materials and preparing for construction. Therefore, the activities and budgets were back-end loaded in the NP2010 Program, because previous DC projects in the ALWR Program had shown that the level of detail needed to obtain DC could be managed by deferring some issues (e.g., by using more design acceptance criteria [DAC] in the DC). Similarly, the level of detail needed for DF could be limited, since procurement specifications would not be implemented with suppliers until later.

However, after passage of EPACT 2005, the nature of the NP2010 program changed. Five of the NuStart members decided to pursue six **AP1000** design COLAs, in addition to the one already being pursued by NuStart and TVA for the Bellefonte site. (In addition, Westinghouse received a contract to supply portions of the **AP1000** plant for four units in China.)

Partly because of the milestone dates for the production tax credit incentives in EPACT 2005, each utility needed to begin preparing for construction even before the COL is issued by the NRC. This effort also accelerated the need for design details to support long lead-time procurements (such as reactor vessels and steam generator forgings). Additional design details were also needed to support negotiation of the EPC contracts needed to support state PUC approval of the new projects.

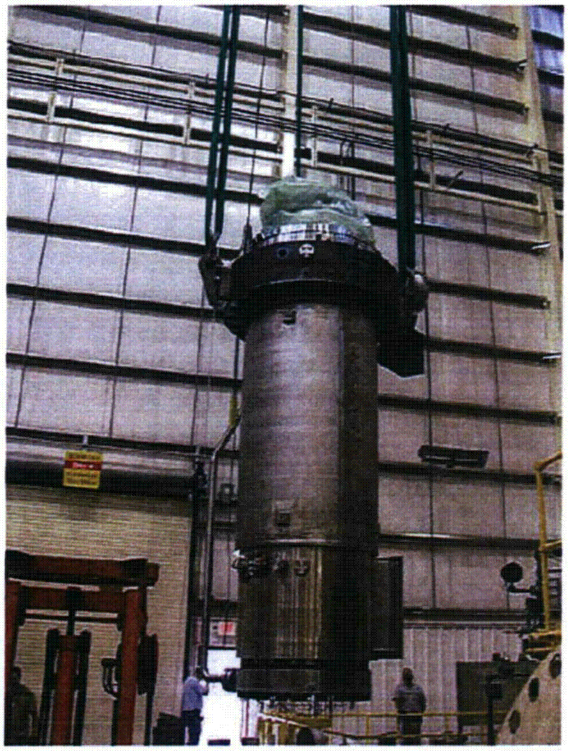

Figure 7. ***AP1000*** *Reactor Coolant Pump Manufactured in Cheswick, Pennsylvania*

Furthermore, because the utilities were seriously considering deployment projects, they became much more heavily engaged in directing the **AP1000** design effort, increasing the level of detail. The utilities pressed for a higher level of standardization than had been envisioned during the ALWR program, which required additional DF effort. For example, the utilities wanted the control room design for all **AP1000** units to be completely identical. As another example, they wanted small-bore piping runs to be designed and analyzed as part of the standard design, instead of using field-run piping that could vary from site to site.

Feedback from equipment subsuppliers during the DF process and from China construction activities resulted in the need for numerous changes to the standard design. In addition, the NRC was in the process of revising 10 CFR 52, issuing new regulations (e.g., AIA), issuing new review guidelines and standards, and increasing the size of its staff to handle the wave of new licensing applications. These new NRC requirements also resulted in changes to the standard design. During this transition, NRC expectations increased substantially beyond that anticipated regarding the level of design detail needed to support DC and COL reviews. The NRC found it difficult to conduct the DC and COL reviews in parallel while trying to maintain aggressive schedules.

As a result of the above factors, it became clear that the activities and budgeting for the NP2010 Program needed to be much more front-end loaded than when the program began. These factors also increased the costs of completing DC and DF for the **AP1000** standard design. Although DOE agreed to increase its cost-share funding to the project in 2008, DOE also stipulated that it would not fund further cost increases. As a result, the DOE cost-share was completed in 2010, even though the DC and DF efforts would not be completed until 2011. Westinghouse is concluding the DC and DF efforts without additional DOE funding to support the initial **AP1000** design COLs and deployments in the United States.

2.6 Deployment Activities Following the NP2010 Program

The NP2010 program was intended to cover licensing activities up to issuance of the DC and COL, as well as completion of DF. However, as was noted in DOE's Near Term Deployment Roadmap, there are still important activities to be completed before the first new nuclear plants successfully go into operation.

In addition, a number of new regulatory processes remain to be exercised for the first time, including:

- Implementation and closeout of the ITAAC on a schedule that does not delay fuel load

- Implementation of an NRC construction inspection program
- NRC approval of design changes during construction
- NRC Engineering Design Verification (EDV) audit

This risk of regulatory delay during construction and startup was perceived to be large enough by the government that EPACT 2005 included the DOE Regulatory Standby Protection Program to provide insurance coverage for regulatory delays to the first six new nuclear plants. However, this coverage is going unused because the estimated fees to be charged to applicants are considered prohibitively expensive.

The Near Term Deployment Roadmap also expressed concern about whether there is sufficient manufacturing and construction infrastructure (including training programs) to support new nuclear plants in the United States. Although some of the infrastructure issues were partially addressed by implementation of the DF activities, much remains to be resolved after the COLs are issued and DF has been completed.

*Figure 8. Manufacture of **AP1000** Control Rod Drive Mechanism in Newington, New Hampshire*

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3 Design Certification Activities

This section summarizes Westinghouse's activities to complete the initial DC of the **AP1000** standard design during the first year of the DOE program and to obtain an amendment to the DC during the remainder of the DOE program.

3.1 Initial AP1000 Design Certification

Prior to the signing of the Westinghouse subcontract from NuStart under the NP2010 Program in May 2005, Westinghouse had submitted an application for NRC DC of the **AP1000** standard design based on an uprate of the AP600 standard design that had received NRC DC in 1999.

On March 28, 2002, Westinghouse submitted a DC application for the **AP1000** standard design in accordance with 10 CFR 52, Subpart B. The application included the **AP1000** Design Control Document (DCD) and the **AP1000** design probabilistic risk assessment (PRA). The NRC formally accepted the application (Docket No. 52-006) on June 25, 2002.

The NRC staff completed its review of the **AP1000** design and issued a final safety evaluation report (FSER) in September 2004. Westinghouse completed the rulemaking activity for the **AP1000** DC under the subcontract from NuStart. The NRC voted to approve the rule on December 31, 2005, and formally published the DC in the Federal Register on January 27, 2006. The **AP1000** DC was based upon Revision 15 of the DCD.

3.2 Technical Reports

During 2006, Westinghouse began preparing information that could be used to close out the DAC in the DC to the extent possible and to proactively address the COL information items from the DC. At the time, there was not a plan to amend the **AP1000** DC, because 10 CFR 52 did not yet provide a mechanism to amend a DC. It was initially expected that all **AP1000** design licensing documentation would be submitted to the NRC on the NuStart COLA docket.

Westinghouse prepared a series of technical reports for submittal to the NRC. The reports, each of which addressed a specific issue for the **AP1000** design, were intended to do the following:

- Resolve specific COL information items from the **AP1000** DC
- Identify changes to the **AP1000** standard design resulting from the DF activities
- Provide information on topics in the DCD pertaining to the design process and acceptance criteria

Meanwhile, the NRC initiated a rulemaking proceeding to make a number of changes to 10 CFR 52. One of the changes being contemplated was to include a provision in 10 CFR 52 that would allow for amendment of an already-issued DC. As a result, by the time that Westinghouse and NuStart submitted the series of technical reports to the NRC, there was an expectation by Westinghouse, NuStart, and NRC staff that the reports could be used either in NuStart's COLA or in an application from Westinghouse to amend the **AP1000** DC if 10 CFR 52 were changed.

3.3 Amendment to the AP1000 Design Certification

In the meantime, a number of the NuStart members began informing the NRC of plans to submit their own COLAs for potential **AP1000** plant projects. It seemed highly likely that several **AP1000** design COLAs for NuStart members would be reviewed in parallel or soon

after the review of the NuStart COLA and the application to amend the **AP1000** DC.

Once it became clear that 10 CFR 52 was likely to be modified to allow for amendment to a DC, Westinghouse began discussions with the NRC about plans for submitting Revision 16 to the DCD to the NRC, with a request to amend the **AP1000** DC rule. The amended DC would be referenced by the NuStart COLA and by the COLAs of NuStart members. The objective of the DC amendment was to close out as many NRC review issues for the **AP1000** standard design as possible, address new NRC requirements (e.g., AIA), and incorporate design changes that were resulting from the DF engineering activities. It was felt that closing out the issues in a DC amendment would be more efficient than addressing them in each COLA and would reduce licensing risks for all of the COLAs. Although the NRC had issued four DCs under 10 CFR 52, this would be the first demonstration of the DC amendment process.

Ultimately, the NRC did make the expected revisions to 10 CFR 52 on August 28, 2007 (Federal Register Vol. 72, No. 166, pp. 49352-49401), and included a provision for amending an already-certified design.

3.3.1 Application for Design Certification Amendment and Nuclear Regulatory Commission Review

Westinghouse submitted Revision 16 of the DCD to the NRC on May 26, 2007, before the revision to 10 CFR 52 went into effect. The application was docketed by the NRC on January 28, 2008. The NRC staff shifted its review from the technical reports that had been previously submitted by Westinghouse to the DCD itself, essentially in parallel with the NRC's review of the NuStart COLA for the TVA Bellefonte site and the COLAs submitted by NuStart members.

During the NRC review of the **AP1000** standard design, Westinghouse issued Revision 17 of the DCD to the NRC on September 22, 2008, and Revision 18 on December 1, 2010. Each revision incorporated information provided earlier to the NRC in response to NRC questions, as well as design changes necessitated by new NRC requirements and the **AP1000** DF activities.

The DCD revisions also addressed a number of the COL information items from the original **AP1000** DC and two of the major areas of DAC: instrumentation and control systems (I&C) and human factors engineering.

Approval of the DCD revisions by the NRC (and the subsequent DC amendment rulemaking) protects the information in them from further NRC review and from further public intervention for all of the COLAs referencing the amended DC, since the opportunity for public input would occur during the DC amendment rulemaking.

The NRC staff completed its review of the **AP1000** standard design amendment request and issued its advanced final safety evaluation report (AFSER) on DCD Revision 18 on December 28, 2010.

Questions from the NRC staff to applicants are referred to as requests for additional information (RAIs). Approximately 2197 RAIs were closed out in the three DCD revisions, as follows:

- 201 RAIs in Revision 16
- 901 RAIs in Revision 17
- 1095 RAIs in Revision 18

3.3.2 Formation of Design Centered Working Groups

Five of the utilities in NuStart submitted COLAs for twin unit **AP1000** plants on six different sites, not including the COLA already being planned by NuStart and TVA for twin units on the TVA Bellefonte site.

The **AP1000** DC amendment is referenced in seven COLAs for a total of fourteen units:

- Vogtle 3 and 4
- Bellefonte 3 and 4
- Levy County 1 and 2
- Shearon Harris 2 and 3
- Turkey Point 6 and 7
- V.C. Summer 2 and 3
- William States Lee III 1 and 2

This substantially affected Westinghouse's activities on the **AP1000** DC/DF project related to both regulatory and design issues. To support review of the large number of anticipated COLAs, the NRC requested that the COL applicants form DCWGs for each of the standard designs. NuStart formed the DCWG for the seven **AP1000** design COLAs, which is by far the largest of the DCWGs, adding to the complexity of Westinghouse's efforts to support them.

The **AP1000** DC amendment was reviewed by the NRC in parallel with the NuStart COLA, which originally was for the TVA Bellefonte site; however, during the DOE program, NuStart shifted the reference COLA (R-COLA) to the application for the Southern Vogtle site.

3.3.3 Significant Review Issues

The NRC review of the **AP1000** design occurred just as the NRC issued a number of revisions to its requirements and guidance for new plants, as well as substantially increased and reorganized its review staff. Collectively, these changes increased Westinghouse's efforts to prepare licensing documents for NRC review and **AP1000** DF materials needed to support the licensing documents.

The level of design detail required during the NRC review was substantially greater than had been experienced during previous DC reviews. Much of the Westinghouse work scope under the DOE project that had been categorized as DF was, in fact, needed to support the NRC review. The engineering schedule for the **AP1000** design was accelerated and routinely adjusted to ensure that details needed to support NRC review would be available when required.

The most significant NRC review issue was related to changes that were made in the design of the containment shield building to address the new NRC regulation regarding AIA. Resolution of the issues included further design changes to the shield building and performance of a significant structural test program.

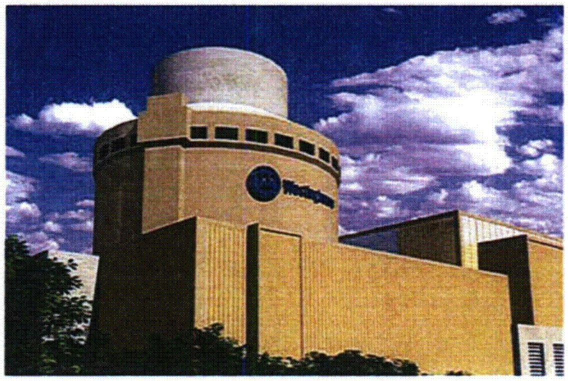

*Figure 9. **AP1000** Shield Building*

The NRC GSI-191 on PWR containment sump blockage and long-term cooling was another challenging issue that required a new set of test programs by Westinghouse to reach closure. It also resulted in stringent limits on fibrous materials allowed in containment.

During the latter stages of the NRC review, Westinghouse needed to incorporate the numerous **AP1000** design changes that were resulting from Westinghouse DF activities; NRC review; input from NuStart members concerning operability and maintainability insights; and feedback from equipment suppliers, construction projects in China, and construction preparation projects in the United States. The NRC, NuStart, and NuStart members all worked diligently with Westinghouse to manage this effort.

In November 2009, the NRC issued the generic "Interim Staff Guidance on Finalizing Licensing Basis Information" (DC/COL-ISG-011), which specified criteria for identifying whether design changes made during the NRC review would have to be included in the DCD for a standard design. After Revision 17 of the **AP1000** DCD was submitted to the NRC, Westinghouse reviewed design changes to the **AP1000** standard design in accordance with the guidance of ISG-11 and incorporated those design changes that met the criteria into Revision 18 of the DCD.

3.3.4 Demonstration of Closure of Inspections, Testing, Analyses, and Acceptance Criteria

Late in the **AP1000** design project, DOE facilitated a small demonstration project to test the process for industry and the NRC to close out ITAACs after the COL has been issued. Westinghouse, Southern, and the NRC selected a small number of sample ITAACs and are working together to verify that both the industry closure processes and the NRC verification processes are reliable and efficient.

Southern and Westinghouse are simulating the development of six ITAAC closure documents and the submission of the associated ITAAC closure notifications under 10 CFR 52, Part 99 (c) (1). During the process, NRC Region II participants are simulating inspection planning and the documentation of inspection results in the NRC Construction Inspection Program Information Management System (CIPIMS). Participants from NRC headquarters staff in the Office of New Reactors (NRO) are simulating the review of the ITAAC closure letters submitted by Southern, and inspection results are documented in CIPIMS. NRO is also simulating the NRC's internal ITAAC closure verification process. After the simulation has been completed, the participants will identify improvements that are needed in the industry and NRC processes.

3.3.5 Completion of NRC Staff Review

At the end of 2010, the NRC staff was completing its review of the DC amendment for the **AP1000** reactor. Westinghouse and the NRC staff supported a number of Advisory Committee on Reactor Safeguards (ACRS) meetings on the amendment. As might be expected, much of the ACRS's interest has centered on the major issues that surfaced during the NRC staff's review. The ACRS has since issued favorable letters to the Commission, and the NRC has initiated the formal rulemaking process. Completion of rulemaking and issuance of the **AP1000** DC amendment is anticipated in September 2011.

A more detailed description of the NRC staff's review is provided in SECY-11-0002, which is included as an Appendix to this report.

4 Design Finalization

The objective of the DF activities under the **AP1000** design DOE project was to provide sufficient information about the **AP1000** standard design so that one or more utilities could make commercial decisions about whether to proceed with deployment projects.

4.1 Scope of Design Finalization

At the beginning of the DOE project, DF was defined as follows:

- The scope of the DF effort is to include the activities necessary to develop the engineering design for the site-independent features of the **AP1000** plant to a level of detail sufficient to define and confirm credible plant cost estimates, construction schedules, and design standardization required for plant procurement and construction at all potential U.S. sites.
- The level of design will minimize the schedule and cost risk due to design work that has not been completed by the time of pouring the first structural concrete. The effort includes preparing equipment specifications; identifying, evaluating, and preselecting equipment suppliers; and creating the interface between the plant detailed design and the selected supplier's equipment.
- DF encompasses the required engineering beyond that performed as part of the DC and COLA process, and provides the technical and physical baselines for commercial standardization.
- DF does not include the following: adaptation of the design to the specific site on which the plant will be built, other than the site selected for the **AP1000** reference plant; incorporation of as-built information necessary as part of the normal construction process; and procurement of plant equipment and/or materials.

4.2 Summary of Design Finalization Activities

Following are brief descriptions of the types of activities needed to support DF of the **AP1000** standard plant design. (Note: This is not intended to be all-inclusive of the activities in the DF task.)

Structural and Seismic Analysis

Westinghouse completed mechanical equipment analysis and structural evaluations, developed engineering drawings for concrete and steel structures, developed design guides and criteria, performed seismic and soil foundation analyses, and conducted other design activities to address the structural- and seismic-related design.

Engineering was completed to the extent necessary in the following structural areas:

- Structural mechanical equipment analysis
- Structural concrete and steel structural evaluation
- Structural concrete and steel basic engineering drawings
- Structural design guides and criteria
- Structural construction review

Westinghouse determined the structural applicability of the AP600 design information, and then completed the subsequent structural and seismic analyses required to support the **AP1000** standard plant design.

This included the following:

- Soil-structure interaction and rock seismic analysis
- Load definition
- Structural software automation development
- Structural general drawings

- Structural soil foundation analysis
- Structural global finite element analysis
- Structural design reconciliation and reports

The **AP1000** design's ability to sustain large commercial aircraft impact and possible terrorist acts was also reviewed in detail. The scope included:

- Defining potential attack scenarios
- Developing vital area barriers designs
- Evaluating the feasibility of conceptual designs (construction and stress)
- Stress analyses
- Defining aircraft loading
- Simplified analysis methods
- Dynamic analyses
- Aircraft impact simulation
- Scale testing
- Mitigation of fire damage

Piping and Supports

Westinghouse performed much of the design and analysis of the **AP1000** design piping, piping supports, and layout. This included ASME Class 1 piping as well as non-Class 1 piping and piping supports.

Instrumentation and Control Development

The **AP1000** design I&C system was addressed, including the plant control system, display systems, alarm system, computerized procedures system, plant safety and monitoring system, qualified data processing system, nuclear instrumentation system, advanced rod control system, diverse actuation system, digital rod position indication system, operation and control centers, and simulator. This effort included development of the human-system interface.

Equipment Qualification

Westinghouse developed equipment-specific qualification methodology and documentation requirements, prepared equipment specifications and procedures, and performed other activities necessary to support the standard plant design.

Primary Equipment Reports

Westinghouse designed the reactor vessel internals, reactor vessel, steam generator, reactor coolant pump, pressurizer, and other major components; performed stress and other analyses as necessary to confirm the designs; conducted design reviews; and prepared ASME code stress reports for these components. Similar efforts were performed for the core and fuel designs.

For example, the pressurizer design effort included preparing the pressurizer design specification; preparing and analyzing nozzles, manway, lower and upper heads, cylindrical shell, support bracket, lower support pad, trunnions, and heater well weld; preparing the intermediate design review package; and conducting the intermediate design review. The scope also included preparing the ASME design report, preparing the final design review package, and conducting the final design review meeting.

The following were designed and specified to the extent necessary to support the standard plant design: safety-related valves, reactor coolant loop piping, integrated head package, reactor coolant pump handling cart, passive residual heat removal heat exchanger, control rod drive mechanisms, polar crane, safety vessels, squib valves, etc.

Programmatic and Procedural Tasks

Addressing the programmatic and procedural tasks necessary for operating the standard plant includes the development (with NuStart utility support) of normal, abnormal, and emergency operating procedures as necessary to support the performance of control room human factors testing and required verification and validation activities.

Westinghouse prepared specifications for preoperational and startup procedures; normal, abnormal, and emergency operating procedures; and other procedures.

Systems Design

Westinghouse developed the **AP1000** reactor systems design details, performed design calculations, and prepared design documentation including system specification documents and process and instrumentation diagrams for each system. As part of this effort, Westinghouse prepared necessary inputs addressing system design to the level necessary for the standard plant design. Efforts included system integration support and oversight for development of the **AP1000** unit's I&C design, layout design, and component engineering evaluation and verification. It also included establishing and delivering plant and fluid system interface information and directions.

The following types of systems were addressed: auxiliary fluid; electrical; heating, ventilation, and air conditioning; mechanical handling; nuclear fluid; reactor cooling; steam and power conversion; waste water treatment, and radioactive waste.

Westinghouse also completed PRA work on the standard plant design and developed the standard **AP1000** plant construction and startup schedule.

*Figure 10. **AP1000** Control Room Simulator*

4.3 Design for Modularization

The **AP1000** standard design makes use of modern modular construction techniques, including both structural and equipment modules. Modularization will allow construction tasks that were traditionally performed in sequence to be completed in parallel. The modules for **AP1000** reactor projects in the United States will be manufactured at The Shaw Group Inc.'s new module fabrication facility in Lake Charles, Louisiana, and shipped to the plant sites, where they will be assembled into larger assemblies.

Experience gained from module fabrication and installation during construction of **AP1000** units in China is being applied to the design of the modules for **AP1000** plant projects in the United States.

The techniques that are used for modular design and construction are well tested in industries, such as the petrochemical industry, and are being adapted to the needs of the nuclear power industry. Experience from other industries was applied during the development of modular layout standards and details. These standards and details permit efficient and effective designs to be developed, which in turn allows prefabrication of plant components in a controlled fabrication shop environment while

site preparation activities are performed in parallel.

Assembly of the individual structural modules into the final structure is performed inside a building at the site to minimize environmental effects on the assembly process. Final installation is performed after assembly at the site. Smaller structural modules (such as floors and leave-in-place structural formwork), mechanical equipment modules, and piping modules are installed after the major structural modules are in place.

Figure 11. Shaw Modular Solutions Facility

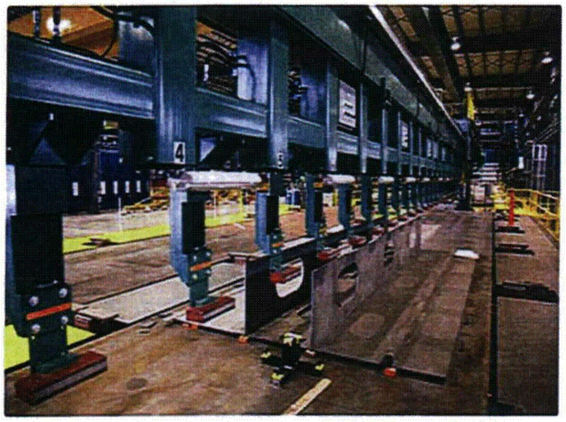

Figure 12. Shaw Modular Fabrication

All mechanical, piping, and structural modules are designed to be transportable by rail or truck. Shipping sizes are limited to 12 feet (height) × 12 feet (width) × 80 feet (length) and to weigh less than 80 tons. If barge access is available at the plant site, smaller submodules can be assembled into larger subassemblies and shipped to the site by barge.

4.4 Relationship of Design Finalization to Design Certification and Combined Operating License Application Reviews

During the NP2010 Program implementation, the DF activities were performed essentially in parallel with NRC reviews of the DC and COLA for each standard design. Support of these parallel activities added to the efforts of both industry and the NRC.

If time constraints were not a concern, it would be possible to consider a sequential process for design and licensing, e.g.:

1. The NRC develops and publishes all applicable regulations, regulatory guides, safety-related plans, and resolutions of generic safety issues needed.
2. The reactor vendor completes DF for its standard design and prepares the DC application.
3. The NRC reviews and approves the DC.
4. The NRC reviews and approves the first COLA referencing the DC.
5. The NRC reviews and approves the subsequent COLAs referencing the first COLA and the DC.
6. Procurement contracts are negotiated between the reactor vendor and the subvendors supplying equipment for deployment of the plants.

7. EPC contracts are negotiated between the reactor vendor and the utilities purchasing the standard designs.

However, in reality there are substantial interactions that occur between each of these steps that require some degree of rework, no matter how the steps are implemented. As a result, the processes are often iterative.

All of these steps can be performed in parallel, which is the experience of the NP2010 Program and the **AP1000** DC/DF project. This approach is leading to the deployment of the first new nuclear plants on a schedule that is many years shorter than a sequential process would have produced. It has also likely minimized the amount of rework needed. Most importantly, it has achieved the NP2010 Program's primary goal of expediting deployment of the first new nuclear plants.

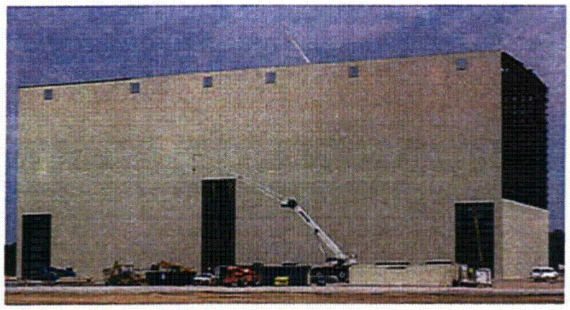

Figure 13. VC Summer Module Assembly Building

Figure 14. Vogtle Module Assembly Building Construction, November 2010

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5 Plant Cost Estimates

5.1 AP1000 Plant Cost Estimate Removed from Project Scope

At the start of the NP2010 project, NuStart had intended to hold a down-selection between the **AP1000** design and the other standard design being considered by NuStart, before submitting a single COLA to the NRC. A cost estimate for the **AP1000** design was to be generated to support this process. However, during the NP2010 Program, DOE restructured the cooperative agreements with NuStart and Dominion (which had already selected another standard design for its COLA) such that NuStart would proceed forward with a COLA for the **AP1000** design. Therefore, NuStart did not need to perform a down-selection.

Meanwhile, a number of NuStart members decided to pursue their own **AP1000** design COLAs, initiate the approval process with their own state PUCs, and initiate negotiations with Westinghouse for potential EPC contracts. As a result, the detailed design and licensing information for the **AP1000** standard design, generated under the NP2010 Program, was used as input to the cost estimates prepared to support these deployment efforts by individual NuStart members. However, the preparation of cost estimates and contractual terms for EPCs was not performed under the NP2010 Program.

5.2 Factors Affecting Plant Cost Estimates

The specific details and bases for current prices in EPC contracts for **AP1000** units are considered commercially sensitive. The release of any information regarding the pricing is governed by strict nondisclosure provisions between Westinghouse and the other parties. As a result, Westinghouse cannot provide information on current prices for the **AP1000** plant. However, an explanation of the major factors that have affected cost estimates for the **AP1000** plant over the last several years is provided below.

Before discussing the **AP1000** design cost estimates specifically, it is valuable to review the nature of estimating nuclear plant costs in general. The estimated plant cost for a new standard design can vary substantially as a function of time during the various phases of design, licensing, construction, and startup until the nth-of-a-kind plant has been constructed.

The EPRI Technical Assessment Guide[2] (TAG®[3]) for evaluating different electric generating technologies explains that much of this variation during development and deployment phases applies to any power generation technology, not just nuclear energy technology, because of factors such as the amount of design detail that is available throughout these phases. However, it should be recognized that the potential magnitude of the variation can be exacerbated by factors almost unique to the nuclear industry, such as the following:

- Long period of time that it can take to complete the development and deployment phases (more than 10 years)
- Even longer period of time that has transpired since the industry last supported new plant deployments (more than 25 years)
- Very stringent and still-evolving regulatory process that promotes extremely high levels of safety
- Large upfront investments that equipment suppliers must make to develop and qualify new designs for nuclear-grade equipment

2. *Program on Technology Innovation: Integrated Generation Technology Options*. EPRI, Palo Alto, CA: 2009. 1019539.
3. TAG is a registered trademark of the Electric Power Research Institute.

- Highly complex process for identifying financial risks in a deployment project and implementing contractual arrangements for allocating the risks among the various parties in the project
- Substantial external financing that must be arranged, including interactions with state PUCs, because of the capital-intensive nature of the nuclear power generation

Figure 15. Preparation for Construction at Vogtle Site, July 2009

As Admiral Rickover noted in his timeless 1953 speech about academic reactors versus practical reactors, cost estimates naturally tend to start low, early in the development phase, because the difficulties to be faced in working out the details are simply not yet known. This is corroborated by the shape of the cost curve in the EPRI TAG (shown in Figure 18). Cost estimates need to be prepared and updated at various steps during the development and deployment phases; however, it is important to recognize the project's status at the time the estimate was prepared and the potential for the estimate to change as the project progresses.

5.3 Early AP1000 Plant Cost Estimates

Westinghouse's early cost estimates for **AP1000** units were based on studies that stemmed back as far as the cost estimates prepared for AP600 under the ALWR FOAKE program. Prior to the start of the NP2010 Program in 2004, the cost estimate for an **AP1000** plant was approximately \$1500/kWe (overnight[4] cost in 2003 dollars). This estimate was based on a number of assumptions, the critical ones being the economic conditions at the time, assumed scope, business model, and contractual basis (including risk allocation) under which the units would be provided. Very importantly, the estimate was based on the status of the **AP1000** design as it existed at that time, including the limited level of design detail and the limited degree of input from potential constructors, equipment suppliers, and utility operators.

5.4 Updating Cost Estimates as the Design Progresses

Subsequent to the early cost estimates, licensing and detailed design of the **AP1000** standard plant have nearly been completed. Therefore, Westinghouse's current estimates are based on detailed specifications for the equipment and specific vendor quotations for all major items of equipment.

Additionally, the early cost estimates were intended to be representative of an nth-of-a kind-unit, with reduced construction schedules as part of a significant new-build nuclear program of identical units. The current prices in existing EPC contracts reflect the fact that these are the first **AP1000** units to be deployed in the United States, and the number of contractually committed units is limited thus far. Also, current price quotations are all being provided in response to extensively customized, individual utility specifications for the technical and supply scopes, as well as the commercial basis and risk allocation for the quotations.

4. Overnight cost does not include escalation or interest costs.

Construction schedules and estimates are based on extensive constructability reviews performed by Shaw construction experts in consultation with the Westinghouse and Toshiba equipment and systems designers. These reviews used state-of-the-art techniques such as three-dimensional computer models of the plant, as well as the latest information on construction labor costs and productivity performance. These detailed efforts identified a number of new or increased cost items, as compared to those assumed in estimates prior to the NP2010 Project.

5.5 Changing Economic Conditions

Economic conditions have changed very substantially since the start of the NP2010 Program. In addition to the amount of cost escalation that would normally be expected, an abnormally large increase in the costs of many key elements of major, capital-intensive infrastructure projects such as power plants, refineries, and chemical plants has occurred since that time. While overall inflation in the United States (as measured by the implicit price deflator for the gross domestic product) increased by about only 20 percent, the North American Power Capital Costs Index (PCCI) shows that power plant costs nearly doubled over this same time frame. The PCCI is a proprietary measure of power plant construction project cost inflation, similar in concept to the Consumer Price Index (CPI), which has been developed by IHS Cambridge Energy Research Associates®, Inc. (IHS CERA®)[5].

5. IHS Cambridge Energy Research Associates and IHS CERA are registered trademarks of IHS Cambridge Energy Research Associates.

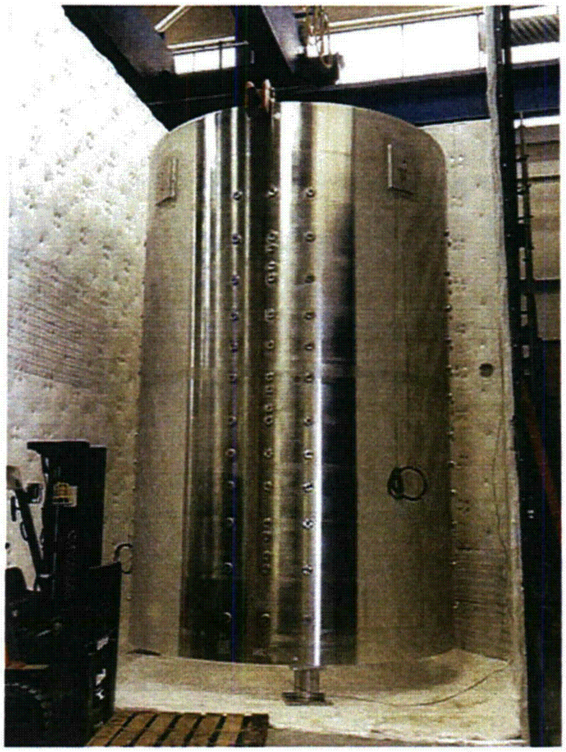

*Figure 16. Manufacture of **AP1000** Core Barrel Assembly in Newington, New Hampshire*

In part, these cost increases reflect unique circumstances associated with the substantial increase in demand (and the resultant price impact) for the types of specialized equipment, engineering, and construction resources required to support the high level of infrastructure projects being built in North America during this period. Also, a portion of this cost inflation was reflective of the worldwide impact of the increased prices of fundamental commodities, such as nickel, copper, stainless, and other specialty steels, and industrial equipment, driven by the economic growth and associated infrastructure-related construction activity in emerging markets such as China. During this time frame, the IHS CERA European PCCI increased by approximately 50 percent, demonstrating that a significant portion of the cost escalation seen in North America was reflecting worldwide trends.

The combination of cost growth at rates substantially above trend, very significant levels of volatility in such fundamental economic drivers as the price of oil, and rapid shifts in foreign exchange rates and interest rates have caused providers at all tiers of the supply chain to have significantly increased levels of concern regarding cost risk, which is then reflected in prices. The long-term nature of capital-intensive projects, particularly power plants and other heavy industrial facilities, has led to significant additional price increases as suppliers attempt to address the risks arising from such market volatility.

5.6 Changing Contractual Relationships

Another major factor behind the increase in prices is the result of the assumptions surrounding the business model and contractual basis that underpinned the original cost estimates. The current contracting and delivery model that has emerged since the start of the NP2010 Project is completely different from the contracting and delivery model that was used when existing nuclear plants were constructed in the 1970s and 1980s, in which the utility separately selected the architect-engineer, constructor, nuclear steam supply system supplier, and turbine-generator supplier.

In contrast, current commercial contracts for nuclear plants are based on a model in which the utility requires the nuclear plant supplier to take essentially turnkey responsibility to provide all elements of the finished power plant, including all FOAKE costs, licensing, design, equipment supply, construction, and startup, on a partially fixed-price basis, including much of the cost escalation and currency adjustment risk. While this contracting approach should provide a substantially greater degree of protection to the utility's shareholders and ratepayers, it requires the nuclear plant supplier to have a great deal more information about the details of its plant design and licensing, along with costs and schedule for procurement and construction, when the EPC contract is signed. This also means that the nuclear plant supplier must include sufficient contingency in the cost estimates to cover uncertainties and other unknown factors.

Not surprisingly, the nuclear plant supplier needs to flow these factors down to the vendors that are supplying equipment, material, and services to the plant supplier. This translates into substantial entry costs for any vendor to re-enter the nuclear supply business because of the unique requirements of the nuclear industry. U.S. suppliers are reluctant to make the needed financial commitments to capital investment, given the uncertain timing and magnitude of the long-term, new-build program in this country. Those who do participate must, because of the uncertainty, include much or all of their FOAKE costs in their initial supply contracts, which significantly increases the costs for the earlier units. Until a reliable, sustained marketplace for new nuclear plants is established, these factors both limit the availability of alternate suppliers and increase the costs that they must factor into their bids.

Besides helping to provide the more detailed information and certainty that are needed for deployment, the NP2010 Program helps to reduce the FOAKE costs that must be recovered in pricing the initial units. Because of this benefit, it is easier for the nuclear plant supplier and the utilities to overcome the higher economic hurdle for the initial deployment projects.

5.7 Looking Beyond the First Units

A number of organizations, including DOE's own Energy Information Administration, have published estimates of nuclear plant costs in recent years. One analysis worth consideration is the NEI publication on this topic, "The Cost of

New Generating Capacity in Perspective," updated in October 2010, in which NEI assumes an EPC price range of $4000/kWe to $4500/kWe for a new nuclear energy plant and analyzes electric generating costs compared to natural gas and coal plant alternatives. NEI's analysis demonstrates that, even with nuclear plants in this price range, nuclear energy can be competitive with fossil generation sources.

Figure 17. Setting of Containment Vessel Bottom Head at Sanmen Unit 1, December 2009

The cost to build future plants of a standard design should decrease as the number of units approaches the nth-of-a-kind unit because of the learning curve that is applied from one unit to the next. A good explanation of how cost estimates can vary during the development and deployment phases of a new technology (which is not limited to nuclear energy plants) is provided in the EPRI TAG from which Figure 18 is taken.

Accordingly, Westinghouse expects that the target price for future **AP1000** units would decline below the current range once FOAKE impacts have been addressed, successful experience has been demonstrated on the delivery of the early units, and the nuclear industry can reasonably forecast a sustainable, enduring market for new nuclear plants (which would support an effective, long-term supply chain). In particular, U.S. government policies to encourage the expanded use of nuclear energy in the United States could have a substantial impact on supply costs, since this would provide U.S. manufacturers with the confidence to make the investments required to either create or expand the needed supply capacity. In addition to reducing the cost of new nuclear units, this would benefit the economy by creating U.S. jobs in the near term.

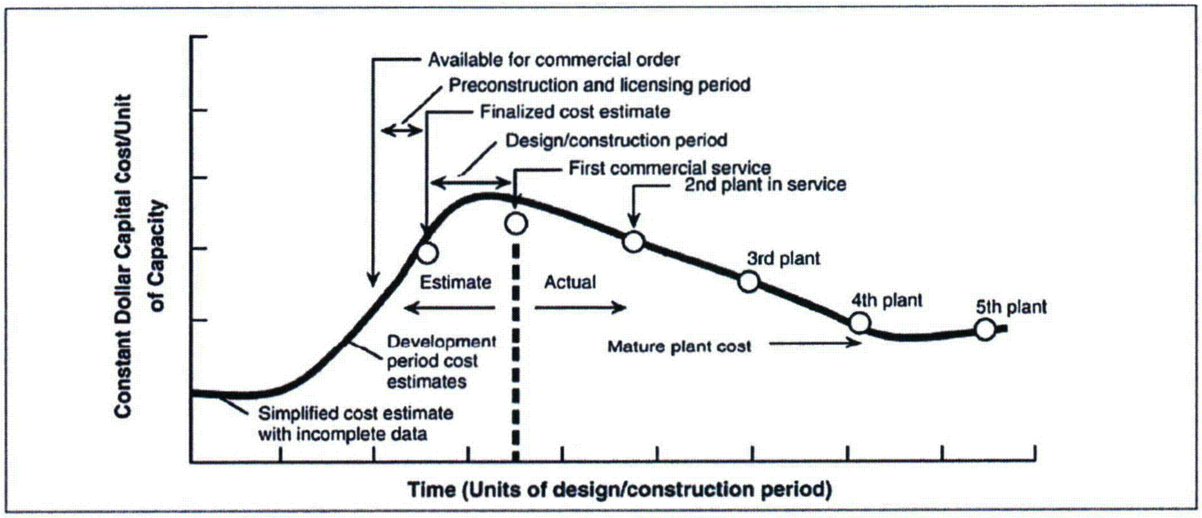

Figure 18. Cost Estimate Curve, Development through Deployment

Source: *Program on Technology Innovation: Integrated Generation Technology Options.* EPRI, Palo Alto, CA: 2009. 1019539.

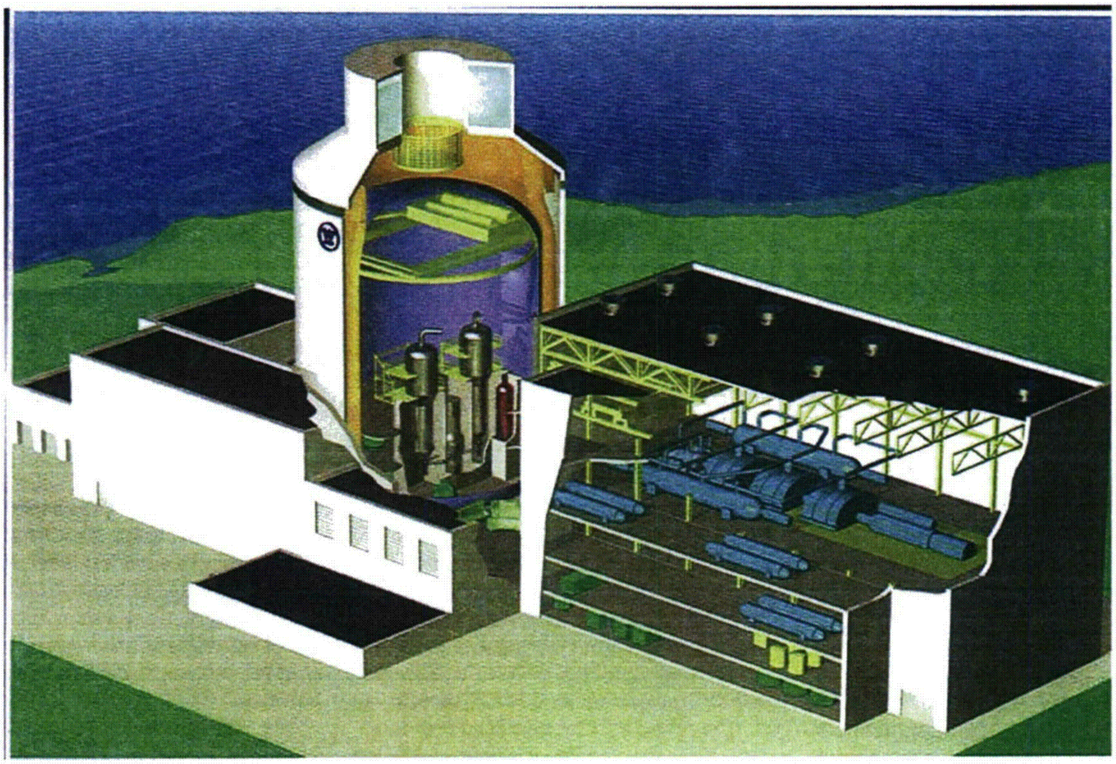

*Figure 19. Cutaway View of **AP1000** Unit*

6 Project Management

This section summarizes the project management approach for the **AP1000** DC/DF and discusses the interactions with DOE, beginning with the solicitation.

6.1 Earned Value Management System

The DOE cooperative agreement with Westinghouse required the implementation of an earned value management system (EVMS) in conformance with American National Standards Institute/Energy Information Administration (ANSI/EIA)-748. Westinghouse took action at the time of award to develop and implement such a system. Westinghouse chose the EVMS tool PRISM from ARES Corporation to facilitate the control and reporting of EVMS data. The scheduling tool used was Primavera, and the collection of actual cost was done through SAP. PRISM provided the requisite reporting capabilities of EVMS data to DOE, which was done on a monthly basis.

During the NP2010 Program, Westinghouse was awarded contracts to provide engineering and procurement services for the nuclear island portion of four **AP1000** units in China. In addition, several of the NuStart members entered into negotiations with Westinghouse for **AP1000** reactor projects in the United States.

As a result of having multiple **AP1000** reactor projects dependent on information from the standardized design, Westinghouse needed to coordinate EVMS tracking of activities within the DOE project scope with activities of other projects outside the DOE project. It was important to ensure that the costs were kept separate so that DOE funds would only be used to cost-share for the activities covering DC/DF of the standard design and supporting the NuStart COLA.

In the latter stages of the **AP1000** DC/DF project, it became clear that there would not be sufficient DOE funds to cost-share all of the activities planned. (In 2008, DOE capped its cost-share level. Subsequently, Westinghouse's estimate for completing **AP1000** DC/DF increased above DOE's cap.) As a result, Westinghouse reported to DOE on the EVMS status consistent with the scope of activities that fell within the cost-share cap and were completed during 2010. Westinghouse also provided NuStart and DOE with a summary level EVMS status for all **AP1000** DC/DF activities, which will be completed in 2011.

6.2 AP1000 Design Project Milestones

At the beginning of the program, Westinghouse, DOE, and NuStart agreed on a number of key milestones to monitor the progress of the Westinghouse DC and DF activities. On a quarterly basis, Westinghouse issued reports on the progress toward completing these milestones. On an annual basis, Westinghouse and DOE evaluated the status of the program and identified any appropriate adjustments, additions, or deletions of milestones and their due dates. Table 6-1 provides a summary of the program milestones with actual or anticipated completion dates.

6.3 AP1000 Design Project Participants

During the execution of the **AP1000** DC/DF project, Westinghouse contracted with a number of companies to provide resources or services in support of the project's objectives. The companies, listed in Table 6-2, have made a significant contribution to **AP1000** design through the provision of qualified resources to augment the Westinghouse engineering staff or the performance of specific design and testing activities.

Table 6-1. Project Milestones

Milestone	Date
DOE/NuStart cooperative agreement and NuStart/Westinghouse subaward initiated with project kickoff meeting	May 3, 2005
Project execution plan developed per DOE interface and oversight agreement	Sept. 26, 2005
NRC voted to support **AP1000** DC rule (based on **AP1000** DCD Revision 15)	Dec. 31, 2005
AP1000 DC rule published in Federal Register	Jan. 27, 2006
Normal, abnormal, and emergency operation procedures necessary to support the second integrated human factors test completed	April 10, 2006
Seismic analysis report for soft soils completed	April 17, 2006
First **AP1000** design human system interface engineering test conducted	May 26, 2006
First human system interface engineering test completed	Aug. 8, 2006
Cost, schedule, and technical baseline approved by DOE	Feb. 28, 2007
DOE/Westinghouse cooperative agreement project kickoff meeting	May 30, 2007
AP1000 DCD Revision 16 submitted to the NRC	May 26, 2007
All **AP1000** design inputs necessary to support the COL application provided	July 31, 2007
Analysis of **AP1000** plant piping necessary to address COL information items completed	July 31, 2007
Human system interface engineering test completed	July 31, 2007
Technical report addressing equipment qualification-related COL information items submitted to the NRC	July 31, 2007
Primary equipment ASME Code as-designed stress reports necessary to support COL application completed	July 31, 2007
Technical reports addressing fuel-related COL information items submitted to the NRC for review	July 31, 2007

Table 6-1. Project Milestones (cont.)

Milestone	Date
Technical reports addressing COL information items in Chapters 6, 9, and 10 submitted to the NRC for review	July 31, 2007
Inputs necessary to address PRA-related COL information items completed	July 31, 2007
Construction schedule to the level of detail required to support COL application completed	July 31, 2007
All **AP1000** design inputs necessary to support the COL application provided	July 31, 2007
Turbine generator design specification, Revision A, completed	August 7, 2007
Revisions to 10 CFR 52 on DC amendment process issued by NRC	Aug. 28, 2007
Project cost and resource loaded schedule baseline established	Oct. 31, 2007
List of agreed design finalization engineering reports completed	Oct. 31, 2007
Analyses necessary to address structural/seismic COL information items completed	Oct. 31, 2007
Human factors engineering integrated engineering test plan completed	Nov. 15, 2007
DOE independent review of cost, schedule, and technical baseline completed	Dec. 31, 2007
Westinghouse application for **AP1000** DC amendment docketed by NRC	Jan. 28, 2008
Plant design system structural model for CA20 module developed	March 31, 2008
All design criteria documents (Revision 0) completed	Dec. 15, 2008
AP1000 DCD Revision 17 submitted to the NRC	Sept. 22, 2008
Second human factors engineering integrated engineering test completed	Nov. 14, 2008
Auxiliary fluid systems preliminary design (Revision 0) completed	Nov. 30, 2008
Reactor coolant pump final design review addenda completed	Nov. 20, 2008
Control rod drive mechanism final design review completed	March 26, 2009

Table 6-1. Project Milestones (cont.)	
Milestone	**Date**
Mechanical modules and verification within plant design system building model finalized	March 31, 2009
Equipment design specifications (Revision 0) for auxiliary heat exchangers completed	April 22, 2009
Squib valve intermediate design review completed	June 23, 2009
Reactor vessel final design review completed	Sept. 4, 2009
Steam generator final design review completed	Sept. 23, 2009
Accumulator final design review completed	Sept. 25, 2009
Reactor vessel integrated head package final design review completed	Sept. 25, 2009
Polar crane final design review completed	Oct. 23, 2009
Passive residual heat removal heat exchanger final design review completed	Nov. 19, 2009
All electrical component design specifications completed	Jan. 13, 2010
Complete pressurizer final design review completed	March 15, 2010
Core makeup tank final design review completed	March 30, 2010
Squib valve functional test report and final design review completed	July 14, 2010
Final design review for the reactor coolant system completed	Oct. 29, 2010
AP1000 DCD Revision 18 submitted to the NRC	Dec.1, 2010
Final design reviews for all nuclear systems completed	Dec. 8, 2010
AFSER on DCD Revision 18 issued by NRC	Dec. 28, 2010
Anticipated NRC issuance of FSER	April 2011
Anticipated issuance of **AP1000** DC amendment	Sept. 2011

Table 6-2. AP1000 Design Project Participants
Alion Science & Technology Corporation
Amit Varma & Associates
Anatech Corporation
ARES Corporation
Ansaldo Nucleare s.p.a.
Chicago Bridge & Iron Company N.V.
Curtiss-Wright Electro-Mechanical Corporation
Curtiss-Wright Flow Control Company (Trentec)
Enercon Services, Inc.
MMI Engineering – A Geosyntec Company
EnergySolutions, Inc.
Equipment & Controls, Inc.
GAI Consultants, Inc.
General Dynamics/Electric Boat Division
GForce Engineering & Technology, Inc.
Hatch Associates Consultants, Inc.
High Bridge Associates, Inc.
Holtec International, Inc.
Korea Power Engineering Company, Inc.
MPR Associates, Inc.
NC Consulting Inc. – Design Engineering Services
NuVision Engineering, Inc.
Obayashi Corporation
Oregon State University
Polestar Applied Technology, Inc.
Purdue University
Siemens Energy & Automation, Inc.
Southern Nuclear Development Company
SPX Corporation – Process Equipment
SSM Industries, Inc.
The Shaw Group Inc./Stone & Webster, Inc.
Tioga Pipe Supply Company, Inc.
Toshiba Corporation

6.4 Interactions with DOE

After issuing a solicitation to utilities for early site permits under the NP2010 Program, DOE planned to issue a solicitation to reactor vendors for DC and DF of standard nuclear plant designs, followed by a solicitation to utilities for combined COLs. To ensure that utilities would go ahead with COL programs before DOE committed funds to the DC and DF programs, DOE modified its plans to instead issue a single solicitation for DC, DF, and COL combined. The projects were intended to be a demonstration of the COL process that was being implemented for the first time and provide enough detailed information for the standard designs to support commercial decisions by utilities on whether to proceed with deployment of a project. This solicitation prompted the formation of NuStart.

After awards were made under the NP2010 Program, Congress passed EPACT 2005, which provided incentives for nuclear plant deployments. Five of the NuStart members decided to pursue six **AP1000** plant COLAs in addition to the one already being pursued by NuStart and TVA for the Bellefonte site. In addition, Westinghouse received a contract to supply portions of the **AP1000** plants for four units in China. Meanwhile, the NRC was revising and updating regulations and guidance for licensing new plants.

These events resulted in the need to adjust the schedule for engineering activities in the **AP1000** design DOE project while the program was being carried out. DOE's flexibility in accommodating these changes was essential to the program's success. It was particularly important that DOE recognized that the ultimate goal of the NP2010 program was to facilitate industry decisions to deploy new nuclear plants in the United States, and not simply to demonstrate the DC, DF, and COL processes.

As with many multi-year DOE cooperative agreements, DOE funding was subject to the availability of annual appropriations, which created a degree of uncertainty as to whether full funding would be available each year to support the work scope specified in the cooperative agreements. Although some research projects might be able to accommodate DOE funding shortfalls in a particular year by simply delaying work scope and stretching the overall schedule, projects involving NRC review activities are not so easily adjusted. Fortunately, the **AP1000** DC and DF project did not experience any delays because of the annual appropriations process. Westinghouse was able to inventory costs (at its own risk), and thus be flexible in the timing of DOE funds during the project because of other activities related to deployment of the **AP1000** design (such as the **AP1000** plant projects in China and the negotiation of EPC contracts in the United States).

During the NRC review of ITAACs in the **AP1000** DC amendment and COLA, DOE recognized that uncertainties would remain after issuance of the COL when it came time for the NRC to approve closure of the ITAACs. As a result, DOE was proactive in initiating a small demonstration activity for Westinghouse, Southern, and NRC staff to perform a set of tabletop exercises to test the interactions in closing a small sample set of ITAACs. This activity will be completed in 2011 and should help industry and the NRC to be better prepared to process ITAAC closures during the construction and startup phases.

After the NP2010 Program participants identified increased costs for completing the program, DOE agreed to increase its cost-share funding to the project in 2008; however, DOE also stipulated that it would not cost-share in any further cost increases.

Except for completion of the ITAAC demonstration activity, the DOE cost-share for **AP1000** DC and DF was exhausted in 2010, even though the DC and DF efforts will not be completed until 2011. Westinghouse is completing the DC and DF efforts without DOE funding during the last year because of Westinghouse's EPC commitments to support the initial **AP1000** plant deployments in the United States. Thus, DOE will still achieve its ultimate goal for the NP2010 program – initiating deployment of new nuclear plants in the United States – without having to fully cost-share on all of the DC and DF activities that will ultimately be necessary.

6.5 Structure of NP2010 Program and Awards

Overall, the use of cooperative agreements in the NP2010 program was very effective. The DOE cost-share provided the incentive that was necessary for industry to commit the resources and its matching cost-share to proceed with the DC/DF projects, well in advance of the incentives offered in EPACT 2005. Industry cost-sharing also provided a basis for DOE to approve patent waiver requests, which were essential for reactor vendors to agree to proceed with the projects. DOE participation, along with NuStart, in the management of DC/DF activities in the cooperative agreements ensured that the activities provided generic benefits to the entire industry.

The NP2010 Program solicitation's requirement that DC/DF activities for the standard design be linked to COLAs likely played a major role in the program's success by ensuring utility oversight, involvement, and commitment to the program. The solicitation resulted in reactor vendor DC/DF activities being performed as subcontracts to the utility awards. However, combining the DC/DF activities and the COL activities into a single solicitation delayed the start of DC/DF activities until DOE and the utilities were prepared to proceed with the COL solicitation. It may have been more efficient if the reactor vendors had been given a head start in initiating the DC activities before beginning the COLA activities, even though much of the NRC's reviews of the DC and COL applications might still overlap.

During the NP 2010 Program, DOE restructured the projects such that each reactor vendor's DC/DF project was in a direct cooperative agreement with DOE. Each reactor vendor also entered into an agreement with NuStart to continue with the same support to NuStart as previously provided under the original subcontract. However, the direct cooperative agreement with DOE ensured that each reactor vendor's DC/DF project would continue to completion and under direct DOE management. It also provided each reactor vendor with the flexibility to adjust the schedule for engineering activities as needed to support commercial deployment decisions by individual utilities.

For future DOE solicitations, a possible improvement might be to allow reactor vendors to submit DC/DF proposals that are separate from, and earlier than, the utilities' COL proposals, but require that the proposals be linked at some point. This could allow an earlier start to the DC/DF activities for the standard designs and avoid the need for restructuring the cooperative agreements later.

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7 Lessons Learned

The following tables provide a summary of the insights gained from experiences during the project relative to the expectations that existed when the NP2010 Program began. The purpose of identifying them here is to enable future programs to benefit from the knowledge gained though these lessons learned. Where possible, the lessons learned have already been applied by industry and the NRC during the remainder of the NP2010 Program.

Figure 20. Aerial View of Haiyang Site, December 2010

Figure 21. Setting of Containment Vessel Ring Number 4 at Sanmen Unit 1, December 2010

Lessons Learned Related to the Program Summary (Section 2)

Number	Insights	Lessons Learned
2-1	Completing the design and licensing before construction of a plant begins (via DF, DC, and COL) has substantially reduced the risks of schedule delays and cost overruns during construction, which is a prerequisite for utilities to make a decision to proceed with construction of a new nuclear plant. However, it also significantly increases the upfront investment that is required to introduce a new standard design in the U.S. marketplace.	The high level of design detail needed to support NRC licensing and to support a commercial decision to deploy a plant creates a very high threshold for introducing a new standard design. An investment of several hundred million dollars is required.
2-2	There were frequent interactions between the processes (being performed in parallel) for completing the DF, DC, and COL activities, as well as accommodating feedback from construction and procurement activities. This led to occasional observations that it would be better to perform processes in sequence rather than in parallel.	To deploy a new standard design in less than a decade, the activities for DF, DC, COL, and commercial contracting of the initial units cannot realistically be performed in sequence, even though this may seem to be the ideal. The activities will overlap and there will be considerable interaction between them.
2-3	There were frequent interactions between the reactor vendor, individual utilities, DCWG, NEI, Nuclear Power Oversight Committee, INPO, NRC, EPRI, ASME, and others in order to develop guidance and resolutions to issues as generically as possible, promote standardization, share experiences, and minimize overall resource needs.	A very strong commitment to standardization within the industry, as well as between industry and the NRC, is necessary to minimize human resource needs, minimize rework, and maintain the schedule for deployment. Communication, cooperation, and clear buy-in between all parties are also extremely important.
2-4	The NP2010 Program prompted industry to organize (e.g., formation of NuStart), begin planning and preparation for new nuclear plant deployment activities (e.g., NEI New Plant Working Group activities), and begin working with the NRC to establish requirements and detailed guidance for licensing new plants at least 2 years sooner than would have occurred if industry waited for passage of EPACT 2005. This head start profoundly impacted industry's ability to react to EPACT 2005 incentives.	Initiation of an industry partnership program by DOE (e.g., NP2010), in advance of legislation that provides financial incentives for deployment, can dramatically improve the likelihood that industry will be successful in commercial deployment of an advanced new technology.

Number	Insights	Lessons Learned
2-5	External factors (e.g., NRC review, interaction with construction projects in China, and support of deployment plans by several NuStart members) required adjustments to (and acceleration of) the engineering schedule, and eventually increased the work scope. Recognizing the importance of these adjustments to achieve the goal of a decision by industry to proceed with deployment, DOE was very cooperative in allowing adjustments during the project.	Flexibility in the implementation of the cooperative agreement between DOE and the plant supplier (for DC and DF) is necessary to allow the engineering and licensing activities for the standard design to adapt to external forces in the evolving marketplace.
2-6	Active engagement of NuStart and individual members of NuStart in the **AP1000** design engineering and licensing activities throughout the process has been extremely valuable in ensuring that the end product meets the needs of the marketplace.	Active participation by utilities that are seriously evaluating commercial deployment projects is the best means available for providing input and guidance to the plant supplier, obtaining buy-in, and ensuring that the program will meet the needs of the marketplace.
2-7	The NRC expected a much greater level of detail in plant design for review of the **AP1000** plant DC amendment application than was provided for the NRC review of the original **AP1000** plant DC application. In addition, Westinghouse sought to close as many licensing issues as possible under the DC amendment to minimize the number of issues to be addressed in the COLAs, which added to the detail and review cycle.	For any part of the design scope that is remotely related to the DC application, the engineering schedule and budget should be front-end loaded in the DC and DF program to support the NRC review and audits.
2-8	Utilities wanted to start safety-related construction immediately after issuance of the COL, which required that some of engineering work needed to be accelerated in the DC and DF program schedule (e.g., to support procurement of long lead-time materials such as reactor vessel forgings).	Engineering schedule and budget planning should reflect a utility's plans for start of safety-related construction relative to COL issuance.
2-9	Because of the lack of new plant orders for more than 20 years, companies involved in the DF project (as well as companies supporting them) needed to increase the sizes of their engineering, licensing, and procurement organizations substantially during the performance of the project. This made the project significantly more complex than it would have been if the organizations were already staffed and functioning.	Budget and schedule planning for the project must consider the complexities that result from the following: • The impact of growing the organization (including management structure and employee training) in each company while performing the work scope in parallel • Managing the interfaces between the companies participating in the DF project

Number	Insights	Lessons Learned
2-10	Input from multiple utilities pursuing COLs for the same standard design sometimes reflected differing perspectives about the most desirable solutions for engineering and licensing issues for the standard design, depending on the schedule for their individual COL, to support start of construction. Those perspectives had to be reconciled among utilities and the reactor vendor to achieve a single solution that did not delay the first deployment projects.	Utilities and the reactor vendor need to develop and implement a process for achieving consensus on a single solution for decisions on engineering and licensing issues for the standard design that does not delay first projects.
2-11	Performance of work scope in the DC and DF project by utilities and the reactor vendor often identified the need for activities by industry groups (e.g., NEI, INPO, ASME, EPRI, and others) to develop generic industry guidance; coordinate with other DC, DF, and COL projects; and, in some cases, interact with regulators. Information from the DC and DF project was helpful in preparing the generic guidance.	Engineering schedule and budget should allow for interactions with industry groups to support generic industry activities, promote standardization, and encourage sharing of experience and lessons learned, since such interactions can impact schedule and budget.
2-12	To start safety-related construction immediately after issuance of COL, utilities needed to enter into EPC contracts prior to COL issuance in order to support reviews by state PUCs and to support applications for DOE loan guarantees. This required that engineering work that might affect contractual issues be accelerated.	Engineering schedule and budget planning should consider the utilities' schedules and plans for seeking PUC approvals and negotiating EPC contracts.
2-13	During the design process, utilities often provided feedback about how operation of the plant could be improved by design changes, which sometimes impacted the DC and DF program budget and schedule.	Engineering schedule and budget planning should include extensive interactions with utilities and implementation of feedback affecting the standard design, since such interactions can impact schedule and budget.
2-14	Fabrication and construction activities for overseas projects on earlier deployment schedules than the U.S. projects (thus, in parallel with the DC and DF program) often provided feedback that required design changes, which impacted the DC and DF program budget and schedule.	Engineering schedule and budget planning should allow for extensive feedback from ongoing projects that are being deployed on earlier schedules.

Number	Insights	Lessons Learned
2-15	The industry and NRC process for closing ITAACs, which ensures the construction projects will not be delayed, was not fully developed and demonstrated during the DC and DF project. The risk of regulatory delays during construction and startup for the first projects of the standard design could be significant, especially if there is a bottleneck in closure of ITAACs just before the NRC must issue its finding that allows fuel load. The small ITAAC demonstration exercise performed near the end of the NP2010 Program only scratched the surface of this issue.	Although the NP2010 Program considered the licensing process to have been demonstrated at the issuance of the first COL for the standard design, there is still significant risk to the construction and startup schedule for the first projects of a standard design that could result from the still unproven regulatory process for closure of ITAACs. Government and industry still need to demonstrate the entire ITAAC closure process for the first units. Such an effort should also include demonstration of a program to support NRC oversight of construction inspection.
2-16	Besides feedback that was incorporated in the DC/DF activities, fabrication and construction activities for overseas projects and the initial U.S. projects are also providing lessons learned that could be applied to future U.S. projects.	Government and industry should develop and implement a program for proactively identifying and collecting lessons-learned data on one project and applying the lessons learned to future projects.
2-17	Because of high hurdles to entering the nuclear supply market and uncertainty about prospects for follow-on sales to future projects, the number of qualified, competitive equipment suppliers was limited (particularly in the United States). This limited the amount of feedback on the standard plant design and likely increased plant cost estimates for the first wave of projects. It also may have delayed capital investments and hiring by potential equipment suppliers.	The availability of adequate infrastructure to support initial deployments in the United States was not directly addressed by the NP2010 Program. A follow-on program by government and industry could accelerate efforts by potential equipment suppliers to enter the market. This could increase competition, reduce plant cost estimates, provide additional feedback for improving the standard design, and reduce risks of schedule delays from an inadequate supplier base.

*Figure 22. Twin Unit **AP1000** Plant*

Lessons Learned Related to Design Certification (Section 3)

Number	Insights	Lessons Learned
3-1	The NRC issued revisions to 10 CFR 52, other regulations, regulatory guides, and standard review plans after the start of the DC and DF program and after preparation of design and licensing documents was initiated. This required changes to the DC/DF program plans, including budget and schedule and rework.	There should be an effort to identify and revise as necessary any related regulations and guidance that might affect the DC and DF program as early as possible. Recognizing that there will inevitably still be some regulation and guidance changes during the DC and DF program, the engineering budget and schedule planning should take this into account.
3-2	EPACT 2005 prompted a number of utilities to submit COLAs in parallel with the demonstration COLA. This required support of multiple, parallel COLA reviews, as well as review of the DC amendment in parallel with the COLAs, including the demonstration COLA (which became the R-COLA). As a result, this increased complexity for the reactor vendor, utilities, and the NRC.	Processes for coordinating support of multiple parallel reviews (e.g., DCWGs) are needed to manage resources of the reactor vendors, utilities, and NRC.
3-3	The NRC interactions with safety regulators in other countries who were also reviewing the standard design resulted in new NRC questions and issues raised late in the review process, which likewise occurred in other countries.	It is important to consider and plan for parallel or overlapping safety reviews of the same standard design by multiple regulators in order to avoid unnecessary regulatory-driven schedule delays and unnecessary regulatory variations from a single standard design for each country.
3-4	The DCWG has been a very effective means for the following: • Coordinating regulatory issues and processes between the NRC, the DC applicant for the standard design, and all of the COL applicants using the standard design • Maximizing standardization of the design, as well as between the COLAs • Avoiding schedule delays during the review	Project planning should include formation of a DCWG and the activities that will be needed to coordinate between the NRC, DC applicant, and COLA applicants. This will require substantial resources to implement, but should benefit future deployment projects by minimizing the risks of schedule delays and by maximizing standardization.
3-5	NEI played a very important role in representing industry during interactions with the NRC for regulatory issues, processes, and policies that were applicable to more than a single DCWG. This also maximized standardization across the industry, e.g., across multiple standard designs.	Project planning should include activities for interacting with NEI on regulatory issues, processes, and policies that can be addressed generically.

Number	Insights	Lessons Learned
3-6	Frequent communications between NRC management and the applicant's management (at multiple levels) were extremely important in quickly resolving issues and maintaining review schedules, especially during the latter phases of the review, when there were multiple NRC issues to track and close.	It is important to establish and maintain frequent communication between NRC management and the applicant's management to track and prioritize closure of issues on schedule.
3-7	During the **AP1000** DC amendment review, NRC staff often questioned issues that were previously closed by the initial **AP1000** DC and were not part of the DC amendment request. Similar issues could surface in the future, e.g., during NRC staff's review of subsequent COLAS (S-COLAs) after the R-COLA has been issued.	Prior to reviewing a DC amendment or S-COLA, the NRC should consider providing detailed guidance about closure of issues from the initial DC or R-COLA and procedures for quickly resolving any questions about whether or not an issue is open for review.
3-8	Interpretation of what is needed to satisfy guidance or criteria for a particular issue (for both the NRC and industry) can often be subjective and vary from one individual to another.	When an NRC reviewer first expresses concern about whether or not guidance or criteria are being satisfied, it is important for the reviewer and the applicant to quickly understand each other's interpretation and reach agreement on a mutually acceptable path to resolution if possible or involve their respective managements to reach resolution. It may be helpful to have a uniform process in place for raising (or appealing) issues to management in a timely fashion.
3-9	In some cases, it was difficult to determine how the information requested by an RAI (or the level of detail in the requested information) was needed to demonstrate compliance with a regulatory requirement. RAIs from the NRC sometimes required clarification.	Before RAIs are formally transmitted to the applicant, it is important for both the NRC reviewer and the applicant to understand specifically what is be requested, the regulatory requirement that is the basis for the request, and the level of detail that will be needed to allow the reviewer to close the issue to meet the regulatory requirement.
3-10	As preparation for construction at Vogtle (R-COLA for the **AP1000** design) became more apparent, the NRC gave appropriate priority to its resources and focused on holding to the schedule for closure of the DC amendment review.	The NRC will provide the appropriate priority and work diligently with the applicant to maintain the review schedule (without sacrificing the quality of its safety review) when there is a construction project for which the start depends upon completion of the review.

Number	Insights	Lessons Learned
3-11	During the **AP1000** DC amendment review, Westinghouse attempted to close out the piping DAC that was in the initial DC. Although a substantial amount of piping-related DF work was accelerated, the level of detail was not sufficient to meet the individual reviewer's expectations. DAC closure post-COL increases the risk of regulatory delay during construction.	There should be an effort to develop uniform guidance on the level of detail needed to close out DACs in order to maximize closures during the DC review and/or COL review.
3-12	In some areas of the DCD, the NRC has increased the level of detail to be included in Tier 2* (which would require NRC review if later revised). This will reduce the licensee's flexibility in making design changes during construction without first obtaining NRC review and approval. This increases the risk of regulatory delay during construction	There should be an effort to develop uniform guidance on the level of detail that should be included in Tier 2*, as well as the process for making 50.59-like evaluations post-COL.
3-13	Although the NRC revised 10 CFR 52 to provide for amendment of a DC, there is no clear guidance for the review process. Westinghouse included many changes throughout the DCD. It was difficult for Westinghouse to establish the boundaries of the review with the NRC staff.	It would be helpful if NRC guidelines were established for submittal and review of an application to amend a DC, recognizing that the size and complexity of amendment requests could vary substantially.
3-14	After the NRC substantially increased the size of its staff to support new plant reviews, Westinghouse devoted a significant amount of effort to briefing NRC staff on the advanced passive technology in the **AP1000** design, since the new reviewers had not been involved in prior reviews of the AP600 or **AP1000** design.	Project planning should recognize and account for a significant up-front effort to familiarize NRC reviewers with the advanced features of a new technology, including the impacts that the advanced features have upon the more conventional parts of the plant.

Lessons Learned Related to Design Finalization (Section 4)

Number	Insights	Lessons Learned
4-1	Utilities requested a higher level of standardization than was envisioned during the ALWR program (e.g., specifying identical control rooms among multiple utilities and routing of small-bore piping during DF instead of field-run piping).	The engineering budget for standard design should be sufficient to cover a higher level of standardization.
4-2	Obtaining firm commitments for schedule, pricing, and contractual terms with equipment suppliers required highly detailed specifications from the reactor vendor, which required a high level of design detail for systems and structures in which the equipment would be located.	Engineering schedule and budget planning should reflect the extensive amount of detailed information needed to support specifications for manufacturing and procurement.
4-3	Feedback from equipment suppliers sometimes resulted in the need to modify the standard design.	Engineering schedule and budget planning should allow for extensive interactions with equipment suppliers that might affect the standard design.
4-4	At the latter stages of the NRC review, it became necessary to freeze the standard design so as to minimize changes to the DCD that would require further NRC review.	To the extent feasible, the schedule and budget for DF should be front-end loaded to minimize any design changes during the latter stages of the NRC review. In addition, recognize that some design changes may be necessary during the latter stages of the NRC review and may have to be addressed by the COLA applicant or foregone entirely.
4-5	U.S. utilities needed to initiate training programs for operators for new plant design several years earlier than originally anticipated. This required acceleration of efforts to develop the control room design and development of a plant simulator.	The engineering schedule and budget should allow for supply of the control room simulator for the first plants of a standard design several years ahead of plant completion. Plant model software needed to run the simulator will accelerate the need for detailed plant design parameters in the engineering schedule and budget.
4-6	Significant engineering resources over a period of several years were required to complete the **AP1000** DF. These resource requirements were beyond those available within the company's sustainable new plant design organization. The use of subcontractors and other temporary engineering resources was essential to completing the design on this schedule.	Careful planning and strong oversight of all design work performed by outside organizations or individuals are critical to successful and efficient execution.

Lessons Learned Related to Plant Cost Estimates (Section 5)

Number	Insights	Lessons Learned
5-1	Earlier plant cost estimates were significantly impacted by the contractual terms and risk allocations that resulted from EPC contract negotiations.	Early plant cost estimates need to consider potential future EPC contractual terms and risk allocations as uncertainty factors.
5-2	Significant increases from the early plant cost estimates for the standard design until the implementation of EPC contracts for the first deployment projects created concern about competitiveness of plant pricing for future deployment projects. This has been exacerbated by the current economic slump and decline in natural gas prices. As explained in the EPRI TAG, cost estimates for any technology can be expected to vary over time as the project proceeds from early development (with incomplete details) until the first units are deployed. Cost estimates can then be expected to decline until the nth-of-a-kind unit has been deployed.	Government and industry should consider a program that could be carried out to identify potential nth-of-a-kind plant cost reductions for a standard design and to identify additional steps that could be taken to further improve competitiveness of future deployment projects.

Lessons Learned Related to Project Management (Section 6)

Number	Insights	Lessons Learned
6-1	Dependence on the annual appropriations process meant that DOE funding to support the DC and DF project budget and schedule did not always align properly, especially when revisions to the project budget and schedule were necessary. This is particularly significant because support of the NRC review cannot easily be adjusted to match the appropriations process without impacting overall project costs and schedule.	Utility and reactor vendor participants in a DOE cost-shared project must be prepared to provide industry funding when needed (and inventory the DOE cost-share at the industry's own risk) to maintain overall schedule and budget, especially when the design is undergoing NRC review. DOE and industry budget planning must be flexible in order to adapt to revisions in the project's budget and schedule that will likely occur.
6-2	Thousands of unique design and licensing activities are required to achieve DC and DF. These activities involve numerous complex interfaces that must be scheduled, budgeted, and integrated.	The development of a resource-loaded schedule and implementation of an EVMS from the onset of the DC and DF projects is critical to successful execution. These project management tools were essential to developing the project-specific procurement and construction schedules for the EPC contracts.

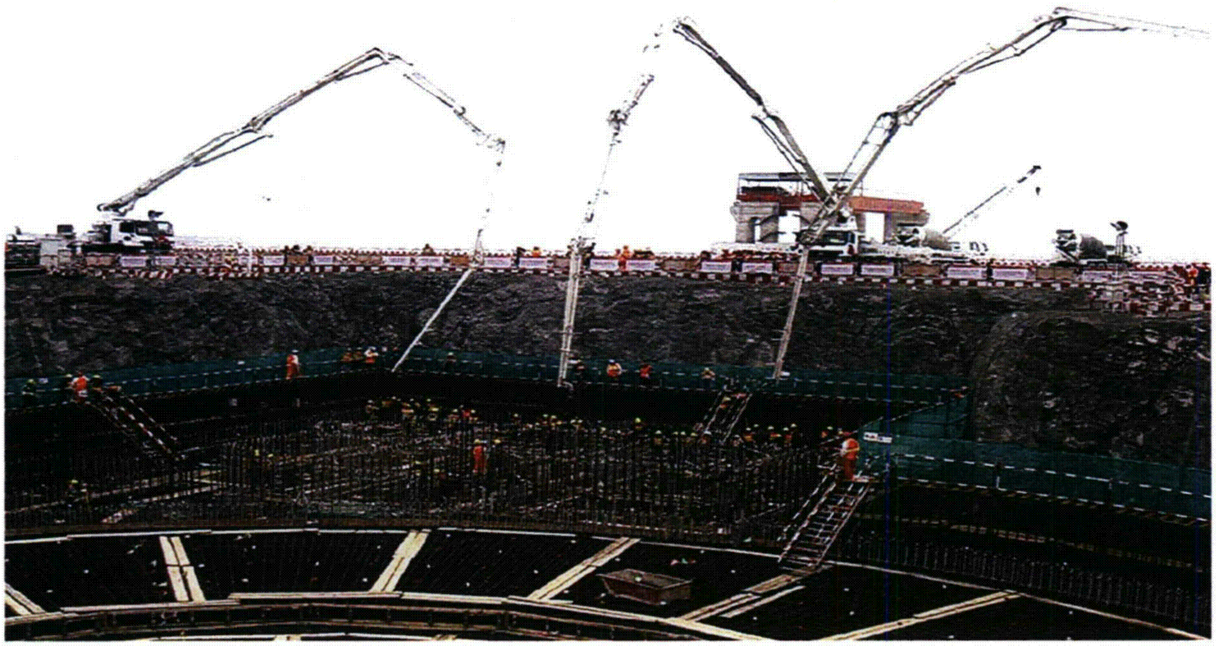

Figure 23. Pouring of First Concrete at Sanmen Unit 1, March 2009

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8 Appendix

RULEMAKING ISSUE
(Notation Vote)

January 3, 2011 SECY-11-0002

FOR: The Commissioners

FROM: R. W. Borchardt
Executive Director for Operations

SUBJECT: PROPOSED RULE: AP1000 DESIGN CERTIFICATION AMENDMENT (RIN 3150-AI81)

PURPOSE:

The purpose of this paper is to request Commission approval to publish for public comment a proposed rule that would certify an amendment to the AP1000 standard design. The amendment would replace combined license (COL) information items and design acceptance criteria (DAC) with specific design information, address compliance with the aircraft impact assessment (AIA) rule, Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.150, "Aircraft Impact Assessment," and incorporate design improvements resulting from detailed design efforts.

SUMMARY:

Westinghouse Electric Company LLC (Westinghouse) requested changes to the AP1000 certified design, which the U.S. Nuclear Regulatory Commission (NRC or Commission) approved in the AP1000 design certification rule (DCR), 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Appendix D, "Design Certification Rule for the AP1000 Design." Westinghouse seeks to replace COL information items and DAC with specific design information, address compliance with 10 CFR 50.150, and incorporate design improvements resulting from detailed design efforts.

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The Commissioners - 2 -

The NRC staff reviewed the requested changes and documented its safety review in the advanced final safety evaluation report (AFSER), related to certification of the AP1000 standard design Revision 18, on December 28, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML103260072). The staff believes that the amendment will continue to meet all applicable requirements in 10 CFR 52.54, "Issuance of Standard Design Certification." The final version of the safety evaluation report (SER) will only be subsequently modified to incorporate editorial (correction of typographic, grammatical, and cross-referencing errors) and conforming changes reflecting the Commission's staff requirements memorandum on this paper. It will be issued and available to the public by the time the proposed rule is published in the *Federal Register*. Therefore, the staff seeks Commission approval to publish in the *Federal Register* a proposed rule amending the AP1000 DCR.

BACKGROUND:

The AP1000 standard design was initially certified in Appendix D, to 10 CFR Part 52, on January 27, 2006 (71 FR 4464). The AP1000 standard design is described in Revision 15 to the design control document (DCD), which is incorporated by reference in Appendix D.

Westinghouse submitted Revision 16 to the DCD in its application to amend the AP1000 design certification on May 26, 2007 (ADAMS Accession No. ML071580939 (public version)). This application was supplemented by letters dated October 26, November 2, and December 12, 2007, and January 11 and January 14, 2008. On January 18, 2008, the NRC notified Westinghouse that it accepted the May 26, 2007, application, as supplemented, for docketing (Docket No. 52-006) (73 FR 4926; January 28, 2008) (ADAMS Accession No. ML073600743).

On September 22, 2008, Westinghouse submitted Revision 17 to the AP1000 DCD. Revision 17 contains changes to the DCD that have been previously accepted by the NRC in the course of its review of Revision 16 of the DCD. In addition, Revision 17 proposes changes to design acceptance criteria in the areas of piping design (Chapter 3), instrumentation and control systems (Chapter 7), and human factors engineering (Chapter 18).

On December 1, 2010, Westinghouse submitted Revision 18 of the DCD. Revision 18 includes all the DCD changes resulting from staff review of Revision 17, as well as additional design changes submitted during 2010, which have also been reviewed by NRC and documented in the AFSER.

The NRC staff completed its review of the AP1000 standard design amendment request and issued the publicly available final safety evaluation report related to certification of the AP1000 standard design Revision 18, on December 28, 2010, under ADAMS Accession No. ML103260072.

The Commissioners - 3 -

The AP1000 standard design certification amendment application has been referenced in the following COL applications:

COL Name	Docketed Date	Docketing *Federal Register* Citation
Vogtle 3 and 4	May 30, 2008	73 FR 33118
Bellefonte 3 and 4	January 18, 2008	73 FR 4923
Levy County 1 and 2	October 6, 2008	73 FR 60726
Shearon Harris 2 and 3	April 17, 2008	73 FR 21995
Turkey Point 6 and 7	September 4, 2009	74 FR 51621
Virgil C. Summer 2 and 3	August 1, 2008	73 FR 45793
William States Lee III, 1 and 2	February 25, 2008	73 FR 11156

DISCUSSION:

Scope and NRC Review of Westinghouse AP1000 Amendment Application

Westinghouse's request to amend the AP1000 certified design contains a large number of changes to the DCD. Many of the proposed changes relate to the satisfactory completion of COL information items and the resolution of DAC and other design changes resulting from detailed design efforts. The staff SER provides the safety basis for acceptability of changes. The changes range from minor editorial revisions to substantive modifications of the design.

The amendment was also reviewed by the Advisory Committee on Reactor Safeguards (ACRS) in 12 subcommittee meetings and 2 full committee meetings. In addition to its review of the application, the ACRS also reviewed the adequacy of long-term core cooling in response to a Commission SRM dated May 8, 2008.

Editorial Changes

Westinghouse requested changes to the AP1000 DCD to correct spelling, punctuation, grammar, designations, and references. None of these changes is intended to make any substantive change to the certified design, and NUREG-1793, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design," Supplement 2, does not address these changes.

Changes to Address Consistency and Uniformity

Westinghouse requested changes to the AP1000 DCD to achieve consistency and uniformity in the description of the certified design throughout the DCD. For example, Westinghouse made a change to the type of reactor coolant pump (RCP) motor and wherever this RCP motor is described in the DCD a new description of the changed motor is used. The staff reviewed this proposed change and all other similar changes (to be used consistently throughout the DCD) to ensure that the proposed changes are technically acceptable and do not adversely affect the previously approved design description. The staff's bases for approval of these changes are set forth in the SER for the AP1000 amendment.

The Commissioners - 4 -

Substantive Technical Changes to the AP1000 Design (other than those needed for compliance with the AIA rule)

Among the many technical changes that are proposed for inclusion in Revision 18 of the DCD, the NRC selected 16 changes for specific discussion in the *Federal Register* notice (FRN) for the proposed rule (Enclosure 1), based on their safety significance. Fifteen of these changes are described in Table 1. The remaining change is for compliance with the AIA rule, such as the revised shield building design. The NRC staff evaluated the proposed changes and concluded that they are acceptable. The NRC's bases for approval of these changes are set forth in the SER for the AP1000 amendment.

A number of design changes were proposed after submittal of Revision 17 that were not related to staff questions on the changes previously offered. The staff had been preparing chapters of the SER (first with open items and subsequently as an AFSER without open items) and had issued several chapters before these changes were submitted. In order to simplify the review of these later changes, a separate chapter (Chapter 23) dedicated to this review is included in the AFSER. This chapter indicates which areas of the DCD are affected by each design change and the correspondence from Westinghouse that submitted the design changes and the basis for acceptability.

Revision 18 of the DCD contains both these newer design changes and those presented in Revision 17 (as modified through the staff review process). As a result of these reviews, a number of DCD revisions were identified as being necessary to support the staff's safety evaluation review. These revisions are marked within the SER as confirmatory items (CIs), meaning that Westinghouse agreed to include them in Revision 18 and NRC agreed that the changes are acceptable. The confirmatory nature is for staff verification that the changes are appropriately incorporated into Revision 18. For the final rule, the staff will confirm implementation of the CI commitments and remove the CI nomenclature from the SER. The final SER will reflect the committed action.

Shield Building Design Change and Non-Concurrence

In Revision 16, Westinghouse proposed to revise the design of the cylindrical wall of the shield building from a reinforced concrete structure to a steel plate concrete composite structure. Other proposed design changes to the building include lowering its height, revising the air vent configuration, and strengthening the roof. These design changes were developed to increase the robustness of the building for malevolent aircraft impact events.

The staff reviewed the revised design with respect to its ability to perform all required safety functions under design basis loading conditions. The staff's primary focus was on the capability of the building for seismic events, and the effect of the revised air vents on passive containment cooling. The staff did not accept the original design of the building as proposed, as discussed in an NRC letter dated October 15, 2009 (ADAMS Accession No. ML092320205). In response, Westinghouse made a number of significant modifications to the design.

The revised shield building design and supporting analysis and testing information are in a report dated September 30, 2010, "Design Report for the AP1000 Enhanced Shield Building" (ADAMS Accession No. ML102790595).

The Commissioners -5-

The staff's safety evaluation for the revised shield building design was issued on November 8, 2010 (ADAMS Accession No. ML102870605) in a proprietary document. A public version with necessary redactions is included in the AFSER (ADAMS Accession No. ML103260072). The complete details of the staff's review are in the AFSER. Summarized below are the staff findings with respect to ductility and safety of the steel composite walls.

The staff finds that the AP1000 shield building design has two different spacings for the tie-bars to ensure that the steel concrete composite (SC) modules will function as a unit. For the regions of the SC wall with higher out-of-plane shear loads, and where yielding of the SC wall would be expected to initiate under a combination of tensile forces and out-of-plane bending for seismic loads in excess of the design-basis loads, the tie-bars in the SC modules are more closely spaced to provide out-of-plane shear ductility.

The staff also finds that the purpose of shear tests is to establish the minimum shear reinforcement (tie-bars) to the SC module so that it can function as a unit to resist both out-of-plane and in-plane shear forces, provide sufficient ductility (energy absorption/dissipation capability) for seismic-induced energy, and provide sufficient stiffness for the shield building to meet the allowable building drift limit. The staff finds that the tests were an acceptable basis to establish this minimum.

The staff concluded that the applicant has: (1) performed testing to obtain data on the response and behavior for key failure modes of the SC wall modules; (2) developed confirmatory analysis models; (3) shown that the models predict the observed experimental behavior and response with acceptable accuracy up to the design-basis seismic load level (safe-shutdown earthquake (SSE)); and (4) used the confirmatory analysis to predict stresses and strains in critical areas of the shield building for the SSE load level.

Based on the above findings and the applicant's SSE load level predictions of low stress and strain values in the SC steel plates, tie-bars, and studs, the staff finds the applicant's confirmatory analysis approach to be acceptable.

On these bases, the staff concluded that the SC wall will provide adequate strength, stiffness, and ductility under design-basis (or SSE) seismic loads. The staff finds the design for strength, stiffness, and ductility to be acceptable.

A non-concurrence was filed on the staff's review and findings of the shield building design. The non-concurrence relates to ductility in regions of the shield building under out-of-plane shear loading. In accordance with agency policy, management has reviewed the non-concurrence and concluded that the AFSER did not require revision to address issues raised in the non-concurrence, and agreed with the staff bases for determining that the AP1000 shield building met regulatory requirements. A proprietary version of the documentation associated with the shield building non-concurrence and the management review is available under ADAMS Accession No. ML103020207. A redacted version of the documentation of the staff non-concurrence is available, "Redacted Version of Dissenting View on AP1000 Shield Building Safety Evaluation Report With Respect to the Acceptance of Brittle Structural Module to be Used for the Cylindrical Shield Building Wall" (ADAMS Accession No. ML103370648). The agency response to the dissenting view refers to the analysis and conclusions summarized above, in particular, the regions of the SC wall with higher out-of-plane shear loads, where yielding of the SC wall would be expected to initiate under seismic loads in excess of the

The Commissioners - 6 -

design-basis loads where the applicant detailed the SC modules with more closely spaced tie-bars to provide out-of-plane shear ductility. The agency response to the dissenting view continues to support the conclusions originally included in the AFSER.

During the ACRS full committee meeting held on December 2–4, 2010, the staff presented its shield building design safety evaluation and the non-concurrence was discussed. The ACRS agreed with the staff's safety evaluation position on the shield building design and concluded that the proposed changes in the AP1000 amendment maintain the robustness of the certified design and that there is reasonable assurance that the revised design can be built and operated without undue risk to the health and safety of the public.

Instrumentation and Controls Non-Concurrences

Subsequent to the completion of the staff interactions with the ACRS in November and December 2010, two non-concurrences were filed on the staff review associated with certain aspects of digital instrumentation and controls. These non-concurrences are discussed in greater detail below.

In Revision 18, Westinghouse proposed to remove an Inspection, Testing, Analysis, and Acceptance Criterion (ITAAC) for the Protection and Safety Monitoring System (PMS), which is the primary protection system for the AP1000. Westinghouse added a PMS ITAAC related to the Component Interface Module (CIM) hardware/software development life cycle. The CIM is part of the PMS; however, the design requirements phase was not completed for the CIM at the time of the amendment review. Therefore, the design requirements phase of the new CIM ITAAC is considered to be a DAC.

In addition to modifications to the PMS, Westinghouse proposed removal of an ITAAC associated with the Diverse Actuation System (DAS). The DAS provides the anticipated transient without scram mitigation functions for the AP1000, as well as the back-up engineered safety feature actuation functions to address a software common-cause failure of the PMS.

Two non-concurrences were filed on the staff's AFSER for Chapter 7 of the AP1000 design (ADAMS Package Accession No. ML103420563). The first non-concurrence, "Insufficient Diversity and Independence in the Implementation Process for AP1000 Instrumentation and Controls Systems," involved concerns identified with implementation of quality assurance and diversity for the developer of the CIM and DAS, which is a Westinghouse sub-supplier. The proprietary documentation associated with this non-concurrence and the management review is available under ADAMS Accession No. ML103510336, and a public version of the non-concurrence package is available under ADAMS Accession No. ML103620506. Since the staff's concerns are related to the implementation of the design, a vendor inspection will be conducted to follow-up on the quality assurance and design implementation concerns in the early part of 2011. Subsequently, this non-concurrence was withdrawn based on the staff's plans to conduct the vendor inspection.

The second non-concurrence involves adequate reliability and demonstration of performance for the DAS, which uses two-out-of-two voting logic. A single failure or on-line maintenance could prevent the DAS from performing its functions. The DAS functions were determined by using a focused probabilistic risk assessment study as opposed to the deterministic, best-estimate analysis recommended in staff guidance in Standard Review Plan BTP 7-19, "Guidance for

The Commissioners -7-

Evaluation of Diversity and Defense-in-Depth in Digital Computer-Based Instrumentation and Control Systems," and the SRM dated July 21, 1993, on SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs." Both design aspects were previously approved in the certified design. In accordance with agency policy, management has reviewed the non-concurrence and concluded that the AFSER did not require revision to address issues raised in the non-concurrence and agreed with the staff bases for determining that the AP1000 DAS met regulatory requirements. The non-concurrence does not identify a basis for, or evidence of, safety concerns associated with the methods used in analyzing either the DAS or the functions and actuations credited in the safety analysis for the I&C system. Further, a best-estimate analysis might have provided some additional support for the conclusions in the safety evaluation; however, the existing technical documents submitted by the applicant and reviewed by the staff meet the applicable regulatory requirements and demonstrate the safety of the digital I&C system. A proprietary version of the documentation associated with this non-concurrence and the management review is available under ADAMS Accession No. ML103620334. A redacted, public version is available under ADAMS Accession No. ML103630486.

Compliance with the Aircraft Impact Assessment (AIA) Rule

As permitted under the AIA rule, 10 CFR 50.150, Westinghouse requested changes to the AP1000 DCD to address the requirements of the AIA rule. In addition, the rulemaking includes proposed changes to the AP1000 rule language in Section X of 10 CFR Part 52, Appendix D. These proposed changes to Section X reflect the AIA change and departure process, and the AIA rule's recordkeeping and reporting requirements, as noted in the Statement of Considerations for the AIA rule (74 FR 28112; June 12, 2009, page 28121, second and third columns).

In the AFSER, the staff finds that Westinghouse has performed an AIA that is reasonably formulated to identify design features and functional capabilities to show, with reduced use of operator action, that the acceptance criteria in 10 CFR 50.150(a)(1) are met.

The staff conducted an inspection of Westinghouse's AIA performed in support of its proposed amendment to the AP1000 certified design on September 27–October 1, 2010. As a result, on October 28, 2010, the staff issued a Severity Level IV Notice of Violation (NOV) to Westinghouse for failing to use realistic analyses for certain aspects of its AIA and for not fully identifying and incorporating into the design those design features and functional capabilities credited. With the exception of the issues identified in the NOV, the staff concluded that the Westinghouse AIA for the AP1000 certified design complies with the applicable requirements of 10 CFR 50.150.

Westinghouse submitted its response to the NOV on November 12, 2010, "Reply to Notice of Violation Cited in NRC Inspection Report No.: 05200006/2010-203 dated October 28, 2010" (ADAMS Accession No. ML103210409). On November 23, 2010, the staff replied to Westinghouse that the staff found Westinghouse's letter acceptable to address the findings described in the NOV, "Westinghouse Electric Company Response to U.S. Nuclear Regulatory Commission (NRC) Inspection Report [05200006/2010-203] and Notice of Violation" (ADAMS Accession No. ML103260447). The NRC staff has no outstanding issues from the inspection of the Westinghouse AIA.

The Commissioners - 8 -

On November 19, 2010, Westinghouse briefed the ACRS on the details of its assessment and on December 16, 2010, the staff briefed the ACRS on its review and inspection. The ACRS plans to issue a separate letter on the AIA following their January 2011 full committee meeting.

Compliance with Backfit Rule and Finality Provisions of 10 CFR 52.63(a)(1)

The staff determined that the changes proposed by Westinghouse, with the exception of the changes necessary to comply with the AIA rule, meet the criteria in 10 CFR 52.63(a)(1) for allowing changes to a DCR. The new provisions of 10 CFR 50.150 contain the requirements of the AIA rule. Table 1 sets forth the 10 CFR 52.63(a)(1) criteria applicable to significant changes. These criteria apply to standard DCRs in effect under 10 CFR 52.55, "Duration of Certification," or 10 CFR 52.61, "Duration of Renewal." The finality provisions of 10 CFR 52.63 limit the Commission's ability to modify, rescind, or impose new requirements on the certification information to cases in which the Commission determines that a change is necessary. The enclosed FRN further describes the significant changes proposed to the AP1000 design and the bases for the NRC's determination that each change meets one of the finality criteria in 10 CFR 52.63(a)(1).

The Commissioners - 9 -

Table 1. Significant Changes to the AP1000 Design

Description of Change	SER Discussion Section	Finality Criterion Satisfied
Removal of Human Factors Engineering DAC from DCD	18.7.6, 18.5.9, 18.2.8, and 18.11	10 CFR 52.63(a)(1)(iv) (detailed design information-DAC)
Changes to Instrumentation and Control DAC and Inspections, Tests, Analyses, and Acceptance Criteria	7.2.2.3.14, 7.2.5, 7.7, 7.8.2, 7.9.2, and 7.9.3	10 CFR 52.63(a)(1)(iv)
Minimization of Contamination	12.2	10 CFR 52.63(a)(1)(vii) (contributes to increased standardization)
Extension of Seismic Spectra to Soil Sites and Changes to Stability and Uniformity of Subsurface Materials and Foundations	3.7, 2.5.2, and 2.5.4	10 CFR 52.63(a)(1)(vii)
Long-Term Cooling	6.2.1.8	10 CFR 52.63(a)(1)(vii)
Control Room Emergency Habitability System	6.4	10 CFR 52.63(a)(1)(vii)
Changes to the Component Cooling Water System	Chapter 23.V	10 CFR 52.63(a)(1)(vii)
Changes to Instrumentation and Control Systems	7.1, 7.3, 7.9	10 CFR 52.63(a)(1)(vii)
Changes to the Passive Core Cooling System – Gas Intrusion	Chapter 23.L	10 CFR 52.63(a)(1)(vii)
Integrated Head Package – Use of the QuickLoc Mechanism	5.2.3 and 12.4.2.3	10 CFR 52.63(a)(1)(vii)
Reactor Coolant Pump Design	5.4.1	10 CFR 52.63(a)(1)(vii)
Reactor Pressure Vessel Support System	Chapter 23.R	10 CFR 52.63(a)(1)(vii)
Spent Fuel Pool Decay Heat Analysis and Associated Design Changes	9.2.2	10 CFR 52.63(a)(1)(vii)
Spent Fuel Rack Design and Criticality Analysis	9.1.2	10 CFR 52.63(a)(1)(vii)
Vacuum Relief System	Chapter 23.W	10 CFR 52.63(a)(1)(vii)

With respect to the changes necessary to comply with the AIA rule, 10 CFR 50.150(a)(3)(v)(B) of the AIA rule requirements allows each of the four current DCRs to be amended to address compliance with the AIA rule, but requires that the DCR comply with the AIA rule no later than issuance of the renewed DCR. Inasmuch as these requirements are inconsistent with the issue finality provisions of 10 CFR 52.63(a)(1) and paragraphs VIII.A and VIII.B of the four current DCRs, the NRC "administratively exempted" the AIA rule, as applied to each of the four current DCRs, from the issue finality provisions in 10 CFR Part 52 (74 FR 28112; June 12, 2009, page 28144, first column). Accordingly, the Commission may approve the changes to the AP1000

needed to comply with the AIA rule without further consideration of the backfit rule, 10 CFR 50.109, or the issue finality provisions in 10 CFR 52.63.

Access to Safeguards Information (SGI) and Sensitive, Unclassified Non-Safeguards Information (SUNSI) (Including Proprietary Information (PI))

As discussed in SECY-10-0142 dated October 27, 2010, under ADAMS Accession No. ML102030495, for the proposed amendment to the Advanced Boiling-Water Reactor (ABWR) DCR to address compliance with the AIA rule, the staff is proposing to revise paragraph E of Section VI, "Issue Resolution," of Appendix D to 10 CFR Part 52, which describes the procedure that an interested member of the public must follow to obtain access to PI and SGI for the AP1000 design to request and participate in proceedings that involve licenses and applications that reference the AP1000 design. The staff is proposing to replace the current information in paragraph E with a statement that the NRC will specify, at an appropriate time, the procedure that interested persons must follow to review SGI or SUNSI (including PI), for the purpose of participating in the hearing required by 10 CFR 52.85, "Administrative review of applications; hearings," the hearing provided by 10 CFR 52.103, "Operation under a combined license," or any other proceeding related to Appendix D to 10 CFR Part 52 in which interested persons have a right to request an adjudicatory hearing. For a COL application referencing the AP1000 amendment, the procedures governing access to SUNSI (including PI) and SGI for the AP1000 amendment will be controlled by the Commission's access order published as part of the Notice of Order, Hearing, and Opportunity to Petition for Leave to Intervene for those COLs.

Rulemaking Procedure

The standard design certification amendment is being conducted in accordance with the applicable requirements in Subpart B, "Standard Design Certifications," of 10 CFR Part 52; 10 CFR Part 2, "Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders"; and 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." The rulemaking package includes the FRN of proposed rulemaking and the NRC's draft environmental assessment for the amendment to the AP1000 design. In addition, the FRN provides a 75-calendar day period for comment on those documents as well as the AP1000 DCD, which would be incorporated by reference into the DCR. The DCD is available on the NRC's public Web site at http://www.nrc.gov/reactors/new-reactors/design-cert/amended-ap1000.html. The proposed rule would also describe the process by which a member of the public could request and access PI, SUNSI, or SGI to provide meaningful comment on the proposed rule. This process and the rationale for this approach are consistent with the staff's proposal to the Commission in its draft proposed rule for amendment to the ABWR in SECY-10-0142.

RESOURCES:

The Office of New Reactors (NRO) has budgeted 0.7 full-time equivalent (FTE) to manage this rulemaking in the fiscal year (FY) 2011 President's budget. The Office of the General Counsel (OGC), Office of Administration, and Office of Information Services (OIS) have budgeted 0.1 FTE each in FY 2011 for this rulemaking.

The Commissioners - 11 -

NRO has requested 0.1 FTE in the FY 2012 budget request. Resources for other offices in FY 2012 and beyond, if necessary, will be requested through the planning, budget, and performance management process.

RECOMMENDATIONS:

That the Commission:

(1) Approve the proposed amendment to 10 CFR Part 52 for publication in the *Federal Register*.

(2) In order to satisfy requirements of the Regulatory Flexibility Act of 1980, as amended (5 U.S.C. § 605(b)), certify that this rule, if promulgated, will not have a negative economic impact on a substantial number of small entities.

(3) Determine that:

(a) The proposed rule does not constitute "backfitting" as defined in the backfit rule (10 CFR 50.109, "Backfitting");

(b) Compliance with the issue finality provisions of 10 CFR 52.63 with respect to changes necessary to comply with the AIA rule were addressed in the AIA rulemaking, when the Commission "administratively exempted" the AIA rule from the issue finality provisions in 10 CFR Part 52; and

(c) The Westinghouse-initiated changes to the AP1000 design meet the issue finality provisions of 10 CFR 52.63.

(4) Note the following:

(a) The NRC will publish the proposed rule (Enclosure 1) in the *Federal Register* for a 75-calendar day comment period.

(b) The staff has performed an environmental assessment that resulted in a finding of no significant impact and evaluated severe accident mitigation design alternatives for the proposed amendment (Enclosure 2).

(c) This proposed rule would amend information collection requirements that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. § 3501 et seq.). These information collection requirements must be submitted to the Office of Management and Budget (OMB) for approval on, or immediately after, the date of publication of the proposed rule in the *Federal Register*. OMB's approval may impact the schedule for this rulemaking if it is not received before the Commission's decision on the final rule.

(d) The staff will inform the Chief Counsel for Advocacy of the Small Business Administration of the certification on the economic impact on small entities and the reasons for it, as required by the Regulatory Flexibility Act of 1980 (Section XIII of Enclosure 1).

The Commissioners - 12 -

(e) The appropriate Congressional committees will be informed.

(f) The Office of Public Affairs will issue a press release.

(g) The staff will use a communication plan that includes frequently asked questions on the DCR process and the use of a DCR in referenced COL applications, as well as questions prepared specifically for this amendment to the AP1000 standard design.

COORDINATION:

OGC has reviewed this paper and has no legal objections, subject to OGC's review of the expected ACRS letter on aircraft impact and the staff response to that letter. The Office of the Chief Financial Officer does not need to review this paper because resources do not exceed 1 FTE in any fiscal year. OIS has reviewed this paper for information technology and information management implications and concurs with it.

The staff presented the Advanced SER for the Westinghouse amendment of the AP1000 design certification to the ACRS on December 2, 2010. In a letter to the Chairman dated December 13, 2010 (ADAMS Accession No. ML103410351), the ACRS stated that the Westinghouse application to amend the AP1000 DCR and the staff's SER are acceptable. Additionally, in a letter to the Chairman dated December 20, 2010 (ADAMS Accession No. ML103410348), the ACRS stated that the regulatory requirements for long-term cooling for design-basis accidents have been adequately met and the issue is closed for the AP1000 design. The staff will provide an information copy of the enclosed FRN to the ACRS after publication.

/RA by Martin J. Virgilio for/

R. W. Borchardt
Executive Director
for Operations

Enclosures:
1. *Federal Register* Notice
2. Environmental Assessment