U.S. Department of Energy

Nuclear Power 2010 Program

Combined Construction and Operating License & Design Certification Demonstration Projects Lessons Learned Report

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DISCLAIMER

Acronyms and Abbreviations

ABWR	Advanced Boiling Water Reactor
ACRS	Advisory Committee on Reactor Safety (NRC)
ACR-700	Advanced CANDU Reactor 700 MWe
AECL	Atomic Energy of Canada Limited
ALWR	Advanced Light Water Reactor
AP1000	Advanced Passive Pressurized Water Reactor
ASLB	Atomic Safety and Licensing Board
CFR	Code of Federal Regulations
COL	Combined Construction and Operating License
COLA	COL Application
DAC	Design Acceptance Criteria
DC	Design Certification
DCWG	Design Centered Working Group
DF	Design Finalization
DCD	Design Certification Document
DOE	Department of Energy
EPAct 05	Energy Policy Act of 2005
EPC	Engineering, Procurement, and Construction
EPR	Evolutionary Power Reactor
EPRI	Electric Power Research Institute
ESBWR	Economic Simplified Boiling Water Reactor
ESP	Early Site Permit
EVMS	Earned Value Management System
FSER	Final Safety Evaluation Report
GE-H	General Electric–Hitachi
ITAAC	Inspection, Tests, Analyses and Acceptance Criteria
LWR	Light Water Reactor
NE	Office of Nuclear Energy
NEI	Nuclear Energy Institute
NP 2010	Nuclear Power 2010 Program
NRC	U.S. Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NTDG	Near-Term Deployment Group
NuStart	NuStart Energy Development LLC
OMB	Office of Management and Budget
RAI	Request for Additional Information
R-COLA	Reference COLA
SER	Safety Evaluation Report
S-COLA	Subsequent COLA
STP	South Texas Project
TVA	Tennessee Valley Authority
US-APWR	US Advanced Pressurized Water Reactor
WBS	Work Breakdown Structure
WEC	Westinghouse Electric Company

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Executive Summary

In 2002, the Department of Energy (DOE) initiated the Nuclear Power 2010 (NP 2010) program to spur commercial development of nuclear power as a vital component of our Nation's energy infrastructure. DOE worked together with the U.S. Nuclear Regulatory Commission (NRC) and industry to address the most significant barriers to deployment of new nuclear power plants. The program's four stated goals were to:

- Evaluate the business case for building new nuclear power plants
- Identify sites for new nuclear power plants
- Demonstrate untested regulatory processes
- Develop advanced nuclear plant technologies

The Code of Federal Regulations (CFR) under 10 CFR Part 52 established an entirely new process for siting and licensing new nuclear power plants. A key provision of the improved CFR Part 52 is the ability to obtain a combined Construction and Operating License (COL) to build and operate a nuclear power plant before a significant investment in procurement and construction occurs. Key recommendations of the 2001 "Roadmap to Deploy New Nuclear Power Plants in the United States by 2010" included demonstration of the Part 52 licensing process and completion of near-term candidate reactor designs. These recommendations were the basis for the NP 2010 implementation of the Combined Construction and Operating License and Design Certification Demonstration Projects.

The cornerstones of these important NP 2010 demonstration projects were DOE's cooperative agreements with industry, initiated in 2005, to:

- Demonstrate the process for submittal, approval, and issuance of a COL;
- Achieve NRC certification of the selected nuclear plant designs; and
- Complete the first-of-a-kind engineering for a standard plant.

Under an agreement with NuStart Energy Development, LLC (an industry consortium), DOE supported the reference COL Application (COLA) for a Westinghouse Electric Corporation (WEC) AP1000 at Tennessee Valley Authority's (TVA) Bellefonte site, as well as certification and design completion of the AP1000 design. A separate agreement with Dominion Nuclear North Anna, LLC, now Dominion Virginia Power, supported a reference COLA for a General Electric-Hitachi (GE-H) ESBWR at Dominion's North Anna site, as well as certification and design completion of the ESBWR design. DOE subsequently established separate cooperative agreements with the two reactor vendors, WEC and GE-H, for the design certification (DC) and completion of the first-of-a-kind engineering of their advanced standard plant designs. After the initial COL submittals to the NRC, NuStart transferred their COL efforts from the Bellefonte site to the Southern Nuclear's Vogtle site. In May 2010, Dominion announced a change in reactor technology at North Anna from the ESBWR to Mitsubishi's US-APWR, at which point DOE ended the North Anna COL demonstration project. These changes, explained further in this report, were necessary responses to changing market conditions, and demonstrate the flexibility of the NP 2010 program as well as the flexibility inherent in NRC's Part 52 Rule.

The DOE NP 2010 COL/DC Demonstration Projects with industry have contributed to reducing the regulatory and technical uncertainty for building new nuclear power plants in the U.S. The NP 2010 program has successfully:

- Demonstrated the COL licensing processes with the issuance of the first COL for Vogtle Units 3 & 4 in February 2012;
- Enabled the certification of the most advanced passive light water reactors (LWRs) designs available globally, the WEC AP1000 and the GE-H ESBWR; [1]and
- Significantly contributed to finalizing the detailed standard plant design for the first few new nuclear plants.

The NP 2010 COL/DC Demonstration program together with the financial incentives provided by the Energy Policy Act of 2005 are the two primary reasons why a large number of license applications for new nuclear construction are before the NRC today, and why the first new nuclear plants in over 30 years are under construction in the U.S.

As with all significant endeavors, there are lessons to be learned from the planning and implementation of these important NP 2010 COL/DC demonstration projects. The lessons learned, as presented in this report, were developed based on input and information from project participants and the DOE project managers. These lessons learned were developed to help improve future development and demonstration efforts at DOE and identify other areas of potential improvement for public-private partnerships. The lessons learned inputs from the individual COL/DC project reports from NuStart, Dominion, Westinghouse and General Electric-Hitachi were analyzed, consolidated, and summarized into a prioritized list of key lessons learned and areas for improvement.

The following provides a high level summary of the key lessons learned:

- Development of business cases and, most importantly, a roadmap of activities in the early phases of the program were essential.
- The utility-led consortium approach used on the COL demonstration projects with utility partners and reactor vendors worked well.

[1] The AP1000 design was certified by NRC Rulemaking in Dec. 2011; the ESBWR is forecasted by the NRC for certification rulemaking in 2013.

- Significant industry cost share is important on technology development and demonstration projects.
- Utility commitment to a reactor technology or deployment project was not assured prior to initiating NP 2010 and evolved throughout the projects.
- Clearly defined endpoints for First-of-a-Kind Engineering (FOAKE) are necessary.
- First of a kind development and demonstration activities such as certification and engineering development of a new reactor technology and demonstration of new regulatory processes cost more than planned or previously experienced.
- Implementation flexibility was needed on the DC and COL activities to account for evolving regulatory requirements and changing external conditions that had an effect on the projects.

More detailed discussions of the lessons learned are provided in Section V of this report. In addition, specific issues and recommendations from the NP 2010 industry participants are provided in the appendices to this report.

I. Purpose of the Report

This report provides a summary of the activities, lessons-learned, and successes of the DOE's combined Construction Operating License Demonstration projects and the related reactor Design Certification projects. The demonstration projects were completed under the DOE's Nuclear Power 2010 (NP 2010) program, a cost-shared DOE-industry partnership that was launched in 2002 to pave the way for building new nuclear power plants in the United States.

As part of the requirements of the cooperative agreements established for this program, each of the industry participants provided a summary report of its activities under its agreement, as well as a compilation of lessons-learned. The individual industry participant reports are provided as appendices to this DOE report for complete disclosure of their activities and lessons learned. In addition to the industry written input, key industry and DOE personnel participated in follow-up interviews.

This report complements a prior report on lessons learned from DOE's Early Site Permit Demonstration projects, also completed under NP 2010, as well as a "Final Closeout Report" on the overall NP 2010 program.

II. COL/DC Demonstration Project Overview

A. Introduction

In 2001, as part of the Generation IV Program to assemble a 30-year road map for advanced plant and fuel cycle research and development, DOE organized a Near-Term Deployment Group (NTDG) to examine prospects for the deployment of new nuclear plants in the U.S. during that decade, and to identify obstacles to deployment and actions for resolution. The NTDG membership included senior personnel from nuclear utilities, reactor vendors, national laboratories, and academia. Key recommendations from the report of this effort, "A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010," relevant to the COL and DC projects, include:

1. Implement a phased plan of action for new nuclear plants, by means of industry/ government collaboration on generic and plant-specific initiatives, as follows:

   Phase 1: <u>Refine and demonstrate the 10CFR52 process</u>, as described in Volume II, Chapters 3 and 5 *[of the Roadmap]*. Resolve the uncertainties regarding the new plant regulatory approval process through actual use, and secure regulatory approval for several reactor design and siting applications on a time scale that will support plant deployments in this decade.

   Phase 2: <u>Complete the design of several near term deployment candidates</u>, as reviewed in Volume II, Chapter 5. Complete the detailed engineering and design work for at least one light water and at least one gas-cooled reactor, in time to allow start of plant construction on a schedule that could achieve deployment by 2010.

To implement these recommendations, DOE conceived the NP 2010 program structured around industry cost-shared demonstration projects to achieve both regulatory demonstration and design completion for at least two advanced LWR designs.

B. Objectives of the COL/DC Program

The Near Term Deployment Roadmap and a concurrent DOE study performed by Scully Capital[2] identified licensing uncertainty as the primary obstacle to new nuclear plant deployment. The Part 52 licensing process was established in 1989 to reduce licensing uncertainty, but the new process was largely untested. This improved licensing process was structured to allow timely public access to relevant information, thorough NRC review, and resolution of all issues related to siting, plant design, and operation before construction begins. Note that the successful demonstration of this process is one of the key steps needed to confirm regulatory predictability, essential to spur future commitments by power generation companies to order and build new nuclear power plants in the United States.

Part 52 contains three Subparts:

A. Early Site Permits

B. Standard Design Certifications

C. Combined Licenses

Of these three, Subpart B had been tested prior to the inception of NP 2010, but Subparts A and C had not. Although several designs had been certified, no one had yet applied for either an ESP or a COL. One of the key NP 2010 objectives was to demonstrate this entire licensing process through the COL. In late 2003, DOE issued a solicitation requesting proposals from power generation companies for demonstration projects designed to obtain NRC approval and issuance of a COL under 10 CFR Part 52. The purpose of the COL/DC projects was to conduct pilot demonstrations of the previously untested COL application and review process. Under the COL/DC projects, the industry partners implemented a plan to obtain NRC approval and issuance of COLs for two advanced nuclear power plants.

In addition to the COL/DC, demonstration projects supported efforts to finalize advanced reactor designs to a sufficient degree that U.S. power-generation companies were willing to build. So in addition to activities focused on design

[2] "The Business Case for Nuclear Power," July 2002

work sufficient for NRC review and certification of two advanced standardized LWRs, the NP 2010 program conducted First-of-a-Kind Engineering (FOAKE) to a sufficient level of detail that firm cost and schedule estimates could be generated for these designs. The passively safe reactor designs that were selected by utilities for this purpose, the AP1000 and the ESBWR, represented the most advanced and safest light water reactor technology available in the world. This scope addressed the NTDG recommendation on technology development and regulatory approval of several reactor designs. It should be noted that since technology selection was left to industry and they didn't choose to pursue a gas-cooled reactor, this NTDG recommendation was not implemented under the NP 2010 program.

III. COL Demonstration Project Activities

A. Demonstration Projects Work Scope [3]

DOE awarded three cooperative agreements in response to its solicitation: (1) TVA ABWR Feasibility Study at Bellefonte, (2) Dominion North Anna COL Demonstration Project, and (3) NuStart Energy LLC COL Demonstration Project.

The TVA ABWR Feasibility study was a cost and schedule analysis of building a Toshiba ABWR design at TVA's Bellefonte site. Following the ABWR study, TVA changed course, joined NuStart and offered its Bellefonte site for the NuStart COL Demonstration Project.

The NuStart Energy COL Demonstration project down selected the Bellefonte site for the AP1000 COL demonstration but subsequently transitioned from the Bellefonte site to Southern Nuclear's Vogtle site for the lead COLA for the AP1000 in 2009. The NRC issued the final Design Certification Rulemaking for the AP1000 in December 2011, and issued the COL for the Vogtle site in February 2012.

The Dominion North Anna COL Demonstration project resulted in the design finalization of the ESBWR and completion of NRC's Safety Review in 2011. Issuance of the ESBWR Design Certification Rulemaking is expected in 2013. As discussed later, Dominion changed its technology selection for the North Anna site in June 2010. The lead COLA for the ESBWR design is now being pursued by DTE Energy for its Fermi site, outside the NP 2010 program.

B. Organizations Involved in the COL/DC Projects

Industry Participants

NuStart Energy Development LLC (NuStart)

[3] For complete details on COL/DC Demonstration Program work scope, refer to the DOE NP 2010 website: http://www.nuclear.energy.gov/NP 2010/publications.html.

During the major phases of the COL/DC Demonstration Project, the NuStart consortium comprised ten utility companies (DTE Energy, Duke Energy, EDF International North America, Entergy Nuclear, Exelon Corporation, FPL Group, Progress Energy, SCANA Corporation, Southern Company, and Tennessee Valley Authority). The NuStart consortium also included two reactor vendors (GE-H and WEC). NuStart was created in 2004 for the purpose of responding to the NP 2010 solicitation. The consortium approach permitted cost and risk to be spread over multiple companies while promoting industry standardization, sharing, and cooperation. NuStart subcontracted the work to develop the COL application. It was the subcontractors' responsibilities to integrate its COLA activities with those of the reactor vendors (WEC and GE-H) and with related NuStart work. NuStart developed a matrix organization composed of the utilities that constituted its membership. The role it reserved for itself was one of oversight and general management of the COLA effort.

Dominion Nuclear North Anna, LLC (now Dominion Virginia Power)

The Dominion project organization consisted of an integrated project team led by Dominion, and included GE-Hitachi and its Nuclear Steam Supply System (NSSS) vendor partners, and Bechtel Power Corporation (Bechtel), which was responsible for coordination of the COL application preparation and for site engineering.

Westinghouse

The Westinghouse Electric Company (WEC) integrated project team was led by WEC, which had management responsibilities for reactor design, construction and operations activities; and Shaw Engineering, which was responsible for engineering and design of the secondary, non-safety-related, power block systems within the boundaries of the design certification. International design partners included Ansaldo, Obayashi, Doosan, SPX, GSE, Toshiba, CB&I/IHI, Curtiss-Wright (EMD), and Holtec.

General Electric-Hitachi

GE-H developed a broad team of expert companies to execute the project objectives. This team included partnerships with multiple experienced engineering, procurement, and construction (EPC) companies to augment the GE-H staff in performing plant design and preparation for deployment, including URS, Black & Veatch Zachary, EA, Shimizu, and Hitachi.

NRC

As part of its mission, the NRC protects the health and safety of the public and the environment by regulating the design, siting, construction, and operation of commercial nuclear power facilities. For new reactor facilities, the NRC reviews applications submitted by prospective licensees, and issues, when its requirements are met, standard design certifications, early site permits, limited work authorizations, construction permits, operating licenses, and combined licenses.

NRC established a critically important approval process for a standard COLA, under which the first COLA for a certified reactor design served as the "reference" COLA (R-COLA) for all subsequent COLAs (S-COLAs) of that same reactor technology. This simplified and shortened the licensing process for subsequent COL applicants, because NRC agreed that it only need review those portions of the S-COLA that differed from the R-COLA.

C. Preparation, Submittal, and NRC Review of COL Applications

Dominion North Anna Construction and Operating License Demonstration Project

The DOE and Dominion Virginia Power (formerly Dominion Nuclear North Anna, LLC; now referred to as Dominion) entered into Cooperative Agreement Number DE-FC07-05ID14635 in April 2005. The Dominion project selected for the cooperative agreement initially had the AECL ACR-700 as the selected reactor technology. This design uses a very different reactor core design that employs heavy water neutron moderation. It is based on earlier Canadian heavy water reactor designs that were familiar to Canadian nuclear regulators, but less so to the U.S. NRC. Shortly after award selection, Dominion notified DOE of their intention to change the project reactor technology to the GE-H ESBWR. This change was the result of a careful review of the NRC schedule and cost for ACR-700 certification, and recognition by both AECL and Dominion that the ACR-700 could face significant uncertainties under a U.S. NRC licensing review.

The Cooperative Agreement established under the Nuclear Power 2010 program created the management framework for the North Anna combined license (COL) project. The objectives of the North Anna COL project included:

- Prepare and submit a COLA for the ESBWR at the North Anna site
- Obtain NRC approval and issuance of the COL
- Prepare and submit the GE-H ESBWR design certification application
- Obtain NRC design certification for the ESBWR
- Complete the ESBWR design and site-specific engineering
- Develop a business case necessary to support a decision on building a new nuclear power plant.

Figure 1: North Anna Station - Unit 3 ESBWR

Dominion developed and submitted for NRC review a COLA for the ESBWR (Unit 3) at the North Anna site. Site-specific engineering was performed, and a business case was developed to support a decision to build a new nuclear power plant at the North Anna site. The NRC review of the COL application was well advanced by late 2009, as indicated in the schedule below:

- ESBWR design certification application submitted – August 2005
- ESBWR DC application accepted by NRC for review – December 2005
- Submission of North Anna 3 COL application to NRC – November 2007
- GE-H ESBWR certification scope separated by DOE from Dominion COL Cooperative agreement – June 2007
- COL Safety Evaluation Report with open items published - August 2009
- ACRS review of COL Safety Evaluation Report completed – October 2009
- Final Supplemental Environmental Impact Statement Issued – February 2010

However, delays associated with the detailed design of the ESBWR, in part related to the need to reply promptly to a multitude of NRC Requests for Additional Information (RAIs) on the design certification document (DCD), slowed the plant design engineering effort for site-specific facilities. As a result, Dominion was unable to enter into a satisfactory EPC agreement with GE-H for its ESBWR design. In late 2009, after a considerable amount of licensing had been completed, Dominion announced a competitive process to select a different nuclear technology supplier at the urging of its Public Utility Commission. In May 2010, Dominion announced, as a result of the competitive process, that it had selected Mitsubishi Heavy Industries' US-Advanced Pressurized Water Reactor (US-APWR) as the technology for North Anna Unit 3.

This technology switch and consideration of the progress to date achieved on the ESBWR COL led DOE to conclude that further support of the Dominion COL with a new reactor technology would not further the objectives of the NP 2010 COL projects. Much had been accomplished: a reference COLA for the ESBWR was nearly complete; NRC COLA review had made major progress while linked to the Dominion COLA, and much of the design-specific COL work initiated by Dominion could be used by Dominion and other future utility customers. At least one other utility was interested in pursuing a COL based on this technology.

DOE and Dominion mutually agreed to end the Dominion demonstration project cooperative agreement in 2010. The ESBWR R-COLA is now being led by the Detroit Edison Company for the Enrico Fermi Nuclear Generating Station, without DOE support. In addition, the business case that Dominion developed for the construction and operation of a new nuclear power plant at North Anna, as well as the Early Site Permit it developed for North Anna, both facilitated the decision to proceed with NRC licensing review of a COLA based on the US-APWR. Much of this work was applicable to the new Dominion COL using US-APWR technology.

<u>Dominion Summary Conclusions</u>

> "The North Anna COL project Cooperative Agreement was successful in advancing the site-specific plant design for North Anna Unit 3, furthering the development of the licensing process for COLAs that reference an early site permit (ESP), producing license application documents supporting the likely approval for the construction and operation of a new nuclear unit at the North Anna site, and establishing the business case supporting the development of a new nuclear facility. The ultimate goal of the DOE Nuclear Power 2010 program is to reduce technical, regulatory, and institutional barriers to the construction and operation of new nuclear power generating units. Given the current advanced state of the North Anna COL effort, the Cooperative Agreement between DOE and Dominion was a success because it served as a demonstration of much of the COL process for a proposed new plant at a location with an existing Early Site Permit. The Cooperative Agreement also helped to stimulate the entry of multiple vendors into the U.S. commercial market for new nuclear power plants."[4]

Lessons learned from the Dominion project are incorporated in Section V of this report.

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[4] Nuclear Power 2010 Program Dominion Virginia Power Cooperative Project Construction and Operating License Demonstration Project Final Report, November 2010, Cooperative Agreement DE-FC07-05ID14635

NuStart Energy Construction and Operating License Demonstration Project

Created in 2004, NuStart was a consortium of ten nuclear utility members and two reactor vendors selected to receive an NP 2010 COL demonstration project award from DOE. Under the cost-shared, cooperative agreement with the DOE, NuStart's two main objectives were to demonstrate the untested regulatory processes associated with 10 CFR Part 52 by obtaining a COL from NRC and support the standardization and finalization of the selected reactor vendor technology designs.

At the inception of their demonstration project, NuStart supported development of the Bellefonte AP1000 and the Grand Gulf ESBWR COLAs, as well as certification and design finalization of both designs. NuStart planned to do a technology down-selection to one reactor design prior to COLA submittal to the NRC and support the COLA and design finalization of the selected design. The NuStart utilities expressed interest and support for both reactor technologies although the majority of the NuStart utilities were interested in the AP1000 technology. (NuStart members interested in the AP1000 technology subsequently submitted COLAs for that technology.) To limit Federal expenditures and provide the broadest industry support, DOE made the decision to support the Dominion ESBWR R-COLA and the Bellefonte AP1000 R-COLA. Three NuStart members (Exelon, Entergy, and DTE) continued to develop S-COLAs for the ESBWR, following the lead of the Dominion R-COLA, through late 2008, after which only the DTE COLA remained active.

Figure 2: Vogtle Unit 3

By early 2009, it became apparent that the Vogtle COL application, an S-COL at the time, was proceeding through the regulatory review at a pace ahead of the Bellefonte COL application. If Bellefonte remained the designated AP1000 R-COLA, it could have potentially delayed the licensing and construction for the planned Vogtle AP1000 units. Therefore, NuStart decided and announced in April 2009 that it will switch the AP1000 R-COL location from Bellefonte to Southern Company's Vogtle site. According to NuStart, "The change is designed to align industry and regulatory resources with a license application that has specific, near-term construction plans" in order to allow the NRC to complete the AP1000 COL licensing process sooner, allowing other plants to be constructed on schedule. NuStart continued to support the TVA COL for Bellefonte. DOE continued funding to the NuStart cooperative agreement in support of the Vogtle application.

The resultant NuStart AP1000 R-COLA schedule developed as follows:

- R-COLA Submitted (Bellefonte) – October 2007
- Application docketed – January 2008
- Switched R-COLA to Vogtle – April 2009
- Safety Evaluation Report for Vogtle COLA issued – December 2010
- ACRS review of Safety Evaluation Report completed – March 2011
- Final Supplemental Environmental Impact Statement issued – April 2011
- Final Safety Evaluation Report issued – August 2011
- Final COL issued for Vogtle – January 2012

<u>NuStart Summary Conclusions</u>

It is NuStart's position that the NP 2010 Program far exceeded the expectations of the industry. The success of NP 2010 was summarized by NuStart as follows:

NuStart formed the AP1000 Design Centered Working Group to further the NRC's new "one issue, one review, one position" standardization approach to reduce costs, resource needs, and schedule impacts for both NRC and applicants. The NuStart approach was held by NRC as the model for other reactor technologies to emulate, and led development of the form and content of COL applications.

A key concern of the industry on nuclear projects had been the uncertainty of the NRC regulatory process. As a result of experience with the reference COL applications (e.g., the AP1000 R-COLA) obtained through the NP 2010 program, that regulatory process is no longer viewed as a significant contributor to the overall risk profile of a nuclear investor. To date, 18 COL applications have been submitted to and accepted by the NRC.

NuStart has achieved its program objectives on schedule, paving the way for the initial four U.S.-based AP1000 reactors expected to begin operation in 2016-2019 (two each at Southern Company's Vogtle site and SCANA's V. C. Summer site (both of which were NuStart members).

NuStart has strongly encouraged design and licensing standardization among its members and the reactor vendors to improve designs, reduce costs, and reduce time to market.

Working with NEI and NRC, NuStart has helped to establish review processes and procedures needed to make Part 52 implementation a reality.

D. Completion and Certification of Standardized Advanced LWR Designs

Westinghouse AP1000

Westinghouse submitted a DC application to NRC for the AP1000 standard design in accordance with 10 CFR 52 in March 2002. 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. This all occurred prior to the signing of the Westinghouse subcontract from NuStart under the NP 2010 Program in May 2005.

Westinghouse then completed the rulemaking activity for the AP1000 DC under the new 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.

At that time, there were proposed changes to Rev. 15 of the DCD that were favored by NuStart, WEC, or both, but 10 CFR 52 did not provide a mechanism to amend a DC. Therefore, it was anticipated that all AP1000 design licensing documentation, including necessary updates to design information previously approved in Revision 15 to the DCD, would be submitted to the NRC on the NuStart COLA docket. This was not optimum because each subsequent COLA would have to incorporate all these updates as well.

Figure 3: Twin Unit AP1000

Meanwhile, NRC initiated a rulemaking proceeding to make a number of changes to 10 CFR 52. One of the changes contemplated was to include a provision in the regulations that would allow for amendment of an already-issued DC. Once it became clear that 10 CFR 52 was likely to be modified to allow for amendment of a DC, Westinghouse began discussions with NRC about plans for submitting Revision 16 of the DCD to NRC with a request to amend the AP1000 DC rule. The objective of the DC amendment was to close out as many open NRC review items for the AP1000 standard design as possible as part of a certification amendment rather than on the NuStart COLA docket and subsequent COLA dockets. This strategy would address new NRC requirements, enhance standardization, and incorporate design changes that were resulting from FOAKE activities that were within the purview of NRC review.

Further design changes became necessary following submittal of DCD Revision 16. The final AP1000 certification is based on Revision 18 to its DCD. The schedule for the AP1000 Design Certification Amendment follows:

- Initial AP1000 DCD amendment application submitted to NRC – September 2008
- Final DCD Revision submitted to the NRC Staff – June 2011
- Final Safety Evaluation Report issued – August 2011
- DC rulemaking – completed December 2011

Westinghouse Summary Conclusions

The benefits achieved as a result of the NP 2010 Program have proven to be substantially greater than were originally envisioned at the start of the NuStart subcontract, especially in terms of utility participation and standardization.[5]

Under the cooperative agreement, Westinghouse achieved the following three primary objectives:

- Substantially complete the engineering of the AP1000 standard design;
- Obtain NRC approval via a rulemaking amendment for the AP1000 standard design
- 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 were satisfied upon completion of the project in May 2012. By then, Westinghouse had completed 80% of the standard AP1000 design, more than sufficient for firm cost and schedule estimates. By February 2012, Westinghouse had completed approximately 90% of the engineering.

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 05); adjustments to the NRC regulations, requirements, and review processes; orders for AP1000 units in China; and plans by some 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 05 led a number of U.S. utilities to pursue COLAs for potential new plant projects. Five of the utilities in NuStart submitted COL applications 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, 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 NP 2010 Program and the

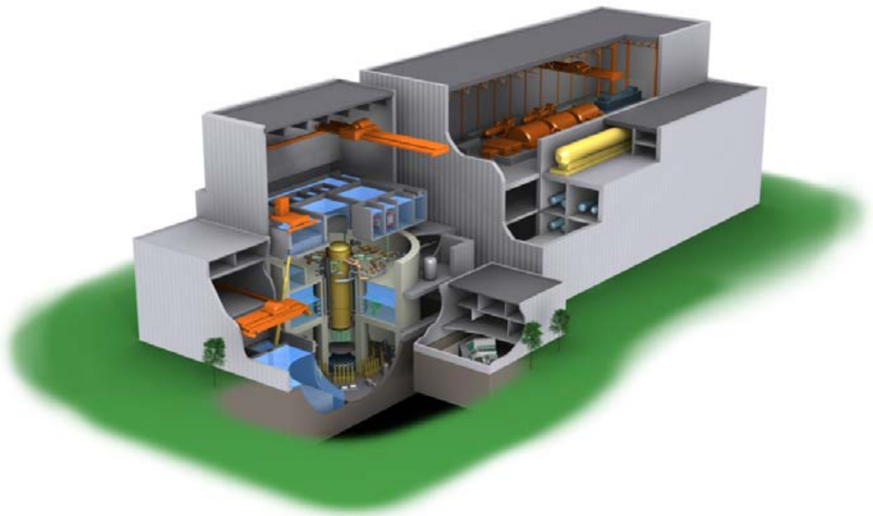
[5] *Westinghouse Electric Co.: Report on AP1000® Design Certification And Design Finalization Project With Lessons Learned*, March 2011, p.1

formation of NuStart, it is likely that industry efforts to respond to the incentives in EPAct 05 would have been delayed by 2 to 3 years.

More importantly, DOE's overall goal for the NP 2010 Program itself – an industry decision to deploy at least one new advanced nuclear power plant – was satisfied by completion of AP1000 design certification, and COLs at the Southern Company Vogtle site and the SCANA Corporation V.C. Summer site (a total of four units). Construction is now underway at both sites. The deployment of the first new nuclear plants in the United States in more than a generation is clear evidence that the NP 2010 Program has been a major success for DOE and U.S. taxpayers.

General Electric-Hitachi ESBWR

General Electric (GE), now General Electric-Hitachi (GE-H)[6], sought participation in the NP 2010 program due to alignment of the NP 2010 program goals with the GE-H new plant business strategy. Prior to the NP 2010 program, GE-H had completed the licensing of the ABWR design and had already performed significant research and development of an advanced reactor design that incorporated passive safety features and a natural circulation design, the Simplified Boiling Water Reactor (SBWR). GE-H worked with both NuStart and Dominion in the development of their respective responses to the DOE NP 2010 program solicitation. The NP 2010 program served as a vehicle that provided unified goals and objectives for the U.S. nuclear industry in terms of licensing standardization. As the program progressed, the NP 2010 program



combined with the incentives in EPAct 05 provided a catalyst for significant new plant licensing activities throughout the U.S. nuclear industry.

Figure 4: ESBWR

[6] On June 4, 2007, GE and Hitachi, Ltd of Japan formed a global alliance combining their respective nuclear businesses into a new company, GE-Hitachi (GE-H).

Initially, GE-H was part of the Dominion and NuStart cooperative agreements supporting the ESBWR COLA application for each team. In 2007, DOE made the decision to streamline its projects by continuing support of the Dominion COLA as the reference ESBWR COLA, while eliminating its support for the NuStart ESBWR COLA. In addition, DOE initiated a separate cooperative agreement with GE-H that would support the completion of analyses and licensing activities necessary to:

- Complete engineering and NRC certification of GE-H's standard ESBWR design.
- Complete the first-of-a-kind engineering for the standard ESBWR plant design to the extent possible under the available, allocated DOE funding.
- Complete detailed ESBWR plant engineering and design and construction planning to be ready for construction of the standard ESBWR plant to the extent possible under the available DOE funding.

The schedule for the ESBWR certification effort follows:

- Design certification application submitted to NRC – August 2005
- ESBWR DC application accepted by NRC – December 2005
- ESBWR Safety Evaluation Report to ACRS – August 2010
- ESBWR Final Safety Evaluation Report and Final Design Approval Issued –March 2011
- Design Certification Rulemaking – currently GE-H is working to achieve DC rulemaking by the end of 2012, however NRC projects the rulemaking to occur in 2013.

Within the time frame and available funding of the NP 2010 program, GE-H did not complete the design finalization scope in the cooperative agreements; however, sufficient DC and FOAK engineering for the standard ESBWR plant design was completed to achieve design certification, expected to be issued in 2013. At the end of the project in May 2012, it is anticipated that all key nuclear island systems and major turbine island systems are at the conceptual design completion stage with significantly more detail in specific component and system design areas based on the level of detail required to support the DCD and COL licensing efforts. This represents completion of about 60% of the standard ESBWR plant design, sufficient for firm cost and schedule estimates.

GE-H Conclusions

GE-H provided the following summary of its demonstration project experience. "Overall, the NP2010 program was a very successful program that benefited the industry greatly. Although the number of utilities moving forward with new plants is significantly less than the number of COL applications submitted, the program provided a real catalyst for the ongoing industry activity. The cost sharing nature of the program promotes effective stewardship of the federal funds while supporting industry growth and development of new innovative products."[7]

From the GE-H reactor vendor perspective, one of the most challenging aspects of the NP 2010 COL/DC program was to predict the scope and timeline of the NRC licensing process. The amount of effort originally envisioned and the timeline for completing the NRC review of the ESBWR was significantly underestimated based on the previous GE experience in licensing the ABWR design. This challenged GE-H's ability to resource detailed design activities to the level originally envisioned under the proposed program funding levels. This was discussed routinely with DOE and other program participants, and resources were consistently prioritized to complete the NRC review and obtain the design certification as the primary goal. The lengthy NRC certification timeline and associated reallocation of resources applied from FOAKE resulted in frustration among the partnering utilities and GE-H.

IV. COL Demonstration Projects: Results and Outcomes

The NP 2010 COL/DC Demonstration projects achieved significant results including:

- Reduced regulatory uncertainty by exercising a previously untested regulatory process for the combined Construction and Operating License. In addition, the regulatory process for an amended design certification was also exercised.
- Development and submittal of standardized COL applications based on two reactor technologies (i.e., R-COLAs) for NRC review and approval, the Vogtle COLA for the AP1000 and the North Anna COLA for the ESBWR (now the FERMI COLA). This effort, in conjunction with EPAct 05 incentives, resulted in the nuclear utilities submitting an additional 16 COL applications (i.e., S-COLAs), two of which have been approved and issued by NRC (Vogtle and VC Summer), and eight of which are currently under NRC review.
- Creation of the design-centered COL review approach with design centered working groups proved an effective model for future new licensing applications.
- The development of guidance documents for combined license applicants and NRC staff for implementing 10 CFR Part 52 that, when coupled with industry's commitment to standardization and approval of the R-COL applications, ensures that S-COLA development and review will be more efficient, significantly reducing licensing schedules.
- NRC amended certification of the AP1000 ALWR design and the NRC final design approval of the ESBWR design. Certification of the ESBWR is expected to be completed in 2013. Both of these ALWR designs employ passive safety

[7] GE-Hitachi ESBWR Design Certification and Finalization Project Final Report, Revision 1, 8/10/2012, p.41

attributes representing the latest and safest reactor technology being deployed in the world.

- Completion of extensive first-of-a-kind engineering for two advanced light water reactor designs. The AP1000 first-of-kind engineering was at about 80% complete and the ESBWR was at about 60% complete when the NP 2010 projects completed, i.e., when NP 2010 funds to each respective reactor vendor were exhausted (May 2010 for AP1000; May 2012 for ESBWR). This satisfied the NP 2010 program objective (see p. 2), to complete the designs to a sufficient level of detail to support firm cost and schedule estimates. Subsequently, the level of engineering completion for the AP1000 was further extended by Westinghouse to about 90% by Feb. 2012, at its own expense.
- The COL/DC Demonstration projects were essential for development of the detailed design and engineering necessary to develop a firm plant capital cost estimate. Without a firm estimate of capital cost, utilities would not be able to seek corporate board or state public service commission approval for new nuclear plant construction.
- The goal of the NP 2010 program, *"to achieve a utility decision to deploy new nuclear plants in the U.S."*, has been successfully achieved with the construction initiated at the Southern company Vogtle site on Units 3&4 and at SCANA's V.C. Summer site on Units 2&3.

Overall, the NP 2010 program was a highly effective government and industry partnership, achieving its stated objectives and goals for new nuclear plant deployment in the United States.

V. Lessons Learned

A. Introduction

The lessons learned input from the individual COL/DC project reports from NuStart, Dominion, Westinghouse and General Electric-Hitachi was analyzed, consolidated and summarized into a prioritized list of key lessons learned and other improvement areas. Explanations are provided for each of the key lessons learned. Specific industry input for these lessons learned and improvement areas can be found in the individual participant reports in the appendices.

In addition, during the development of this report, meetings with DOE staff were convened to discuss the overall effectiveness of the NP 2010 program. Current and former NP 2010 project staff from NE headquarters and DOE-Idaho participated. These meetings provided lessons learned input on the planning, procurement, project implementation, and project controls and reporting in the NP 2010 program COL/DC Demonstration projects.

B. Key Lessons Learned

The following provides a prioritized list of the key lessons learned with detailed explanations in subsequent paragraphs:

- The development of the business cases and, most importantly, a roadmap of activities in the early phases of the program were essential.
- The utility-led consortium approach used on the COL demonstration projects with utility partners and reactor vendors worked well and promoted the implementation of NRC's Design Centered Review approach.
- Significant industry cost share is important on technology development and demonstration projects.
- Utility commitment to a reactor technology or deployment project was not assured prior to initiating NP 2010 and evolved throughout the projects.
- Clearly defined endpoints for First-of-Kind Engineering (FOAKE) are necessary.
- First-of-a-kind development and demonstration activities such as certification and engineering development of a new reactor technology and demonstration of new regulatory processes cost more than planned or previously experienced.
- Implementation flexibility was needed on the DC and COL activities to account for evolving regulatory requirements and changing external conditions that affected the projects.

<u>Roadmap</u> - Development of business cases and, most importantly, a roadmap of activities in the early phases of the NP 2010 program were essential.

The Near-Term Deployment Roadmap, developed by an independent group of experts in 2001, defined the essential elements and activities of the NP 2010 program (e.g., site characterizations, siting decisions and the ESPs; COL, design certification and FOAKE). In addition, roadmaps typically define specific roles of involved stakeholders, activity timing, durations and expected cost of activities. The NP 2010 Roadmap developed a consensus among a diverse group of stakeholders on what actions were necessary to achieve deployment of new U.S. nuclear power plants and what role industry and the Department should have in the program's activities. DOE program managers used the Roadmap to plan the NP 2010 program.

Equally important is analysis of the economics of the intended actions and whether a real business case will exist for follow-on industry deployment of new nuclear plants. The Roadmap attempted to do that in a preliminary way, but sufficient engineering and licensing work to support and validate a solid business case for deployment were essential aspects of NP 2010.

Future nuclear programs involving significant technology research, development and demonstration focused on deployment of new nuclear technology would benefit from availability of a program roadmap prepared by subject matter experts and stakeholders. In addition, independent business case analysis is recommended to ensure activities will have a positive economic outcome.

Utility-Led Consortium Approach - The utility led consortium approach used on the COL Demonstration projects with utility partners and reactor vendors worked well and promoted the NRC's Design Centered Review approach.

The NP 2010 COL Demonstration Project solicitation encouraged the formation of utility-led industry consortia, thus putting the utility industry in the project leadership role, especially with respect to reactor technology selection. This helped ensure NP 2010 maintained a market-driven but industry cost-shared approach. In the view of DOE, the utility-led consortia provided a more favorable approach for a successful project due to the significant number of industry participants involved and contributing to the project, thereby enabling a consensus approach to standardization. The consortium approach permitted cost and risk to be spread over multiple companies while promoting industry standardization, sharing, and cooperation. This approach ensured a common set of project goals among the industry consortia and put the utilities in the position of selecting the reactor technology of choice for licensing and deployment, thereby taking DOE out of the position of having to choose reactor technology "winners and losers."

The utility consortia approach helped ensure plant design standardization with its concomitant future benefits to safety. The utility consortia approach provided the forum and motivation for utility and reactor vendor cooperation on technical design standardization. Multiple utility participation in reactor design development and review activities was viewed as very beneficial to industry, to NRC, and ultimately to U.S. ratepayers and taxpayers. Both vendors attributed significant improvements in their designs to utility participation. As discussed previously, this utility consortia approach was made possible by the market-driven flexibility in the NP 2010 Program.

As the COL projects progressed, the utility consortia also implemented the NRC's Design-Centered Working Group (DCWG) review approach in the licensing area, endorsing the NRC's notion of "one issue, one review, and one position." Use of the "Design Center" or reactor technology working group approach brought a greater degree of standardization to license applications, which in turn enabled resolution of NRC issues (including responses to RAIs) with common industry responses, utilizing generic license guidance documents such as writer's guides, NEI guideline documents, etc., as well as the COLA standardization matrix. This approach promoted standard COL applications with minimal site specific exceptions or conditions, establishment of the "Reference COLA" and

"Subsequent COLA" approach and standard resolution of licensing and technical issues, and helped minimize the risks of schedule delays. The standardization of design and associated licensing documents was cited as resulting "in regulatory efficiencies not anticipated by the industry."[8]

The COLA process and schedule would be greatly simplified by having an approved design certification at the time of COL application. However, there were advantages to utility engagement during the development and review of the vendor Design Control Document (DCD), including the ability to resolve many COLA issues within the DCD (as opposed to later within individual COLAs), and the ability to work with the DC applicants to improve the reactor designs from the owner/operator standpoint, and the quality of the DCD from NRC's perspective.

The timing of the COL demonstration projects and the timing qualification for the production tax credits forced early development of both the reference or R-COLA and subsequent or S-COLAs for the AP1000 and ESBWR, thus putting DC and COL efforts on parallel tracks thru the NRC review. The main point should be to have early engagement of potential utility customers in the design review process.

The Design Centered Working Group (DCWG) provided a good forum to interact with NRC on various topics. Combined DCWG meetings allowed for all technologies to address cross-cutting NRC questions consistently. In addition to the DCWG, which was mostly licensing focused, GE-H and the utilities also formed a Technical Oversight Group that focused on issues of a technical or operational nature. This was also a good forum and allowed GE-H to get consolidated industry input on various technical topics related to design.

DOE should continue to encourage active industry-wide participation supporting new reactor development and deployment in a highly standardized manner. The concepts of a reference standard plant (e.g., R-COLA) leading the NRC review process and Design-Centered Working Groups were both valuable assets to the NP 2010 program and the NRC.

In hindsight, the DOE decision in 2006 to separate the reactor vendors and utility consortia into separate cooperative agreements had advantages and disadvantages. From the utility viewpoint, it was seen as a mistake, having caused a breakdown in consortia relationship with respect to one vendor. From DOE's perspective, the direct reporting relationship of the reactor vendors provided a clearer picture of vendor activities, associated progress and funding status.

[8] NuStart Energy Construction and Operating License Demonstration Project Final Report, June 27, 2012, p.7

Industry Cost Share - Significant industry cost share is important on technology development and demonstration projects.

Cost sharing at a meaningful and equitable level was essential to ensuring alignment of federal and industry goals in the NP 2010 licensing and design completion projects. Such an industry government arrangement was recommended in the Near-Term Deployment Roadmap. DOE concurred with that recommendation and determined that industry participants needed significant financial stake in these important projects to better ensure successful outcomes. As such, DOE set a 50-50 minimum industry cost share for these projects in the solicitation. Industry participants were receptive to this level of cost share. In fact, several of the project participants have exceeded the DOE cost share levels. As one participant stated, "The cost sharing nature of the program promotes effective stewardship of the Federal funds while supporting industry growth and development of new innovative products."[9]

While cost share arrangements worked well, it was not without some difficulties. An acceptable cost share arrangement under EPAct 2005 is the use of "in-kind" man-hours by members of the project participants. On the NP 2010 projects, the cash value of the utility man-hours was an acceptable cost share option in lieu of funding. The 'in-kind' cost-share provisions need to be tightly controlled and should be agreed to up front with industry participants. In several cases as additional industry participants joined the projects, additional work scope was being identified and requests for additional DOE cost-share funding were made as a result of the additional utility man-hours.

In addition, DOE funding was not always available at the beginning of the annual budget period. Dependence on the annual appropriations process meant that DOE funding to support the design certification, COL, and design finalization project budget and schedule did not always align properly. Utility and reactor vendor participants in a DOE cost-shared project must be prepared to provide industry funding when needed (and augment the DOE cost-share at the industry's own risk), in order to maintain overall schedule and budget. The NRC review process and schedule do not easily accommodate budget-driven fluctuations in applicant responsiveness. 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.

Utility Commitment - Utility commitment to a reactor technology or deployment project was not assured prior to initiating NP 2010 and evolved throughout the projects.

The DOE solicitation for the COL Demonstration Projects sought project teams of utility or utility consortia and reactor vendors to conduct the site selection,

[9] GE-Hitachi ESBWR Design Certification and Finalization Project Final Report, Revision 1, 8/10/2012, p.41

combined Construction and Operating License demonstration, reactor technology design certification and plant design completion. The eventual goal of NP 2010 was a utility decision to build a new nuclear plant with the license obtained during the demonstration projects. This approach worked for several utilities involved in the NuStart Project since Southern and SCANA are building AP1000 reactors at the Vogtle and V.C. Summer sites, respectively.

However, for several of the other industry participants, the reactor technology and/or COL applications changed from the original funded projects. The decision to build a nuclear power plant is a very complex and demanding business decision by a utility, involving future power demand, load growth, economics, financing, public utility commission considerations as well as the cost and schedule to license and build the nuclear plant. The lack of the design certification and especially the amount of completed FOAKE had an effect on the commercial readiness of the design selected. Dominion Energy switched reactor technologies twice during the demonstration project due to too long a certification schedule and the lack of acceptable commercial deployment terms (cost and risk allocation); TVA chose to finish the existing nuclear units at the Bellefonte site while the Bellefonte reference COLA for the AP1000 was under NRC review. The flexibility inherent in the NP 2010 program and in Part 52 allowed these changes, necessitated by changing market conditions, to proceed without government intervention.

One of the utility participants noted that "One of the more significant lessons learned from the use of Part 52 (10CFR Part 52 regulations) is that commercial negotiations for any specific nuclear project need to proceed well ahead of the development of the COLA. Without such consideration, potential customers may find themselves in a situation where significant capital and effort have been spent developing and seeking approval for a COL referencing a particular design, thus resulting in a very weak commercial negotiating position for those customers with the selected reactor vendor."[10]

Cost and schedule were among the key drivers for each of these decisions. If the reactor vendors had the certification and engineering completed on their respective technologies, better plant cost estimates and risk allocations could be developed for contract negotiations. On future demonstration projects where nuclear plant deployment is the ultimate goal, reactor technology development (DC and FOAKE) should ideally have made significant progress before site-specific nuclear plant licensing proceeds. The earlier discussion of a utility-led consortium approach presented advantages of utility engagement during the DCD preparation and FOAKE phases. The challenge is devising a cost-share program with industry that succeeds in bringing major utility engagement to the design process without using COLs as a prerequisite "driver" for that engagement.

The biggest disadvantage of the COLA and DC reviews proceeding in parallel is the potential for the DC schedule to negatively impact the COLA schedule. Since a COL

[10] NuStart Energy Construction and Operating License Demonstration Project Final Report, June 27, 2012 P.32

cannot be issued before the reactor design is certified, the COL applicant's schedule is completely dependent on the design certification schedule. Another significant disadvantage of the reviews proceeding in tandem is the associated burden of ensuring that the COLA designs are maintained in accordance with DC designs (i.e., ensuring robust configuration management is in place).

On balance, the parallel DCD/COLA reviews had a positive impact on the quality of the DCD from a customer/operator standpoint. Since the first design certifications were issued without significant operator input, significant revisions to the DCDs were required to address operability, testability, maintainability and programmatic issues.

Developing the DCD content in conjunction with utilities preparing a COLA provides a highly integrated package of licensing products. However, the division of responsibility between what needs to be provided in the DCD and what was to be provided in the COLA is not always well defined, especially in new or unique products or design features. This could become an area of contention in some cases where the COL applicants may want topics addressed in the DCD while a reactor vendor may believe that these topics are not its responsibility.

Increased cooperation between vendors and utilities in working together on DCDs prior to COLA submittals could reap the greatest benefits without the rework and other potential cost and schedule risks associated with parallel DCD/COLA reviews.

The rate at which the design advances should coincide with the needs and sequencing from a licensing standpoint. Sufficient design detail should be available to provide complete information for each licensing submittal. However, accelerating design before licensing basis requirements have been finalized could cause significant rework.

To deploy a new standard design in less than a decade, the activities for DC, COL, FOAKE, 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.

Several options to accomplish this project phasing were proposed:

- For future solicitations, encourage reactor vendors to submit certification and design proposals ahead of utility licensing proposals, but require the proposals to be linked – i.e., a phased solicitation approach with reactor vendor activities proceeding ahead of a second phase of utility licensing activities.
- For future similar programs, DOE should encourage the utilities and reactor vendors to have an appropriate level of commercial negotiations, up to and including a deployment contract, supporting a particular nuclear project, before commencing significant licensing efforts toward a COL. This might

involve a consortium-led competitive selection process, as envisioned by NuStart early in its planning process.

Finally, the financial incentives in EPAct 05 were key to encouraging utility commitment. The timing of those incentives in relation to the demonstration program schedule is important. In the case of the EPAct 05 incentives, it turned out that without NP 2010, industry would not have been in a position to respond in a timely manner to those incentives. On the other hand, uncertainty in the implementation details for those incentives reduced their effectiveness and their ability to contribute to detailed cost estimates and utility business decisions.

The high level of design detail needed to support NRC licensing and 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 most likely required for a new standard design.

<u>FOAKE Endpoints</u> – Clearly defined endpoints for First-of-a-Kind Engineering are necessary.

DOE used the term "First-of-a-Kind Engineering" or FOAKE in the project solicitation and defined the term as *sufficient engineering for the vendor to develop a firm price and schedule to build a nuclear plant*. However, the endpoint of the reactor engineering activity was not specified clearly in the industry demonstration project cooperative agreements. It was intended that the reactor vendors specified what this endpoint was in terms of engineering documents, drawings and analyses. It was also intended that DOE would only support the detailed engineering until the vendors were able to propose cost and terms for a deployment contract, and that additional detailed engineering would be up to the vendor and utility.

In the solicitations and cooperative agreements, terms such as plant and site engineering, and design finalization were used which, in retrospect, could have been more clearly defined. In addition, a clear definition of the "engineering scope" of the project needs to be well understood to support realistic demonstration project cost and schedule baselines and subsequent changes thereto. For future reactor technology engineering projects, the end point or boundaries of terms such as "First-of-a-Kind Engineering" or "Design Finalization" need to be clearly and specifically spelled out in contract documents, so all participants have a common understanding to support realistic project cost and schedule estimates.

Another consideration, in addition to the need for precise definitions, contributed to the problems stemming from differing views on FOAKE endpoint. That consideration was budgetary. As discussed in the next "Key Lesson Learned" neither industry nor DOE (nor Congress) anticipated the major expansion in NRC expectations for level of engineering detail required to make its safety determinations in the licensing process. As a result, funds expected to be available for FOAKE were spent on additional work on DC engineering and the associated licensing costs for RAI processing. This budgetary pressure put at risk the ability of both industry and DOE to complete FOAKE to its defined limits (sufficient to develop firm cost and schedule estimates) before approved funding ran out.

<u>Demonstration Activities Cost More than Planned</u> – First-of-a-kind development and demonstration activities such as certification and engineering development of a new reactor technology and demonstration of new regulatory processes cost more than planned or previously experienced.

The activity level and associated costs for design certification were significantly higher than the reactor vendors experienced previously due to evolving regulations and the inability of industry participants to adequately predict the scope and timeline of the NRC review process. The level of design and engineering detail expected by NRC during NP 2010 was much greater than previously experienced by the reactor vendors in design certifications completed prior to NP 2010. For example, the requirements to certify the AP1000 (DCD Rev. 18) were much more extensive than required for the AP1000 (DCD Rev. 15). Similarly, the requirements to certify the ESBWR were much more extensive than required for the ABWR. Specifically, many more Requests for Additional Information (RAIs) were received by the reactor vendors than previously experienced. Each RAI required additional time to address and to ensure an understanding by the NRC reviewer.

As a result, the baseline cost of design certification was under-estimated by the reactor vendors. Evolving regulations (aircraft impact, sump blockage) also had an impact on the level of design needed and cost for certification. The time required for NRC review of design certification documents as well as COL applications took many more man hours than planned in the project baselines. In addition, the NRC review fee rate increased over the course of the projects. As a result, baseline costs were underestimated requiring the industry participants to seek additional funding. DOE ended up limiting the total funding to each project, thus limiting achievement of project objectives. For example, ESBWR engineering and design finalization activities were reduced due to larger than planned design certification costs. In addition, the desire by utility partners for a greater degree of safety-related engineering completion within the DC scope (thereby reducing the licensing burden on both NRC and industry during the COL phase), required reactor vendors to front-end load engineering activities, man-hours, and project funding to achieve this objective.

Evolving regulatory requirements presented significant challenges and caused rework in many cases. Examples include: changes to the Standard Review Plan (SRP), revisions to NRC Regulatory Guide 1.206, revisions to various Interim Staff Guidance Documents (ISGs), rule changes and new rule implementation such as aircraft impact assessments (AIA). Additionally, new standards or expectations for implementation of existing regulations were also challenging. Examples are set point and jet impingement analysis methodologies.

There is no doubt that some technical issues were identified that resulted in significant delays in achieving design certification, which in turn resulted in delays in COL issuance. Two key examples were the AP1000 shield building composite wall design change and the ESBWR steam dryer flow and vibration analyses.

Projects involving an industry first-of-a-kind effort to develop a COL application should take into account the schedule impact of changing regulations, standards, and guidance. There should be an effort to identify and revise as necessary any related regulations and guidance that might affect the DC program as early as possible. Recognizing that there will inevitably still be some regulation and guidance changes during the DC program, the engineering budget and schedule planning should take this into account.

The level of design detail “required” by NRC to review a design is both subjective and unpredictable. Design details judged by industry to be outside regulatory scope (based on prior NRC review precedents) were later found to be necessary to satisfy NRC expectations. Further, expecting a vendor to completely finalize a design without a paying customer is ambitious, as is expecting a customer to take a chance on an incomplete design.

Future large, complex, multi-year projects involving new reactor design and licensing activities could employ one or more of the following:

- An up-front understanding with NRC on the level of detail required to make safety determinations for DC, followed by a more disciplined process to limit the natural desire to request additional details during NRC review.
- A DOE total project funding cap once the project scope, licensing and engineering cost and schedule baselines are clearly defined and approved. DOE could pay NRC review fees as incurred, or it could pay a flat fee for NRC review. A flat fee might encourage applicants to apply better discipline to the NRC review scope and to avoid excessive iterations on licensing issues.
- Strive to achieve an agreed-upon baseline cost of the total project once the project scope/cost/schedule baselines are approved. This total project cost should be used as a ‘project target’ for scope and schedule issues. This target, or de facto ‘cap,’ could be modified only through DOE high-level involvement with OMB and Congress.
- Structuring cooperative agreements with separate phases and decision milestones permitting off-ramps or project scope redefinition opportunities for DOE participation. This could be combined with cost performance measures for each project phase to address potential cost overrun issues. This would also require close coordination with Congressional appropriations committees and OMB, seeking their flexibility on year-to-year funding to the project.

- Structure future award funding distribution to achievement of program or project milestones rather than a simple matching of industry investment. This approach would also require close coordination with OMB and Congress.

Project Implementation Flexibility - Implementation flexibility was needed on the DC and COL activities to account for evolving regulatory requirements and changing external conditions that had an effect on the projects.

The decision to deploy a new first-of-a-kind nuclear plant requires a joint effort by utilities, reactor vendors, and state and Federal regulators. Future power demand, financing costs, public utility commission considerations and commercial terms and risk sharing with the constructor are only a few of the critical issues that need to be addressed before that utility decision is made. These "real world" commercial and institutional considerations had to be accommodated by the demonstration projects implemented under the NP 2010 program. While the NP 2010 goal was a utility decision to deploy new plants, no utility was ready to commit to plant deployment when the demonstration projects were initiated; utilities were initially only really committed to regulatory demonstration projects. As a result of reactor vendor design certification and engineering activities to complete the designs, it was believed that commercial contract terms could be developed between vendors and utilities such that the COL demonstration projects would lead to real deployments.

However, many external factors had an effect on how the vendors and utilities proceeded. Flexibility on implementation (acceleration of engineering schedule, manpower, and funding, etc.) of the cooperative agreements was necessary to achieve deployment. This was successful since two utilities – Southern Company and SCANA – are moving forward with construction of the AP1000 at sites in Georgia and South Carolina, respectively. However, this success was not how the projects were originally planned. Changes to the reference COL site were required on the NuStart project, and reactor technology changes were made on the Dominion project. These changes, driven by changing market conditions and accommodated by a flexible NP 2010 Program, allowed the demonstration projects to continue with limited impact.

NRC's regulation has proven to be remarkably robust in dealing with various permutations (e.g., parallel DC and COLA reviews versus DC and ESP followed by COL), as experienced under the NP 2010 program.

One change that had a negative impact (at least from the perspective of the utilities) was the separation of the reactor vendors from the original utility-led cooperative agreements. There was a resultant relationship change (lack of direct accountability of the vendor to its future customer(s)) that eventually contributed to a utility decision to select a different reactor technology.

On future complex demonstration or deployment type projects, flexibility in the implementation of the cooperative agreement work scopes is necessary to allow engineering and licensing activities to adapt to external forces in the evolving marketplace. DOE should provide clear performance outcomes in the cooperative agreements rather than detailed prescriptive project sequencing and work scopes as the measures or objectives to achieve. It should be noted that 10 CFR Part 52 contains remarkable flexibility in the sequencing of ESP, DC and COL submittals. Future licensing demonstration programs should embrace (as did NP 2010) this licensing flexibility.

It is important for DOE to encourage competition and improvement, rather than narrowing down the technology options and selecting a winner. Including multiple vendors whose designs are based on extensive and proven technologies that conform to utility requirements will increase the success rate of a program.

C. Other Lessons Learned

Industry Interactions; Project Management; DOE Interface

Effective project management leadership throughout the COL application project proved essential, especially during the planning stages and initial startup. Although some changes in leadership and personnel are inevitable, continuity and consistency should be maintained to the greatest extent possible.

Project planning and budgeting should include interactions with industry groups (e.g., NEI, INPO, ASME, EPRI, and others) on regulatory issues, processes, and policies that can be addressed generically.

At project inception, and periodically throughout the project, the project team should re-evaluate the responsibility for application sections based on the experience of the individuals, workload, and other factors. The team should be ready to adjust. Formalized training should be developed for off-project personnel. The need for additional indoctrination and training should be continuously evaluated throughout the project.

Clear lines of responsibility between the reactor supplier (and its subcontractors) and the utility (and its site characteristics information support contractors) need to be established early to ensure that support for each calculation or analysis is a shared responsibility. Careful planning and strong oversight of all design work performed by outside organizations or individuals are critical to successful and efficient execution.

Up-front planning and automation are essential to the efficiency and overall success of the project. A good document control system, as well as a transmittal tool, needs to be implemented at the start of the project.

Thousands of unique design and licensing activities are required to achieve DC and design finalization. Although some cooperative agreement partners felt that the uniqueness of a first-of-a-kind effort like the NP 2010 program did not lend itself easily to use of project management tools such as Earned Value Management System, EVMS, others felt strongly that every effort should be made to develop a resource-loaded schedule and to implement an EVMS from the onset of the DC, COL and FOAKE activities.

The schedule for development of COL sections should also seek to define activities for each section in a chronological manner. Information needs such as engineering calculations supporting a section's development should be grouped at the beginning of a section schedule to lend focus to those items needed prior to section development.

A common problem with early COLA section drafts was that descriptions of the same information presented in multiple sections were not consistent. This was solved by developing a 'style guide' and providing it to team members prior to any sections being written. Consistency issues and adherence to such a guide were addressed during section presentations and/or pre-job briefings.

The combination of routine status phone calls, monthly project status reports (with EVMS data and narratives), routine formal project reviews with DOE senior management and senior Cooperative Agreement participant management project reviews were all judged to be important good practices.

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.

It is critical to come to early agreement on the site plan, including location of nuclear/turbine island complex and all yard structures. Site topography should be understood by all stakeholders. All stakeholders should be involved in this review. The site layout should be frozen early in the project planning and schedule process. All parties should establish and work to a clear milestone date for freezing the site layout.

For projects involving multiple members such as consortia, solid commitment is needed to provide the time and effort required to reach consensus among a large, diverse, and opinionated group of licensing and engineering professionals on issues of critical importance (and sometimes not-so-critical importance) to the project. Goal and financial congruence within the consortium is essential so that all members are motivated to work together when unexpected issues arise. It is also necessary to get as many members as possible actively participating in order to achieve enduring standardization and successful results.

Regulatory Issues & Regulatory Interface

The regulatory lessons learned presented below are grouped in four categories:

- Effective Communications
- Level of Detail
- NRC Guidance
- Core Team/Subject Matter Experts

Effective Communications:

Additional emphasis, planning, and resources should be allocated to support pre-application interactions with NRC staff. 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 any advanced or unique features have on the more conventional parts of the plant.

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. NRC worked diligently with the NP 2010 applicants to maintain the review schedule (without sacrificing the quality of its safety review). This was especially true when there was a construction project for which the start depended upon completion of the review.

Early ACRS reviews were important to allow the ACRS members sufficient time to air concerns early in the review process. Based on these early reviews, the NRC staff had sufficient time to address issues as part of the course of their review.

The number and type of questions asked by NRC staff varied, depending on individual NRC reviewer experience and mindset. 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 to 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.

The speed of information distribution from NRC is an area for improvement. A mechanism is needed for situations where there is information to be transmitted to industry, but not enough information for a full day's meeting agenda. The time it takes for interim staff guidance (ISG) to be distributed was an issue. Many of the topics where discussions were requested with the NRC were delayed until the staff was able to put draft ISG together. A faster method for issuing draft ISGs would allow discussions to start sooner, which could accelerate the resolution of issues.

NRC position alignment between reviewers on DCD topics and COLA topics at times led to conflicting messages and inefficient use of resources. The reviews were impacted by not having common reviewers take a single position and a common interpretation of issues between design (DCD) and implementation (COLA) reviews. To the extent possible, NRC should employ the same reviewer or reviewers on DCD and COLA topics.

It would be very helpful if NRC established a standard review schedule for DC reviews. This would allow reactor vendors to develop and implement adequate planning and resource loading tools. Additionally, this would impose some reasonable pressure on both NRC and reactor vendor staffs to perform in accordance with agreed-upon schedule commitments.

Level of Detail

NRC requirements in the Code of Federal Regulations are written in a concise manner. NRC expands on those requirements by providing guidance illustrating acceptable ways to meet the requirements. It is not unusual for permit and license applicants to be similarly concise in their submittals; however, in such instances, NRC often issues Requests for Additional Information (RAIs) soliciting the details and descriptions that "tell the story." Therefore, it is advisable to review all previously docketed RAIs to understand what level of detail is currently expected by NRC. Early communication with NRC greatly reduces response time on emergent issues. Learning about these topics via NRC electronic RAIs and through weekly status calls with NRC enabled the DCWG to learn more quickly about and respond to new issues. Making the electronic RAI process public and keeping it up to date was extremely beneficial.

Uniform guidance is needed on the level of detail needed to close out design acceptance criteria (DACs) in order to maximize closures during the DC review and/or COL review.

In some areas of the DCD, NRC requested an increased level of detail to be included in Tier 2 documents. An effort should be undertaken by both industry and NRC to develop more 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.

NRC RAIs generate the next level of detail required in a COL application. An NEI process could be put in place to review RAIs against the COL application content requirements in NRC Regulatory Guide 1.206, and identify the next level of detail being required by NRC reviewers for COL applications.

NRC Guidance

Industry proposed changes to the LWA rule (via NEI), and the NRC staff accommodated the request. Those changes were not accompanied by careful enough consideration - by NRC staff or applicants - of changes to guidance. As a result of these changes, and changes to the definition of "construction," uncertainty in this area actually increased somewhat. This included changes in how other agencies interact during the NRC review.

Prior to reviewing a DC amendment or a Subsequent COLA (S-COLA), NRC should consider providing detailed guidance about closure of issues from the initial DC or Reference COLA (R-COLA), as well as procedures for quickly resolving any questions about whether or not an issue is open for review.

Guidance is needed on which systems (or system classifications) require P&IDs in the FSAR and the level of detail required by system or system classification. This is an issue to be addressed for both DCDs and COL applications.

Guidance is also needed on which site structures (or structure classifications) require fire zone drawings and which fire hazards analysis tables should be included in the COL application FSAR.

Where there is a need in the COLA to support seismic category I structural fill, testing should be performed on fill materials (either the onsite materials or materials similar to the type that will be used) at the time of the site investigation.

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.

Regulatory processes often make it difficult to introduce new technology. The level of questioning to prove new technology is adequate from a safety standpoint may make incorporation of new technologies unattractive from a licensing standpoint even if they are better, safer technology. Advanced digital controls are prime examples of this dilemma.

Core Team / Subject Matter Experts

Establishing a licensing core team that includes highly capable licensing experts from both the applicant and applicant's contractor organizations is critical to development of a complete and quality COL application. This was identified as a Best Practice.

The keys to success in interactions between applicants and NRC are thoughtful engagement and credible spokespeople and subject matter experts (SMEs); identification and use, to the maximum practical extent, of meaningful analogs/precedents; and non-confrontational escalation of issues that do not receive prompt resolution.

NRC Part 51 Environmental Licensing Reviews; EPA Interface

Development of design documentation and environmental input must be adequately coordinated. Internal reviews should be conducted of all work that involves engineering and environmental assessments such that environmental considerations are appropriately addressed in the design documents (e.g., site layout plans and power line routing).

If a COL application references an ESP, 10 CFR 51.50(c) (1) requires that the COL application Environmental Review include "any new and significant" information for issues related to the impacts of construction and operation of the facility that were resolved in the early site permit proceeding. However, NRC failed to provide more detailed regulatory guidance to implement the "new and significant" requirements of 10 CFR 51.50(c) (1) for an extended period of time, causing delays in COLA reviews.

Environmental investigations for a greenfield project (or existing site where the location of the proposed unit[s] has not been previously investigated) should include the scope of work to support the subsurface investigation. All environmental subcontracts for COLA work should be issued early in the project and should include an investigation for items that may impact the subsurface testing and analyses.

Analysis of liquid discharges to meet NRC criteria should also include analysis of conformance to EPA drinking water standards. The latter may not need to be reported in the ESP or COL applications, but will need to be considered within the project's overall regulatory framework.

State/Local Authorities

Coordination, primarily on environmental issues, between NRC, state agencies, and other environmental permitting agencies is critical. Knowledgeable individuals should be sought and empowered to work with NRC as well as other Federal, state, and local regulators on environmental issues. Future projects should plan on a very proactive, early engagement with state and local agencies and concerned citizens.

ESP and COL applicants should assume that state and local regulatory agencies will continue to need to become more familiar with the NRC nuclear licensing processes. Therefore, the project should be prepared to provide significant background education and support to these agencies.

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Appendix A:

Dominion Virginia Power NP 2010 COL Demonstration Project Report

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Nuclear Power 2010 Program
Dominion Virginia Power
Cooperative Project

U.S. Department of Energy
Cooperative Agreement DE-FC07-05ID14635

Construction and Operating License
Demonstration Project
Final Report

November 2010

Table of Contents

List of Abbreviations and Acronyms

ACRS	Advisory Committee on Reactor Safeguards
ASLB	Atomic Safety and Licensing Board
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
CDI	Conceptual Design Information
CMS	Content Management System
COL	Combined License
COLA	Combined License Application
CY	Calendar Year
DCD	Design Control Document
DCWG	Design-Centered Working Group
DEIS	Draft Environmental Impact Statement
DHS	(U.S.) Department of Homeland Security
DNNA	Dominion Nuclear North Anna, LLC
DOE	(U.S.) Department of Energy
DOR	Division of Responsibility
EIS	Environmental Impact Statement
EP	Emergency Plan
EPA	(U.S.) Environmental Protection Agency
EPC	Engineer, Procure, Construct
EPRI	Electric Power Research Institute
ER	Environmental Report
ESP	Early Site Permit
EVMS	Earned Value Management System
ESBWR	Economic Simplified Boiling Water Reactor
FAA	(U.S.) Federal Aviation Administration
FEMA	(U.S.) Federal Emergency Management Agency
FOIA	Freedom of Information Act
FSAR	Final Safety Analysis Report
GE	General Electric
GEH	General Electric-Hitachi
GIS	Geographic Information System
IFIM	Instream Flow Incremental Methodology
ISG	Interim Staff Guidance
NAPS	North Anna Power Station
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NOAA	(U.S.) National Oceanic and Atmospheric Administration
NP 2010	Nuclear Power 2010
NRC	(U.S.) Nuclear Regulatory Commission
PMF	Probable Maximum Flood

PMP	Probable Maximum Precipitation
PPE	Plant Parameters Envelope
QA	Quality Assurance
PSWS	Plant Service Water System
RAI	Request for Additional Information
R-COLA	Reference COLA
RFI	Request for Information
RTNSS	Regulatory Treatment of Non-Safety Systems
S-COLA	Subsequent COLA
SEIS	Supplemental Environmental Impact Statement
SER	Safety Evaluation Report
SME	Subject Matter Expert
SSAR	Site Safety Analysis Report
STP	Sewage Treatment Plant
UFSAR	Updated Final Safety Analysis Report
US-APWR	US-Advanced Pressurized Water Reactor
VDEQ	Virginia Department of Environmental Quality
VDHR	Virginia Department of Historic Resources
VPDES	Virginia Pollutant Discharge Elimination System

1. Executive Summary

The United States Department of Energy (DOE) and Dominion Virginia Power (formerly Dominion Nuclear North Anna, LLC; hereafter referred to as Dominion) entered into Cooperative Agreement Number DE-FC07-05ID14635 in April 2005. The Cooperative Agreement, established under the auspices of DOE "Nuclear Power 2010 (NP 2010)" program, created the management framework for the North Anna Construction and Operating License (commonly referred to as the "Combined License" or "COL") project. The purpose of the project was to promote the economic, technological, and engineering evaluations necessary to determine the feasibility of establishing a new nuclear plant at the North Anna Power Station and to support the creation of a COL application (COLA) for the proposed new plant.

The Cooperative Agreement ended in the spring of 2010 with total project costs of approximately $150 million. At the conclusion of the 5-year North Anna COL project, significant progress had been made towards the goals set forth in the Cooperative Agreement. Multiple revisions of the ESBWR design certification application had been submitted for NRC review, a Combined License application for the ESBWR at the North Anna site had been submitted to the NRC, ESBWR and site-specific engineering for a new nuclear power plant was advanced, and a business case was developed to support a decision to build a new nuclear power plant at the North Anna site.

In April 2007, ESBWR design and NRC design certification activities were removed from the Cooperative Agreement and assigned to a separate Cooperative Agreement between DOE and GE-Hitachi (GEH). Delays associated with the detailed design of the ESBWR, in part related to the need to reply promptly to a multitude of NRC Requests for Additional Information (RAIs) on the design control document (DCD), slowed the plant design engineering effort for site-specific facilities. Increased NRC requirements for detailed information, limits on GE funding and resources, and GE submission of incomplete versions of the DCD contributed to delays in obtaining NRC Design Certification and approval of the North Anna Unit 3 Combined License Application. Dominion was unable to enter into a satisfactory engineering, procurement and construction (EPC) agreement with GEH. In late 2008, Dominion announced a competitive process to select a nuclear technology supplier. In May 2010, Dominion announced that, as a result of the competitive process, it had selected Mitsubishi Heavy Industries' US-Advanced Pressurized Water Reactor (US-APWR) as the technology for North Anna Unit 3.

The North Anna COL project Cooperative Agreement was successful in advancing the site-specific plant design for North Anna Unit 3, furthering the development of the licensing process for COLAs that reference an early site permit (ESP), producing license application documents supporting the likely approval for the construction and operation of a new nuclear unit at the North Anna site, and establishing the business case supporting the development of a new nuclear facility. The ultimate goal of the DOE Nuclear Power 2010 program is to reduce technical, regulatory, and institutional barriers to the construction and operation of new nuclear power generating units. Given the current advanced state of the North Anna COL effort, the Cooperative Agreement between DOE and Dominion was a success because it served as a demonstration of much of the COL process for a proposed new plant at a location with an existing Early Site Permit. The Cooperative Agreement also helped to stimulate the entry of multiple vendors into the U.S. commercial market for new nuclear power plants.

2. Introduction

The Nuclear Power 2010 (NP 2010) program was initiated by the United States Department of Energy (DOE), Office of Nuclear Energy, in 2002. The goals of the program are to reduce the technical, regulatory, and institutional barriers to building new nuclear power plants in the United States as well as to secure industry decisions to construct and operate the new plants. The NP 2010 program is structured to promote a partnership between government and industry to reach these goals, with DOE and industry sharing the costs of program activities.

The NP 2010 program promotes the development of new nuclear power plants in the United States, in part through the support of reactor design activities, development of licensing processes to meet United States Nuclear Regulatory Commission (NRC) requirements for the siting, construction, and operation of new plants, and cooperative projects with industry for intensive study of certain technologies at specific prospective locations. One of the cooperative projects undertaken by the NP 2010 program was a task to develop NRC COL documentation and determine the feasibility of the GE ESBWR nuclear power plant technology as a new nuclear power unit at the Dominion North Anna Power Station (NAPS) located near Mineral, Virginia. Two years into the five year project, the technology-specific engineering tasks were removed from the Cooperative Agreement and placed in a different one created between GE-Hitachi and DOE. COL development and site-specific engineering activities continued under this Cooperative Agreement into 2010. This document provides an overview of the North Anna COL Cooperative Agreement project (DOE Cooperative Agreement DE-FC07-05ID14635).

Dominion is one of the nation's largest producers and transporters of energy, with a portfolio of more than 27,500 megawatts of generation and 6,000 miles of electric transmission lines. Headquartered in Richmond, Virginia, Dominion serves retail energy customers in 12 states. Under Dominion management and leadership, primary members of the project team included General Electric-Hitachi (GEH) and Bechtel. Specialty contractors supporting Dominion included Tetra Tech NUS, Inc. (environmental data collection and analysis, environmental impact assessments), Mactec Engineering and Consulting, Inc. (site subsurface investigation and laboratory testing), and Risk Engineering, Inc. (probabilistic seismic hazard analyses). Entergy, a member of the ESBWR Design-Centered Working Group (DCWG) preparing a subsequent COLA (S-COLA) for an ESBWR at the Grand Gulf site, and Enercon, a contractor to Entergy, also actively supported development of the R-COLA.

This report serves to summarize the major activities completed as part of Dominion's Cooperative Agreement with DOE, based on periodic status reports and briefings generated during the course of the project (e.g., quarterly reports submitted to DOE by Dominion). Project successes, lessons learned, and suggestions for improvement are also discussed herein, based on a review of project deliverables and input from interviews of Dominion management personnel.

The objectives of the North Anna COL project included:

- Prepare and submit the General Electric (GE) Economic Simplified Boiling Water Reactor (ESBWR) design certification application
- Obtain United States Nuclear Regulatory Commission (NRC) design certification for the ESBWR
- Prepare and submit a COLA for the ESBWR at the North Anna site
- Obtain NRC approval of the COL
- Complete the ESBWR design and site-specific engineering

- Develop a business case necessary to support a decision on building a new nuclear power plant

Dominion completed five submissions of the Reference COLA (R-COLA) for the ESBWR technology and reached the Phase 3 milestone for the NRC Staff's Safety Evaluation Report (SER) by completing the NRC's Advisory Committee on Reactor Safeguards (ACRS) review of the SER with open items. There were only seven open items remaining before Dominion completed a competitive procurement process which resulted in changing the reactor technology. Had Dominion not changed technology to the US Advanced Pressurized Water Reactor (US-APWR) in May of 2010, a Final SER was targeted for February 2011. Because of DOE's NP-2010 program, the COLA process was able to make great strides to facilitate the restart of the industry by creating clear and consistent frameworks for both industry and regulators to follow. The success of North Anna's COLA helped advance the following goals of NP-2010:

- Work with the NRC to resolve technical and regulatory issues associated with the COL process
- Clearly define the form and content of a COLA
- Demonstrate the new COL process

Section 3 of this report provides a brief project summary, Section 4 identifies lessons learned from the project, and Section 5 is a narrative detailing insights and recommendations based on the experience and outcome of the Cooperative Agreement project.

3. COL Demonstration Project

3.1 NP 2010 COL Demonstration Project Purpose and Achievements

The North Anna COL Project was performed by Dominion with the following objectives:

- Prepare and submit a COLA to the U.S. Nuclear Regulatory Commission (NRC) incorporating Economic Simplified Boiling Water Reactor (ESBWR) technology for a third unit at Dominion's North Anna Power Station (NAPS) site located near Mineral, Virginia
- Support the NRC review process and mandatory hearing
- Obtain NRC approval of the COLA and issuance of a COL
- Develop a business case necessary to support a decision on building a new nuclear power plant at the NAPS site

Major milestones of the project included:

- The project began on April 4, 2005.
- Submission 1 of the COLA with Revision 0 of all parts of the COLA was provided to the NRC on November 27, 2007.
- The Early Site Permit (ESP) was issued on November 27, 2007.
- NRC Docketing Decision Letter was issued and the acceptance review completed on January 28, 2008.
- Submission 2 (Non-Public Version) of the COLA and Submission 3 (Public Version) with Revision 1 of most parts of the COLA were provided to the NRC on December 20, 2008.
- Submission 4 (Public Version) of the COLA with Revision 2 of the FSAR and Departures Report was provided to the NRC on May 29, 2009.
- Submission 5 (Public Version) of the COLA with Revision 2 of the Environmental Report (ER) was provided to the NRC on July 29, 2009.
- The Advisory Committee on Reactor Safeguards (ACRS) review of the SER with Open Items was completed on November 4, 2009.
- The Final Supplemental Environmental Impact Statement (SEIS) was issued to U.S. Environmental Protection Agency (EPA) on March 19, 2010.

Appendix 1 identifies schedule milestones for the project.

Applying for a COL is a federal licensing action before the NRC as well as an action that is conducted by the applicant and regulator in the public eye. Given this circumstance, several deliberate opportunities are afforded by the NRC during their review for the public to provide input and comment. There are NRC regulations and guidance that apply directly to the COL process, while other federal, state, and local regulatory authorities interact with the NRC or Dominion during the licensing effort. Such interactions may be as simple as consultation or solicitation of comments, or may be as involved as obtaining certifications and permits for actions to be conducted at the site in coordination with NRC approvals. The National Environmental Policy Act (NEPA) is an example of a federal statute requiring an environmental review by the NRC, in parallel with the NRC's technical review under 10 CFR 52, which necessitates interactions with multiple federal and state agencies. Examples of agencies and organizations with which Dominion interacted during the ESP and COL projects included the U.S. Fish & Wildlife Service, U.S. Army Corps of Engineers, Federal Aviation Administration (FAA), U.S. Department of Energy (DOE), Department of Homeland Security

(DHS), U.S. Environmental Protection Agency (EPA), Virginia Department of Environmental Quality (VDEQ), Virginia Department of Historic Resources (VDHR), National Guard and other emergency responders, Federal Emergency Management Agency (FEMA), Electric Power Research Institute (EPRI), local counties' Boards of Supervisors, and local community, business, and citizen action groups. Considerable information on these interactions during the North Anna COL Project is provided in the COLA and NRC review documents.

3.2 Project Execution

3.2.1 Significant Activities — Calendar Year (CY) 2005

On March 31, 2005, DOE awarded Dominion a financial assistance award in the form of Cooperative Agreement DE-FC07-05ID14635 under the NP 2010 program. The work to be completed under the Cooperative Agreement was to be performed in two phases. The first phase, Phase 1, was the project planning phase. Phase 1 activities included the assembly of the project team and infrastructure, development of a detailed work scope and schedule, establishment of DOE interface and oversight of the project, preparation and submission of the ESBWR Design Certification application, and commencement of COLA preparation. In addition, Phase 1 of the Cooperative Agreement included the economic, financial, risk, and other evaluations and analyses necessary to support a decision whether to proceed with the COL project.

The second phase of the Cooperative Agreement, Phase 2, was the project implementation phase. Phase 2 activities were to include the engineering and licensing actions needed to receive the ESBWR design certification, preparation and submission of the COLA for the ESBWR at North Anna, follow-on activities needed to obtain NRC approval of the COL, and completion of the ESBWR plant design and site engineering.

NOTE: On April 1, 2007, tasks related to the development of the ESBWR design and preparation of the ESBWR Design Certification to the NRC were removed from the scope of this Cooperative Agreement and placed in a separate agreement between DOE and GEH. As a result, this summary does not include details associated with those tasks after that date.

A selection of accomplishments, issues, and activities are detailed below to illustrate the progression of the Cooperative Agreement.

3.2.1.1 2Q05

In April, biweekly project status phone calls were initiated, with DOE, Dominion, GE, and others as participants. On June 30, the final schedule for Phase 1 activities was submitted to DOE.

The DOE Interface and Oversight Agreement was submitted to DOE on June 24, and approved by DOE on June 28.

Work proceeded on establishing quality assurance plans and confidentiality agreements between the entities associated with the Cooperative Project.

Work was undertaken to develop an outline for the COLA and associated regulatory documents. GE initiated development of design certification documentation.

3.2.1.2 3Q05

On August 24, GE submitted the DCD to the NRC. On September 23, the NRC responded to GE that NRC's acceptance review had concluded that portions of the DCD required additional detail, but that those sections containing adequate information would be reviewed while the gaps in other areas of the document were addressed.

On September 12, Dominion notified DOE of the intent to proceed with Phase 2 of the Cooperative Agreement. The preliminary cost and schedule baselines for the entire project were submitted to DOE on September 29.

The COLA outline and list of required environmental permits, consultations, and authorizations were completed.

The GE ESBWR team conducted a training session and information exchange with the NRC on September 27–29.

Site engineering activities during 3Q05 included Dominion and Bechtel inspections of the abandoned North Anna Unit 3 & 4 outfall structure and electrical duct banks on August 23. An inspection report summarizing the findings was prepared.

Dominion met with General Dynamics/Electric Boat to understand how Electric Boat capabilities and approach to modularization could be applied to ESBWR.

The DOE Interface and Oversight Agreement was implemented, effective September 30.

3.2.1.3 4Q05

A meeting to discuss the path forward to obtain the COL was held on October 7 among Dominion, GE, and NuStart. COLA development was discussed at a meeting held on December 1 among Dominion, Entergy, NuStart, GE, Enercon, and Bechtel.

A Special Status Report was submitted to DOE on October 18 in response to a DOE request for information concerning the results of the page-turn and red team reviews of the DCD.

In November, DOE conducted a program management preliminary audit of GE. On November 15–17, the NRC Quality and Vendor Branch A conducted an inspection of GE's implementation of its QA program on the ESBWR project.

On December 22, revised cost, schedule, and technical baselines were submitted to DOE.

The ESBWR DCD was docketed by the NRC on December 1. A tentative schedule for review was established by the NRC, including a projected date of October 11, 2007, for the publication of the Safety Evaluation Report (SER) with Open Items and January 2009 for the final design approval.

During 4Q05, GE selected a steam turbine generator to be designed and manufactured by GE as the basis for the ESBWR standard plant.

3.2.2 Significant Activities — CY 2006

3.2.2.1 1Q06

In the first quarter of 2006, activities associated with both phases of the Cooperative Agreement project were ongoing. Among the project management and administration activities, Six Sigma evaluations of the COLA preparation process were initiated by Six Sigma black belts from Dominion, GE, and Bechtel. Subcontracts were signed by Dominion to undertake an aerial survey and archaeological walkdowns of the North Anna site. In addition, bids were received and were under review for the completion of the site subsurface investigation and testing program.

Schedule and resource estimates for the COL development were established. The schedule reflected a division of responsibility for COLA sections with the NuStart Grand Gulf team. Weekly conference calls to discuss the COLA schedule and action item status were also initiated.

Progress towards NRC approval of the ESBWR design certification application was made with the submission of Revision 1 of ESBWR DCD Tier 2. This revision incorporated resolution to NRC RAIs and other clarifications/enhancements.

ESBWR and site engineering tasks during 1Q06 included a variety of ongoing work, including the initiation of the defense in depth and diversity assessment, review of feedwater heater sizes and heights, and issuance of the site layout drawing.

To support the modular construction approach planned for the ESBWR at North Anna, several site walkdowns were conducted by the GE ESBWR team and an initial modularization assessment was undertaken.

3.2.2.2 2Q06

GE selected Washington Group International as the nuclear island EPC supplier and Worley Parsons to support the development of processes and procedures for the ESBWR generic deployment strategy. A partnering agreement with Hitachi was finalized by GE also, resulting in the formation of GEH.

Dominion awarded Mactec the subcontract for the site subsurface investigation and testing program.

GEH completed the ESBWR cost estimate and schedule approach report and initiated the North Anna Unit 3 price estimate process.

Dominion advised DOE of a change to the COLA submittal date from September 2007 to November 2007.

Preparation and review of draft COLA sections continued. Dominion, NuStart, and Entergy formed a combined team to coordinate the preparation of COLAs for North Anna, Grand Gulf, and River Bend.

GEH continued to respond to RAIs from NRC and submitted Revision 1 of DCD Tier 1.

ESBWR engineering activities completed by GEH during 2Q06 included the issuance of (1) the Service Building General Arrangements for review, (2) the report on ESBWR recommended waterproofing methods, and (3) the ESBWR drywell space study.

Site engineering activities included the completion of aerial surveys of the site and initiation of design of the intake structure.

On May 12, Dominion completed a report defining the assumptions and methodology for the ESBWR construction cost estimate and schedule approach.

3.2.2.3 3Q06

Phase 1 activities were completed during the third quarter of 2006. A summary report was provided to DOE by Dominion on September 26.

The NRC continued work on the draft COLA Regulatory Guide (DG-1145). A final version for comment of DG-1145 was issued by the NRC in September. The North Anna COL demonstration project team participated in the industry review effort.

Dominion, NuStart, and Entergy formed the ESBWR Design-Centered Working Group (DCWG), as described in a July 17, 2006, letter to the NRC. The intent of the group is to develop a standardized approach to facilitate consistency to the extent possible among the various anticipated ESBWR COLAs.

The ESBWR DCWG met with the NRC on September 20. A communication protocol among the DCWG members and the NRC was being prepared during this time period.

By the end of 3Q06, the preparation of first draft COLA sections was noted to be over 80 percent complete, with joint reviews being conducted by the DCWG members. In addition, preparation of second draft COLA sections was noted to be just beginning.

Dominion initiated detailed planning efforts for state, local, and other federal permits, consultations, and authorizations. EA Engineering, Science, and Technology, Inc. was contracted to assist in the permitting effort.

ESBWR and site engineering activities continued. Tasks underway included the development of the electrical building cable tray layout and raceway system design, development of the site layout drawing, and design for switchyard expansion.

GEH continued work on the selection of a heavy haul supplier. In addition, preliminary modularization evaluations continued.

The number of RAIs issued by the NRC on the DCD was noted to have an adverse effect on GEH resources, resulting in delays in maintaining the schedule for multiple tasks (e.g., COLA preparation, ESBWR engineering). GEH indicated that they added additional resources to the project in an attempt to reduce the impacts to the project schedule.

The subsurface investigation task began in August.

3.2.2.4 4Q06

In November, an effort to "re-baseline" the project schedule was initiated, with particular focus on the activities necessary to submit the COLA. Also in November, GEH issued the Project Design Manual for use.

The ESBWR DCWG conducted meetings with the NRC on October 24 and December 7.

The preparation and review of draft COLA sections continued, with preparation of first draft sections more than 90 percent complete. Joint reviews of these sections were being undertaken by DCWG members.

Pilot efforts on the "New and Significant" process for developing the COLA Environmental Report progressed. However, communications with NRC staff during this time period resulted in inconsistent direction on expectations for the New and Significant review process.

Dominion continued detailed planning efforts to understand local, state, and federal permitting and consultation requirements.

Phases 1 and 2 of revision 2 of the DCD were submitted to the NRC in October and November, respectively.

GEH continued to respond to RAIs from the NRC. By mid-December, approximately 2,700 RAI questions had been received by GEH, with replies provided to about 1,900 of them.

ESBWR engineering activities continued. Among the many ongoing tasks was a study of maintenance of the main steam tunnel, detailed piping stress analysis of the Class 1 portion of the main steam system, and development of the initial core design.

The field work associated with the subsurface investigation task was completed in November. Other site engineering tasks included the development of the excavation plan drawings and specifications for the intake structure, intake pump house, and discharge structure.

The number of RAIs issued by the NRC regarding the DCD continued to be a significant burden on the resources of GEH, resulting in a decreased ability to maintain the schedules established for COLA preparation and the ESBWR engineering effort. GEH was dedicating additional resources to the project to reduce the schedule impacts of the RAI volume.

3.2.3 Significant Activities — CY 2007

3.2.3.1 1Q07

In February, a decision was made to prepare and submit DCD Revision 4 in 2007, before the COLA submittal. This decision impacted the previous rebaseline efforts. Further adjustment to the project schedule was needed to reflect activities associated with DCD Revision 4 and the resulting impacts on COLA preparation efforts.

GEH issued an assessment of the Electric Power Research Institute (EPRI) Utility Requirements document.

The COLA preparation team began to issue second draft COLA sections for review. The level of effort on COLA preparation was expected to increase significantly in the coming months. Dominion was working with NuStart/Entergy to establish a division of responsibility to improve the efficiency and effectiveness of the second draft review process.

Work on the Content Management System (CMS) continued during 1Q07. The North Anna ESP Application was loaded into the system at the end of March. DCD Revision 3 (approximately 7,500 pages) was converted for upload into the CMS. A training session on the CMS was held on January 17-18, with attendees from Dominion, GEH, Bechtel, and NuStart present.

The ESBWR DCWG met with the NRC on February 1. The meeting included a joint session with the AP1000 DCWG and an Environmental Report pre-application discussion.

The NRC held a workshop on February 2 to discuss the format and content of the COLA. GEH trained their authors on preparation of COLA sections on February 26–27; Dominion and NuStart representatives attended to answer questions.

Revision 3 of the DCD was submitted to the NRC on February 22.

On March 7, Dominion, NuStart, and GEH met to discuss the parallel processes of DCD revision and COLA preparation. A DCD/COLA integration team was formed to further study the impacts of DCD Revision 4 on the COLA.

On March 9, NRC staff met with Dominion, Bechtel and NuStart personnel to discuss North Anna environmental issues. The NRC agreed that the process proposed by the project to identify new and significant information was acceptable.

On March 19, Dominion, NuStart and GEH determined that DCD Revision 4 would be submitted before the promised delivery date of the COLA to the NRC (November 2007). The DCD/COLA integration team was to determine the content of DCD Revision 4 with a mandate to minimize impact on COLA preparation.

On March 22–23, the ESBWR DCWG met with NRC staff. The meeting was held jointly with the AP1000 DCWG. Key topics included operational programs, the DCD/COLA parallel process, and Severe Accident Mitigation Alternatives /Severe Accident Mitigation Design Alternatives.

GEH continued to respond to NRC RAIs. As of the end of 1Q07, 3,261 RAI questions had been received, with 2,540 responses submitted and 1,109 resolved.

Work continued on ESBWR and site engineering tasks. Examples of the many accomplishments in the first quarter of 2007 included the completion of the initial core design, work on three licensing topical reports for human factors engineering, and the final circulating water system optimization study. In addition, analysis of data from the subsurface investigation completed in November 2006 continued, with testing for soil adsorption scheduled to begin at the Savannah River laboratory in May 2007.

GEH established six task teams to create procedures and processes to govern construction deployment activities. The topics to be addressed were:

- Construction plan (e.g., heavy haul review, labor analysis, crane plan)
- Modularization plan
- Quality assurance plan
- Procurement policy/plan
- Administrative coordination and control plan
- Site engineering plan

The six task teams were to meet monthly and provide progress briefings quarterly.

As in 3Q06 and 4Q06, the number of RAIs issued by the NRC regarding the DCD was noted to be a significant burden on the resources of GEH, resulting in a decreased ability to maintain the schedules established for COLA preparation and the ESBWR engineering effort. GEH was dedicating additional resources to the project to reduce the schedule impacts of the RAI volume.

3.2.3.2 2Q07

On April 1, the Dominion Cooperative Agreement was restructured. ESBWR design certification and engineering tasks were moved to a newly created and separate GEH Cooperative Agreement.

In June, DOE completed an external independent review of the cost and schedule performance baselines. Final DOE acceptance of the cost and schedule performance baselines took place in September 2007.

Also in June, Dominion obtained concurrence from the Commonwealth of Virginia resource agencies on an in-stream flow incremental methodology study and completed a Pennsylvania-Jersey-Maryland interconnection impact study.

The preparation and review of second draft COLA sections continued. Concerns were noted regarding the ability of the team to meet the scheduled delivery date for the COLA. To address the problem, more frequent meetings began to be conducted to resolve issues that, if left unresolved, would delay the completion.

On April 3, the project team began to fully implement the New and Significant process for determining content and scope of the Environmental Report supplement.

On April 30, GEH conducted two training sessions on Revision 2 of the GEH COL Writers Guide.

The ESBWR DCWG, along with the AP1000 DCWG, met with the NRC on May 2–3. Positive feedback was received from the NRC on the following approach to DCD and COLA preparation:

- A limited scope DCD Revision 4 will be submitted to the NRC in advance of submitting COLA Revision 0
- COLA Revision 0 will be submitted to the NRC based on DCD Revision 4
- DCD Revision 5 will be submitted to the NRC following NRC acceptance of the COLA
- COLA Revision 1 will be submitted to the NRC based on DCD Revision 5
- DCD and COLA sections will be prepared in parallel

On May 31, Dominion responded to the NRC regarding the NRC Regulatory Issue Summary 2007-08. In the response, Dominion identified a COLA submittal date of November 2007. GEH also issued a letter to the NRC on June 1 that stated its intention to submit DCD Revision 4 on or before September 28, 2007, and DCD Revision 5 on or before March 31, 2008.

The ESBWR DCWG, along with the AP1000 working group, met with the NRC on June 13–14. Topics discussed included operational programs, COL holder items, and pre-application quality assurance audits.

Site engineering activities during this period included the issuance of the final circulating water system optimization study, as well as preparation of the calculations for dynamic slope stability and earth pressure, static and dynamic properties.

Dominion, GEH, and Bechtel conducted a site walkdown of the North Anna facility on April 13. Site construction logistical plans were noted to be under development. The layout of the site suggests that a multi-phase plan will be needed to construct the new unit.

3.2.3.3 3Q07

In September, biweekly conference calls with DOE to discuss the project status were temporarily suspended pending completion of the COLA in the fourth quarter of 2007. The biweekly calls were expected to resume in 2008. Concerns continued regarding the schedule for the preparation of several COLA sections.

In September Dominion completed the subsurface investigation data report.

Site engineering accomplishments during 3Q07 included the completion of an analysis of cooling tower noise, the site excavation plans and foundation profiles, the design descriptions and COLA calculations for the plant cooling tower makeup system, and storm water management analysis and design.

3.2.3.4 4Q07

The North Anna ESBWR R-COLA was submitted to the NRC on November 27. Two days later, Dominion met with the NRC to provide "orientation training" on the document. On December 13–14, Dominion met with the NRC to discuss the technical content of the COLA.

Further progress was made in resolving site engineering issues. Among the accomplishments during 4Q07 was the completion of an analysis of lake water chemical constituents, completion of the calculation for dynamic slope stability, completion of a calculation demonstrating that the new condenser heat duty had an insignificant impact on previous ESP analysis results, and completion of an accidental liquid release analysis.

3.2.4 Significant Activities — CY 2008

3.2.4.1 1Q08

During this quarter, GEH provided an updated cost estimate for the generic ESBWR power block.

By letter dated January 28, 2008, the NRC notified Dominion that the COLA was accepted for docketing. A subsequent letter from the NRC dated February 27, 2008, provided the COL environmental and safety review schedules to Dominion.

Dominion and Bechtel prepared a number of COLA change packages for upcoming revisions of the COLA, prepared for the planned NRC environmental audit at North Anna (scheduled for April 2008), and continued to review responses by GEH to RAIs on the DCD and draft sections of DCD Revision 5.

On March 20 and 28, respectively, the NRC issued the first two formal questions on the COLA.

Site engineering activities continued during the first quarter of 2008. Activities included the preparation of specifications for yard equipment, design tasks in support of the site separation scope, and the start of "90 percent" design packages. ("Site separation" involves the relocation and replacement of existing site utilities and structures needed to accommodate the siting of the new proposed Unit 3.)

In the 1Q08 quarterly report, it was also noted that the GEH focus on DCD RAIs and DCD Revision 5 had delayed ESBWR engineering and the development of construction costs and schedule. These delays were observed to impact the ability of Dominion to make a decision to build. It was suggested that increased focus and funding by GEH on ESBWR engineering and development of construction costs and schedule should be undertaken.

3.2.4.2 2Q08

Dominion, GEH, and Bechtel participated in a joint workshop on April 15–16 to review revisions to the work breakdown structure and schedule coding structures. Subsequent progress review meetings were held among Dominion, GEH, and Bechtel on April 30 and June 9.

During 2Q08, GEH provided another revised cost estimate for the generic ESBWR power block.

The NRC conducted an environmental audit at North Anna from April 14–18.

Dominion and Bechtel continued the preparation of COLA change packages and review of GEH responses to RAIs on the DCD. In addition, an evaluation was undertaken to determine the impacts to the COLA from changes made in Revision 5 of the DCD.

Site engineering activities continued to progress, with a number of tasks completed. Examples include:

- Architectural concept for administration building, including renderings, plans, and elevations
- Evaluation of the impacts of a new Virginia nutrient general permit on cooling system chemical treatment and sewage treatment plant design
- Case study report for using foundation field bus technology
- Calculations for modifications to domestic water and main fire loop for site separation

In the 2Q08 quarterly report, it was repeated (from the 1Q08 report) that the GEH focus on DCD RAIs and DCD Revision 5 has delayed ESBWR engineering and the development of construction costs and schedule. These delays were observed to impact the ability of Dominion to make a decision to build. It was suggested that increased focus and funding by GEH on ESBWR engineering and development of construction costs and schedule should be undertaken.

3.2.4.3 3Q08

In August, the NRC issued RAIs for all SER chapters, and Dominion completed the draft specification for the hybrid cooling tower.

During 3Q08, Dominion, GEH, and Bechtel continued to review the impact to the COLA from changes made in Revision 5 of the DCD and prepared responses to NRC RAIs.

Schedules for the ESBWR engineering (GEH) and site engineering (Dominion/Bechtel) tasks were under review to develop a plan to better integrate activities by prioritizing the development of information necessary to advance other engineering tasks. It was noted that the tasks were sufficiently "out of step" that site engineering work was sometimes delayed while waiting on needed inputs from ESBWR engineering.

Site engineering accomplishments during this time period included the issuance of (1) rough grading drawings, (2) circulating water system general arrangement, (3) specifications for variable frequency drives and power centers, and (4) the new fuel haul route drawings. In addition, material lists for fire protection, domestic water, sanitary sewage, and construction air system modifications were completed.

3.2.4.4 4Q08

In December, discussions on an EPC contract between Dominion and GEH were suspended and Dominion initiated a competitive process to select a nuclear technology vendor.

Dominion, GEH, and Bechtel continued to respond to NRC RAIs and evaluate impacts to the COLA from changes associated with Revision 5 of the DCD. The first revision to the COLA (COLA submission 2 and 3) was submitted to the NRC in December.

The NRC completed the Draft Environmental Impact Statement (DEIS) in December. The 6-month comment period was scheduled to end in June 2009, with issuance of the Final EIS expected from the NRC in December 2009.

Efforts continued to integrate the ESBWR engineering and site engineering schedules. Delays associated with the ESBWR engineering were noted to have a negative impact on site engineering progress. Examples of site engineering accomplishments during this period included completion of preliminary detail design for the fuel oil storage tank foundations and station water intake structure, issuance of specifications for intake building heating, ventilation, and air conditioning (HVAC) and the makeup demineralizer plant, and participation in a state agency in-stream flow incremental methodology meeting held at North Anna.

A number of "90 percent commercial packages" were completed by Bechtel and provided to Dominion for review, including those for fire protection and domestic water system modifications, new buildings, sanitary sewage, and construction air system modifications.

3.2.5 Significant Activities — CY 2009

3.2.5.1 1Q09

Dominion, GEH, and Bechtel ceased efforts to integrate the ESBWR engineering and site engineering tasks.

Efforts to respond to NRC RAIs and prepare changes to various COLA packages continued. The impacts to the COLA from the changes associated with planned DCD Revision 6 were also evaluated.

Site engineering activities were "re-baselined" during this period to be consistent with Dominion's EPC competitive bid process. As a result, activities shifted from site-specific ESBWR engineering to support of environmental permits. Site engineering activities completed during this period included the preparation of the embassy gate specification for the new security building, issuance of the "90 percent design package" for storm water alterations, and submission of preliminary input to the Joint Permit Application alternatives analysis.

3.2.5.2 2Q09

During the second quarter of 2009, Dominion performed a QA audit of Bechtel. In addition, revisions were completed to the Quality Assurance Program Plan to implement NQA-1-1994.

Dominion, GEH, and Bechtel participated in the first Advisory Committee on Reactor Safeguards (ACRS) subcommittee meeting for the North Anna Unit 3 COLA.

Preparation of responses to NRC RAIs and development of COLA change packages continued during this period. Site engineering activities included the issuance of specifications for storm water alterations pump and controls, the communication tower, and a diesel generator.

3.2.5.3 3Q09

Revision 6 of the ESBWR DCD was submitted by GEH to the NRC on August 31. The SER with open items for all chapters was issued on August 7.

Dominion, GEH, and Bechtel participated in additional ACRS subcommittee meetings for the North Anna Unit 3 COLA. In addition, work continued to address NRC RAIs and prepare COLA change packages.

Among the site engineering highlights was the development of draft design calculations for numerous features, including the oil/water separator modification, manhole designs for reserve station service transformer routing, and the thrust block design for fire water piping.

3.2.5.4 4Q09

During this reporting period, Dominion and Bechtel began preparation of standard R-COLA change packages necessary as a result of the issuance of Revision 6 to the DCD. Work also continued to address NRC RAIs.

Dominion and Bechtel provided support to help resolve NRC concerns regarding the planned use of fiberglass reinforced piping for the underground plant service water system.

The ACRS review of the SER with Open Items was completed on November 4, with no significant concerns noted.

Site engineering tasks continued, with completed actions including the issuance of specifications for steel frame buildings and the motor fuel storage and dispensing facility.

3.2.6 Significant Activities — CY 2010

Preparation of standard R-COLA change packages and responses to NRC RAIs continued during the first quarter of 2010. Dominion and Bechtel also participated in a meeting with current and new NRC project managers to facilitate smooth transition of ongoing NRC review activities.

Site engineering activities included further progress on developing the earthwork commercial package and safety-related specification for trenching and backfill in the flood protection dike.

In February 2010, NRC issued its Supplemental Final Environmental Impact Statement for the North Anna Unit 3 COLA that incorporated ESBWR technology.

On May 7, 2010, Dominion announced the selection of the Mitsubishi US-APWR for the proposed Unit 3 at North Anna.

3.3 Project Management Approach and Controls

Based on experience from the Cooperative Agreement, this section describes the activities necessary to prepare a COLA and support the NRC review and hearing.

3.3.1 Project Formation Activities

Project formation activities to begin a COL project include:

- **Make decision to pursue new nuclear generation as an option**. This is a business decision that would generally occur in advance of the decision to form a COL project- or in North Anna's case, prior to the decision to form the ESP project.

- **Perform site selection study**. The site selection study must satisfy the requirements of 10 CFR 51, 10 CFR 52, and NUREG-1555 (Section 9.3). Use of the "Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application (Siting Guide)," published by the Electric Power Research Institute in March 2002, is recommended. Dominion's site selection study can be found on the DOE website at: http://www.nuclear.energy.gov/np2010/espStudy/espStudyDominion.pdf.

- **Obtain project funding.** Project funding would be obtained by the entity forming the COL project in accordance with its normal business practices.

- **Select the project team**. This includes in-house personnel, consultants, and contractors. Particular attention should be paid to the selection of the specialty consultants and contractors for activities that may be needed to prepare the COLA, including subsurface investigation, geologic field investigations, geotechnical engineering, probabilistic seismic hazards analysis, hydrological evaluations, environmental investigation, legal, and document editing and publication.

- **Select the reactor design that will be used in the COLA**. Depending on which reactor design is chosen, information and support from the reactor vendor will be needed to support preparation and review of the COLA.

- **Prepare project procedures and programs**. These will include the quality assurance program, project execution plan, engineering procedures, licensing and document control procedures, etc.

- **Develop the work breakdown structure, detailed project schedule, and cost estimate**. A project work breakdown structure should be established that is consistent with the various parts, chapters, and sections of the COLA.

  Next, a detailed, resource-loaded project schedule should be created. The activities, durations, and resource estimates should be prepared with direct input from project personnel and should consider lessons learned, RAIs, and experience from previous COL projects. The schedule should be prepared at the section level of the COLA. The activities necessary to prepare each "X.Y" section of the COLA should be identified and resource-loaded in the project schedule. For some sections (particularly SSAR Sections 2.4 and 2.5), the schedule should be further broken down to the "X.Y.Z" level. Typical schedule activities to prepare a COLA section include:

  — **Collect data.** Gather information through internet searches, contacts with agencies and organizations, and requests issued to the reactor vendor or other team member companies.

  — **Conduct pre-job briefings**. Appendix 2 provides a suggested outline for a pre-job briefing which has been adapted from the Author Presentation approach used for the North Anna COL Project. Pre-job briefings should be held early in the effort to prepare the section and can be conducted via meeting, conference call, video conference, webcast, etc. If significant questions and/or data gaps are noted during the pre-job brief, consideration should be given to conducting a follow-up briefing to ensure concurrence with the path forward once the information needs are resolved.

  — **Perform detailed calculations, analyses, and engineering design activities**. Developing the various sections of the COLA will involve a significant amount of supporting engineering and analysis work. Appendix 3 lists many of the types of activities which can vary from project to project. The schedule should show the origination, independent review, and approval activities for each product.

  — **Prepare draft section**. Draft sections should include not only the text, tables, and figures that will be placed in the COLA, but also the supporting regulatory conformance tables and validation package. Any open items should be clearly identified for later resolution.

  — **Perform licensing, legal, management, and coordination reviews**. It is important to perform a full review as draft sections are issued in order to avoid editorial delays as deadlines approach.

  — **Resolve review comments**. Comments should be addressed and their resolution reviewed with the commenter to confirm that the comment was correctly understood and dispositioned appropriately. Depending on the project's quality assurance requirements, these comments and their resolution may need to be fully documented and archived.

  — **Issue final section**. Issuance of the final section should be in the form of a publication-ready document and supporting materials, including conformance tables, validation package, and identification of any open items. This final document package will most likely be a project quality assurance record.

  The schedule should also identify the following activities:

  — **Team reviews of compiled chapters**. After the final versions of all sections of a chapter are completed, a team review of the compiled chapter should be performed.

— **Page-turn reviews**. Once all chapters and parts have been completed, "page-turn" reviews of the complete, compiled COLA should be performed.

— **Pre-application interactions with NRC and state and local agencies**. The NRC affords potential applicants the opportunity for interaction prior to assuming the more formal status of "applicant" and the constraints that are imposed by the governing regulations. Potential applicants should take full advantage of the opportunity. Similarly, the pre-application period offers the opportunity for early interaction with state and local agencies in an informal manner that will serve the applicant well during the more formal licensing process. In particular, early consultation with state agencies concerning the proposed cooling water systems, aquatic impacts, and process for obtaining related certifications under the Clean Water Act and Coastal Zone Management Act should be pursued.

— **Schedule Critical Path**. Particular attention should be paid to the critical path and near-critical paths to ensure the activities, durations, and logic ties are well understood and accurately reflected in the project schedule. Depending on the project, critical and near-critical paths could include:

  — FSAR Section 2.5, including the subsurface investigation, laboratory analyses, and the numerous geotechnical and seismic analyses.

  — FSAR Section 2.4, including the subsurface investigation, collection of groundwater data, and the hydrological evaluations.

  — FSAR Section 2.3 (and the corresponding ER section) regarding the atmospheric dispersion analyses, including the collection and verification of onsite meteorological data and the dispersion analyses.

  — Cooling water sections for the environmental report, including the evaluation of alternatives, conceptual design and analysis, and evaluation of impacts.

  — Development of the plot plan.

3.3.2 Application Preparation

All work to prepare the COLA should follow the detailed project schedule. Good practices are identified below.

- **Regulatory Conformance**. The COLA should be prepared to conform to applicable NRC regulations and guidance. Any deviations from these guidance documents should be identified and fully justified. Lessons learned and RAIs from previous ESP and COL projects should also be specifically considered during section preparation. NRC guidance documents applicable to parts of the COLA include:

  — Part 1* – General and Administrative Information; Regulatory Guide 1.206.

  — Part 2 – Final Safety Analysis Report (FSAR); Regulatory Guide 1.206, NUREG-0800, and other Regulatory Guides.

  — Part 3 – Environmental Report; NUREG-1555, Regulatory Guide 1.206, and other Regulatory Guides.

  — Part 4 – Technical Specifications; Regulatory Guide 1.206, NUREG-0800, NUREG-1555, and other Regulatory Guides.

- Part 5 – Emergency Plan; Regulatory Guide 1.206 and other Regulatory Guides.
- Part 7 – Departures Report; Regulatory Guide 1.206 and other Regulatory Guides
- Part 8 – Security Plan; Regulatory Guide 1.206 and other Regulatory Guides.
- Part 10 – Tier 1/ITAAC; Regulatory Guide 1.206 and other Regulatory Guides.

*NOTE: Early COLA formats developed by industry envisioned different numbers of COLA parts with most technologies settling on 10 or 11 parts. In an effort to maintain consistency between technologies, the industry elected to maintain a consistent numbering scheme for each part. However, in some COLAs, like North Anna's, not all parts were used. For example, Part 6 was reserved for Limited Work Authorizations (LWAs) which was not included in the North Anna COLA. The complete list of COL parts is shown in Appendix 4.

- **Pre-Application Interactions**. The project team should expect and fully support pre-application interactions with the NRC Staff and their contractors. For the North Anna COL project, Dominion had multiple contacts with the NRC Staff prior to submitting the COLA. Beginning with direct conference calls and meetings at NRC headquarters for process inquiry and notification of the proposed action and intended efforts, Dominion also met with other interested industry representatives at forums and meetings. Of utmost importance was the ever-open offer by Dominion to invite and host NRC visitors to the North Anna site and/or local support offices. Face-to-face interactions went a long way to support communications and understanding of meeting regulatory needs. The NRC also visited the North Anna region to meet with other state agencies, local government representatives, and local community associations. This facilitated the open-to-the-public process, was effective in delivering information about the NRC licensing process, and left no surprises as to Dominion's intentions and analyses.

- **Weekly status conference calls**. Weekly conference calls should be conducted with key members of the project team, subcontractors, and consultants to review critical issues, schedule progress, action items, interface issues, upcoming activities, etc. Separate weekly review meetings on specific application sections (e.g., FSAR Section 2.5) are also recommended to allow for further detailed discussions outside the weekly project status meeting.

- **Pre-job briefings**. Pre-job briefings should be held for each COLA section. Efforts should be made to ensure that the section preparation effort directly follows the pre-job briefing. This will maximize the benefits of the discussions and the exchange of ideas and approaches from the pre-job briefing. Additionally, briefings should be used for complicated work activities.

- **Document publication**. Several activities should be completed early in the effort, including selection of the software that will be used to publish the COLA, creation of the Writer's Guide and author training, and creation of the electronic template(s) for the application. The document publication function should also serve as the single source for authors to acquire COLA content.

3.3.3 Support of NRC Review and Hearing

Following acceptance of the application for review, the NRC will publish a schedule outlining the major milestones for the safety and environmental reviews. Good practices to support the NRC review effort and hearing include:

- **Frequent and routine communication**. Conference calls and meetings should be used to ensure good communication with the NRC Staff. A significant amount of coordination with state and local agencies will also be needed, particularly if these agencies are reviewing related permit applications (e.g., water permits, Coastal Zone consistency certification).

- **Responding to RAIs and submitting application revisions**. Procedures and processes for efficiently preparing responses to NRC RAIs and application revisions should be developed and implemented before the application is submitted. The NRC typically expects that responses to RAIs will be submitted within 30 days in order to maintain their published review schedule. RAI responses should include an identification of any corresponding application changes that will be incorporated into the COLA in a later revision.

- **Atomic Safety and Licensing Board (ASLB) Questions**. Beyond the RAIs issued by NRC Staff to support their safety and environmental reviews, the ASLB will also issue questions requesting coordinated responses from the applicant and NRC Staff. The effort to respond to ASLB questions should not be underestimated and will likely require access to numerous technical experts, including experts that may have completed their work several years earlier and are no longer actively supporting the project.

3.3.4 Expected Schedule

Expected schedule durations for a COL project are as follows:

- 6 to 9 months for prerequisite activities (decision to proceed, siting study, project funding).

- 15 to 24 months for project formation and preparation of the COLA. This will vary, depending on site- and project-specific issues.

- 42 to 48 months for the NRC review and approval, including 12 months for hearings.

3.3.5 Cost Summary

Dominion consistently managed project costs within the bounds of the budget established by DOE. Beginning with the first quarter of 2006, each quarterly report provided to DOE included a task-by-task summary status of the total project earned value performance. In addition, each quarterly report contains a table summarizing the status of the approved spending plan for the Cooperative Agreement along with the costs incurred to date. As an example, the last quarterly report details an approved total (i.e., DOE funds combined with Dominion cost share) spending plan amount of $176,169,956, with an actual spent to date (based on invoices) of $149,312,835. Additional financial performance information can be found in the Cooperative Agreement Quarterly Progress Reports provided by Dominion to DOE.

Compliance with the requirements of DOE Order G 413.3-10, Earned Value Management System (EVMS), was accomplished early in the project, with Dominion, GE, and Bechtel providing data by January 2006. Beginning with the first quarter of 2006, each Cooperative Agreement Quarterly Progress report contained an updated table detailing, on a task-by-task basis across seven tasks, the following information:

- Original and current budget hours

- To-date scheduled, actual, and earned hours

- To-date percent complete

- Schedule and job hour performance

- Original and current budget cost

- To-date actual and earned cost

- Estimate at completion- Gold Card and Work Breakdown Structure

- Cost performance- budgeted cost for work performed/actual cost of work performed

- Schedule and cost variance
- Variance at completion- Gold Card and Work Breakdown Structure

Project performance based on EVMS summary data is provided in the quarterly progress reports provided to DOE.

4. Overall Lessons Learned and Experience

The Cooperative Agreement scope included the development of a COLA and site engineering at a site with an approved ESP. This post-ESP approach to obtaining an NRC license to build and operate a nuclear plant is a new method meant to streamline the review and approval process. In addition, few applications for new nuclear plants have been filed in the United States over the past 20 years. As a result, the effort to obtain a license to build/operate North Anna Unit 3 presented a number of learning experiences that may facilitate future nuclear plant licensing efforts. These observations and recommendations are characterized in the tables that comprise Section 4 as "Opportunities to Enhance the Regulatory Process" (Table 1), "Lessons Learned" (Table 2), and "Benefits of the North Anna ESP in Developing the COLA" (Table 3).

Part 1 of Table 2 lists lessons learned that may be important to future COL project management personnel. Several lessons learned are considered to be best practices for future ESP and COL projects. These best practices fall into the general category of up-front planning. Author presentations (also referred to as pre-job briefings for section development) to the project's leadership team were found to be an excellent method for establishing section strategies before significant efforts were expended resulting in redirection and/or rework. Pre-job briefings on individual work activities (e.g., prior to the start of a complicated analysis) were used to discuss the effort and resolve issues before work began. NOTE: Although the North Anna project originally distinguished between Author Presentations completed for the development of each section and pre-job briefings for individual work activities, the pre-job briefing (PJB) terminology is currently being used by Dominion.

Another key lesson learned pointed to the importance of holding frequent coordination meetings to ensure good communication among all project participants, particularly when multiple COL sections addressed common issues.

Of note is a lesson learned that highlights the need to provide extensive training to the team to emphasize the quality of the work. Development of the COLA is a complex and rigorous effort so the quality of work must be continually emphasized to all project participants regardless of their prior experience.

Another dominant theme in several of the lessons learned centered on the need to schedule the project activities and make systematic progress to avoid the "bow wave" of section preparation and review at the end of the effort. Also, author presentations or pre-job briefings should be shown as a scheduled project milestone for each section of the application.

Part 2 of Table 2 lists lessons learned that may be important to future COLA author and licensing personnel.

Preparation of the North Anna COLA began over 2 years before Regulatory Guide 1.206 was issued in June 2007. Draft Guide DG-1145, Proposed Revision 0 was published in September 2006 and was used until Regulatory Guide 1.206 was issued. Thus, the project encountered numerous issues regarding basic licensing principles (e.g., what information must be submitted to satisfy the regulations and the NRC Staff's review) starting in April 2005 and continuing through September 2006 when DG-1145 was issued.

Certain important lessons learned were identified. For example, licensing personnel should plan to have "page turn" reviews of the entire document prior to submittal. These reviews were found to be most effective in ensuring consistency among related sections, consistency of terminology, etc. A minimum of 2 to 3 weeks' duration should be allowed for the "page turn" reviews.

Part 3 of Table 2 lists lessons learned that were captured over the course of the work that may be important to future COLA document production personnel. Lessons learned in this area included technical editing considerations, preparation of a Writer's Guide, and electronic formatting.

Part 4 of Table 2 lists lessons learned that were unique to developing a COLA for a site with an ESP. Lessons learned in this area included regulatory guidance, the plant parameter envelope (PPE) approach, new and significant information, and the need for guidance on the format for a COLA Final Safety Analysis Report (FSAR) that needs to incorporate the content of an ESP application Site Safety Analysis Report (SSAR) by reference.

Table 1. Opportunities to Enhance the Regulatory Process Based on Lessons Learned

No.	Background/Description	Lessons Learned and Enhancement Opportunities
1	During the COLA review process, it was evident that state and local regulatory agencies were becoming more familiar with the COL process than they had previously been with the ESP process. Although these agencies are becoming more attuned to the NRC Part 52 process, some of the environmental permitting processes can still take longer than expected and impact the project schedule. Decisions have to be made by the project regarding when to initiate communication on permitting actions.	ESP and COL applicants should assume that state and local regulatory agencies continue to need to become more familiar with the NRC nuclear licensing processes. Therefore, the project should be prepared to provide significant background education and support to the agencies. As the NRC has gained experience, it, too, has developed a more robust process of informing potential stakeholders when potential applicants identify their interest in a particular site. The DOE should continue to support and expand its public information initiatives related to new nuclear generation.
2	As part of an ESP application, the applicant has the option of including a "major features" emergency plan or a full and integrated emergency plan. Dominion included the "major features" option in its ESP application. The benefit of the major features approach has not been readily discernable. The option has been viewed by some as having no benefit, although it may have benefits for ESP applicants who select a greenfield site. The primary concern is that the same major features approved during the ESP stage are revisited in substantially more detail during the COL process. The resulting impression is that work is being done twice with little or no benefit.	Of the four ESPs issued to date, only two (North Anna Unit 3 [NA3] and Vogtle) have progressed significantly enough through the COLA process to evaluate the "major features" approach vs. the "full features" approach. NA3 selected the "major features" approach to addressing the Emergency Plan (EP), while Vogtle selected the "full features" approach. Based on the information from the RAIs issued by the NRC, there is little benefit to including a "major features" EP in the ESP application for applicants who do not select greenfield sites given that: (1) The number of EP-related RAIs issued to Dominion for NA3 at the time of the COLA was four times the number issued to Vogtle. This indicates that a much greater degree of finality was achieved with the "full features" EP. (2) The number of EP-related RAI questions issued to Dominion for NA3 at the time of the COLA (64) was greater than the average of the applicants through the summer of 2010 (~57), not including the applicants with ESPs for greenfield sites. This indicates that the inclusion of the "major features" EP did not significantly affect "finality" with respect to the EP. However, based on the larger number of RAIs for Lee (greenfield site), it appears that, if the applicant has used the ESP approach and included a "major features" EP, the number of RAIs at the time of the COLA may have been reduced, supporting the supposition that the "major features" EP would be beneficial to a greenfield site.
3	The NRC has no guidance regarding the use of data acquired from the internet.	Dominion chose to attempt to verify internet data sources that were used in the SSAR (ESP application) for those sections that are quality-related. This turned out to be only four sets of data. Weather data obtained from the National

Table 1. Opportunities to Enhance the Regulatory Process Based on Lessons Learned

No.	Background/Description	Lessons Learned and Enhancement Opportunities
		Climatic Data Center was validated. One set of internet data from the Coastal Services Center department of NOAA could not be validated. This same lesson-learned was identified by the NRC's Advisory Committee on Reactor Safeguards (ACRS). No action by the NRC to address this topic has been identified. DOE support to encourage NRC to develop such guidance would be appropriate.
4	At the time of the ESP application, the "Interim Staff Guidance (ISG) on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures" was not available. DC/COL-ISG-7 was issued final on June 23, 2009.	With the issuance of DC/COL-ISG-7, the NRC has made it clear what information is needed in ESP or COLA. The NRC position is that the snow loads for safety-related structures should be based on the 100-year snowpack or snowfall, whichever is greater, recorded at ground level, plus the weight of the 48-hour winter probable maximum precipitation (PMP) at ground level for the month corresponding to the selected snowpack. A COL applicant may choose and justify an alternative method for defining the extreme load combination of maximum snow load and winter precipitation load by demonstrating that the 48-hour winter PMP could neither fall nor remain on the top of the snowpack and/or building roofs because of the specified design of the roof.
5	Extensive back-and-forth correspondence was required to resolve the single bounding roof load (maximum roof load) defined in the Design Certification Document (DCD) with the site-specific winter precipitation characteristics that are inputs to the actual roof loads (i.e., 100-year snow pack, maximum winter precipitation, etc.).	Require a DCD to provide a composite breakdown of the assumed winter precipitation load components, i.e., assumed site parameters (consistent with the ISG-7 requirements) that are used as inputs for the maximum roof loads in design.
6	Review the development and study of long-term weather cycles for periods of up to 100 years. The NRC's ACRS has commented that "The staff has made appropriate modifications to the Standard Review Plan to recognize that there are cycles in the weather. Such cycles are especially well known for the east coast of the United States. The staff has made contact with knowledgeable technical societies, will be attending pertinent scientific conferences, and is proposing research studies of trends in the frequencies and intensities of hurricanes."	In brief, the ACRS is concerned about the potential impact on global warming as it relates to nuclear safety and the environment and is encouraging the staff to develop a regulatory position. Future COL applicants should address climate issues based on site-specific climatology. The DOE should support the NRC's efforts to develop a position on this subject so that it can be appropriately and consistently addressed in future permit and license applications. Since this time, the NRC has issued NUREG/CR-7004, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane- Borne Missile Speeds for Nuclear Power Plants," Draft, December 2009, and Draft Regulatory Guide DG-1247, "Design-

Table 1. Opportunities to Enhance the Regulatory Process Based on Lessons Learned

No.	Background/Description	Lessons Learned and Enhancement Opportunities
		Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," August 2010.
7	NRC requirements in the Code of Federal Regulations are written in a concise manner. The NRC expands on those requirements by providing guidance illustrating acceptable ways to meet the requirements. It is not unusual for permit and license applicants to be similarly concise in their submittals. However, in such instances, the NRC may issue a request for additional information (RAI) soliciting the details and descriptions that "tell the story."	COL applicants should be proactive in providing information at the outset sufficient for the NRC to make its required findings. In addition, applicants need to be mindful that the NRC feels a strong obligation to communicate openly with the public regarding its activities. The additional effort by applicants to "tell the story" in COLAs as they are prepared will serve to preclude a substantial number of RAIs. As the NRC continues to update regulations and guidance, additional information may be necessary to complete the story. Although the North Anna COLA received a small number of ER RAIs, Turkey Point's ER was more detailed because they learned by reviewing all previous RAIs what level of detail is currently expected by the NRC.
8	Although the NRC is the primary licensing authority for a COL, it works in coordination with other federal, state, and local government agencies to discharge its responsibilities.	COL applicants must be mindful that regulatory agencies other than the NRC will have an impact on the review and approval of the application. Applicants should be proactive in identifying and interacting with those agencies early in the licensing process. The interactions should address both the applicant's business goals, a description of the NRC regulatory process, and specific areas where state and/or local agency consultation, certification, or approval will be required.
9	The NRC held a pre-application public outreach meeting on October 24, 2007, in Louisa County to inform the public of the expected submittal by Dominion of a COLA later that year and to provide the public with information on the NRC licensing process. The NRC also conducted pre-application site visits to assess Dominion's data collection techniques and quality processes. Other NRC public meetings in Louisa County included an Environmental Scoping meeting on April 16, 2008, and a Draft Supplemental Environmental Impact Statement (SEIS) public meeting on February 3, 2009.	Pre-application visits by the NRC were beneficial to the NRC, Dominion, other affected agencies, and the public. The NRC continues to develop alternative approaches to enhance and refine its pre-application interactions based on schedule and other considerations. These efforts should include pre-application interactions on environmental and safety review topics. The DOE should continue to encourage and support NRC efforts in this area. The comprehensive Instream Flow Incremental Methodology (IFIM) study was of great interest because the study scope included the river recreational impact and the Lake Anna water level impacts on shoreline and wetlands.
10	The NRC's technical review of the COLA was divided into safety and environmental reviews. The NRC organization was structured similarly,	In Dominion's experience, the RAI process implemented by the NRC on safety issues was efficient and effective. It provided early opportunity to discuss the

Table 1. Opportunities to Enhance the Regulatory Process Based on Lessons Learned

No.	Background/Description	Lessons Learned and Enhancement Opportunities
	with lead safety and environmental project managers. This resulted in different processes to request additional information. On the safety side, the NRC first provided RAIs to Dominion in draft form and afforded Dominion the opportunity to discuss the draft RAIs, including an assessment of the time required to respond. On the environmental side, the NRC process was essentially the opposite: NRC first issued the formal RAI and then afforded Dominion the opportunity to discuss and clarify the RAIs.	NRC's concerns when the questions were in a formative stage. As a result, when the NRC sharpened its focus in the final version of the RAI, Dominion was generally able to provide a timely response because it better understood the issue and the NRC better understood what the applicant was capable of providing. On several occasions, the need for the NRC to actually issue the RAI was eliminated. This approach proved superior to the process used for environmental RAIs. Environmental RAIs were issued without notice in final form, the NRC was less willing to revise the RAI once issued, and any dialogue regarding the question took place "on the clock," i.e., within the time period established by the NRC in the transmittal letter to respond. Near the end of the technical review, NRC management acknowledged the difference in the processes and designated one project manager as overall lead to standardize the process. Since then, the NRC has continued the policy of an overall project lead, but because of the continuing organizational alignment within the NRC and subject matter differences, the tendency for the safety and environmental RAI process to diverge remains. ESP and COL applicants should be mindful of this tendency and take appropriate actions, when necessary.
11	If a COLA references an ESP, 10 CFR 51.50(c)(1) requires that the COLA ER include "any new and significant information for issues related to the impacts of construction and operation of the facility that were resolved in the early site permit proceeding."	Specific regulatory guidance to implement the "new and significant" requirements of 10 CFR 51.50(c)(1) has not yet been issued by the NRC. As part of Dominion's efforts to prepare the North Anna COLA, a rigorous, multi-step process was implemented to identify new and significant information for inclusion in the COLA ER. Dominion's "new and significant" process met the NRC's expectations for the information that must be included in the COLA ER. In fact, the NRC accepted, and complimented, Dominion on its thorough and rigorous approach. The NRC issued the Final SEIS to Dominion on March 19, 2010. Specific and clear guidance, especially for addressing time sensitive information, needs to be issued by the NRC for this challenging process.
12	NRC guidance is now more robust and reflects the Part 52 ESP and COL licensing process. The ESP process has been demonstrated, and the NRC	Some efficiencies are being realized as a result of the first three ESP applications piloted under DOE's NP 2010 Program with the review times decreasing from 50

Table 1. Opportunities to Enhance the Regulatory Process Based on Lessons Learned

No.	Background/Description	Lessons Learned and Enhancement Opportunities
	has worked to improve the efficiency of its review process. Now that the COL process has also been demonstrated, further efficiencies will continue to take place. Reduced review times should start to be realized now that COL applicants can incorporate site-specific and design information by reference under the Part 52 guidance.	months to 37 months. The DOE should continue to encourage and support the NRC's efforts to further improve the efficiency of its safety and environmental reviews and, thus, reduce the resources and time required to review ESP and COLAs.
13	Although Dominion changed reactor technologies before progressing to the hearing stage, the question of whether efficiencies could be gained in the mandatory hearing process is still an issue. A mandatory hearing is required under current NRC regulations. During the North Anna ESP application process, the hearing was uncontested, all contentions having been previously dismissed by the hearing board. The final safety and environmental documents were issued by the NRC Staff at the end of 2006; the ESP was issued in November 2007. No changes to 10 CFR 2.104 have been made as of September 2010.	In April 2007, the NRC COL Review Task Force, headed by then Commissioner Merrifield, presented several recommendations to the Commission to improve the licensing process, including recommendations specifically targeting the mandatory hearing (Reference: COMDEK-2007-001/COMJSM-2007-001). The task force recommended that the Commission revise 10CFR 2.104 to reflect a policy that a contested hearing for a COLA fulfills the requirement in Section 189a.(1)(A) of the Atomic Energy Act that "the Commission shall hold a hearing ... on each application for a construction permit ...." Under the recommended policy, there would be a hearing on uncontested issues only if there were no hearing on contested issues; and any hearing on uncontested issues would be conducted by the Commission itself. The task force also recommended that the Commission request legislative authority from Congress to eliminate the statutory requirement for a mandatory hearing (i.e., a hearing on uncontested issues). On June 22, 2007, the Commission approved the task force proposal that the Commission itself conduct the mandatory hearing (in the absence of legislation eliminating the requirement for a hearing even if a request for hearing is not made). The Commission continues to have the authority and discretion to request that the Atomic Safety and Licensing Board Panel (ASLBP) conduct a hearing in a particular case. The NRC's Office of General Counsel was directed to prepare a plan for the conduct of these hearings by the Commission modeled after the Browns Ferry restart meeting and the Calvert Cliffs and Oconee license renewal meetings. The Commission also approved obtaining legislative authority from Congress to

Table 1. Opportunities to Enhance the Regulatory Process Based on Lessons Learned

No.	Background/Description	Lessons Learned and Enhancement Opportunities
		eliminate, from Section 189a of the Atomic Energy Act, the statutory requirement to conduct a hearing if no one has asked for a hearing. A significant schedule reduction could be realized by eliminating the mandatory hearing, when appropriate, or conducting the mandatory hearing in the manner recommended by the task force. The DOE should work with the NRC and Congress to support these proposed enhancements to the NRC regulatory framework.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
PART 1 – LESSONS LEARNED FOR PROJECT MANAGEMENT		
1-1	Strong Project Management leadership is essential throughout the COLA project and especially during the planning stages and initial startup.	Project Management must take the lead from the beginning and all personnel must buy into the plan, including schedule, licensing approach, document control, information exchange, division of responsibilities, etc. Although some changes in leadership and personnel are inevitable, continuity and consistency should be maintained to the greatest extent possible.
1-2	Much of the float on some front-end activities of COLA development was lost because of lack of discipline in maintaining the project schedule plan, which contributed to the bow wave of activities in the latter half.	Each organization must adhere to the schedule more rigorously from the very beginning of the project. All personnel must understand that "schedules are real." Any float used on the front end of the schedule will cause problems later due to the bow wave effect.
1-3	The process to develop a COLA was effective but overly complex, leading to multiple meetings on the same subject, discussions off topic, and COLA package documentation that was difficult to follow.	COLA development is a complex process with each step in the process requiring guidance in the form of work instructions, automated document file control systems with supporting training, orderly meetings, and conference calls. Project management also plays a key role in limiting off-topic discussions that otherwise impact meeting efficiencies.
1-4	Development of design documentation and environmental input was sometimes not adequately coordinated.	The information put in the environmental report was sometimes not adequately coordinated with design and analysis. Appropriate schedule links must be identified to ensure that inputs needed for environmental assessments are conducted in the appropriate sequence. Internal reviews should be conducted of all work that involves engineering and environmental assessments such that environmental considerations are appropriately addressed in the design documents (e.g., site layout plans and power line routing).

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
1-5	Two schedules were maintained─one for design/engineering work and one for licensing activities. With use of separate schedules, it was unclear why activities were needed at specific times and how change in finish date on one schedule affected completion of activity on the other schedule, even though links identified and used in the P3 schedule indicated that delay in finish was reducing float.	Using an integrated schedule provides better project control and understanding of interfaces required in COLA development by all parties. The detailed project schedule should specifically include each calculation/analysis that must be performed to support the application, including the origination, checking, and approval steps.
1-6	Durations of schedule activities provided/ allowed were sometimes too long to judge the probability of meeting the Early Finish date. Some activities had descriptions such as “Review and Issue” or “Prep and Issue” that included a number of steps.	Experience has shown that durations longer than 3 weeks do not provide a sense of certainty in meeting the expected finish date. Activities with long durations should be split into steps/tasks with smaller, more measurable durations. Preparation of a section could be split into subsections, drawings into sheets, etc. To aid in forecasting/ tracking an activity, each step/ reviewer should have a separate activity, including internal reviews prior to external reviews. The easier it is to identify the person/ group tasked with an action, the easier it is to status a schedule.
1-7	The schedule for COL sections did not always define activities for the section in a chronological manner.	All Requests for Information (RFIs) and engineering/calculations supporting a section’s development should be grouped at the beginning of a section schedule to lend focus to those items needed prior to section development. If the RFIs and engineering activities are scattered among the section activities or placed after section development activities, the ability to focus on these predecessor activities is lost.
1-8	The project schedule was created based on detailed discussions with authors/supervisors and attempted to show logic ties from one section to another. Despite this effort, some inputs/output relationships on the schedule were not properly captured.	Additional emphasis should be placed on front-end scheduling to capture all section schedule logic ties. This is a significant effort.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
1-9	Two utilities, Dominion and Entergy, planned to write COLA based on using the ESBWR technology. These organizations started meeting to discuss issues and share resources and experience. Both the technology vendor and the utilities benefited from this informal working group.	The working meetings were started by the utilities and GE Hitachi Nuclear Energy (GEH) because it made sense for everyone to benefit from years of operational program experience. These eventually evolved into the current Design-Centered Working Groups (DCWGs). In conjunction with the Nuclear Energy Institute (NEI) COL Task Force recommendations and the NRC's Regulatory Issue Summary 2006-06 on May 31, 2006, the design-centered review approach (DCRA) and the DCWGs were formalized.
1-10	Coordination, primarily on environmental issues, between the NRC, state agencies, and other environmental permitting agencies is critical. Skilled and dedicated resources in the applicant/applicant contractor organization facilitate this process because each regulatory body is the centered around its own processes and regulations. During meetings between the NRC and state regulating agencies on environmental quality issues, the NRC needs to have a better understanding of the state's role.	Knowledgeable individuals should be sought and empowered to work with the NRC as well other federal, state, and local regulators on environmental issues. These same individuals are critical when interfacing with the public, which more readily relates to environmental issues than to more esoteric nuclear safety issues. Future projects should plan on a very proactive, early engagement with state and local agencies and concerned citizens. The NRC should consider initiating pre-job briefings with state agencies so that meetings held later between the NRC and these agencies can be conducted more efficiently.
1-11	Close coordination with the NRC project manager facilitated the ACRS meetings. Both parties─Dominion and the NRC Staff─were aware of the information being provided by the other.	All COL applicants should maintain close coordination with the NRC Staff.
1-12	A licensing "core team" evolved and became a critical element in ensuring understanding and consistency within the COLA.	Establishing a licensing core team that includes highly capable licensing experts from both the applicant and applicant's contractor organizations is critical to development of a complete and quality COLA. This was identified as a **Best Practice**.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
1-13	A formal process (e.g., using RFIs) was needed between organizations to acquire information for COLA development. The process is necessary to ensure that accurate and complete information is being used to develop COLA content. Typically, formal processes for transmitting quality technical information can be slow, especially when handling a large volume of information in a limited time.	The process for transmittal of information needed for COLA development should be reviewed prior to use both to familiarize the project team with the process and to ensure that information can be transmitted expeditiously to support the COLA preparation schedule.
1-14	Changes in site layout, relocation of structures, etc., can have significant and cascading effects on development of COLA sections. The final configuration of the site layout is a critical component of the ESP/COLA. This design product serves as the basic input to multiple analyses performed in support of the license application. Such analyses include dose calculations, storm water drainage plans, flooding analyses, and cooling tower drift analyses. Thus, the site layout must be frozen at the earliest possible date within the project execution schedule. For the Dominion COL project, the site layout was not frozen until late in the project schedule because the reactor technology plot plan was in flux due to lack of design progress.	It is critical to come to early agreement on the site plan, including location of nuclear/turbine island complex and all yard structures. Site topography should be understood by all stakeholders. All stakeholders should be involved in this review. Emphasis must be placed on the importance of freezing the site layout early in the final project planning and schedule. All parties must establish and work to a clear milestone date for freezing the site layout.
1-15	The ER portion of the COLA must evaluate the impacts of construction on the site. The impacts include land use, water use, noise, air emissions, haul routes, barge locations, etc. The applicant and subcontractors are reliant on the reactor technology supplier (and their constructor) to provide construction facilities planning information to support the ER impact analyses. Experience on several COLA projects has shown that the reactor technology suppliers are not equipped to provide this information efficiently or on a timely basis to support the schedule. Preparing the ER suffers from receipt of late information from the reactor technology supplier or information that changes at a later time.	The project schedule should reflect receipt of the needed information from the plant constructor (or reactor technology supplier) at a very early stage. The applicant is advised of the importance of early receipt of this information, and should make every effort to expedite the information from the plant constructor on a timely basis.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
1-16	Relative location of cooling towers to plant facilities relies on many factors that should be considered early in the planning process.	An understanding of site wind and meteorological conditions (including prevailing wind; distance from electrical equipment and heating, ventilating, and air-conditioning (HVAC) intakes; and surrounding topography) is needed to properly site the plant cooling towers relative to the plant.
1-17	Author Presentations (or Pre-Job Briefings) were considered to be beneficial by most project participants.	Author Presentations should be continued and initiated as early as possible in the project's schedule. These presentations were felt to be one of the strengths of the entire program to produce the application. Author Presentations or a similar approach should be used to develop sound technical approaches for resolving all regulatory issues, site limitations, and engineering concerns early in the project. Including Author Presentations or pre-job briefings as milestones on the master project schedule was identified as a **Best Practice**. The Author Presentation process (using a "Basis Document" format) was employed for the North Anna COLA to confirm author buy-in, ensure that the review team agrees with the author's approach, and agree on section strategy prior to a large-scale investment in time.
1-18	Detailed planning and scheduling, action item lists, and weekly schedule meetings greatly aided in identifying problem areas and schedule impacts.	These activities should be continued and were identified as a **Best Practice.**
1-19	Throughout the document preparation, several project activities required pre-job briefings. These activities included complicated analyses such as the cooling water analysis, offsite dose analysis, and some of the geotechnical/seismic analyses.	The "pre-job briefing" process was identified as a **Best Practice**. See Table 6 for an example of subjects and discussion topics used in Author Presentations and pre-job briefings.
1-20	Most RAIs issued by the NRC were on a 30-day clock. A schedule template was used and enforced. Early discussions with NRC prior to issuance of RAIs was helpful. Also, strategy calls with Licensing and Engineering Subject Matter Experts (SMEs) held immediately upon receipt of RAIs to determine appropriate response strategy proved extremely beneficial.	A rigorous RAI process and schedule should be maintained.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
1-21	The resurgence of the nuclear industry and the ESP/COL permitting activities involves the use of engineers and scientists who may not have an in-depth exposure to the demands of creating a complex application with zero defects. Personnel resources for the work come from a variety of backgrounds and experience.	Significant training should be mandated for authors, checkers, licensing reviewers, etc., focusing on the need to prepare permit applications with zero defects. Project managers must fully recognize that not all project participants have the same level of experience, and many project participants may be working on their first NRC submittal of any magnitude.
1-22	Some section authors failed to identify all existing information, applicable regulatory requirements and guidelines, and their interface.	Institutionalize front-end planning requirements. The use of Author Presentations and pre-job briefings is very useful in identifying existing information and applicable regulatory requirements and guidelines.
1-23	Many issues need to be addressed in more than one section of the COLA, either the FSAR and/or the ER. Several team members felt that this could have been handled more efficiently. The way in which transmission systems was handled was cited as an example.	The approach (strategy) to be employed for these issues needs to be communicated clearly to each affected author. These common issues could have been the subject of additional Author Presentations to stress the themes or strategies to be employed in multiple affected sections.
1-24	Based on many different factors (including size of the engineering or licensing group, background, and experience) some of the sections in the COLA were assigned to off-project personnel.	At project inception, and periodically throughout the project, the team should re-evaluate the responsibility for application sections based on the experience of the individuals, workload, and other factors. The team should be ready to adjust. Formalized training should be developed for off-project personnel. The need for additional indoctrination and training should be continuously evaluated throughout the project.
1-25	A Level 3 schedule was created that identified dates by when first draft (Revision A) sections should be issued for review.	For a document of the size and complexity of a COLA, it is critical that the intermediate scheduled dates are met for each issue of the document's revisions. Delays in the preparation of the initial submittals serve to aggravate the "bow-wave" when too many sections must be reviewed and approved at the end of the schedule.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
1-26	Schedule activities for review and comment of Revision A sections should be tailored to the section content.	The project schedule should recognize that some sections require more extensive, longer reviews than other sections. All groups must exhibit higher discipline at the front end of the schedule so the “bow wave” effect can be avoided.
1-27	The time and resources necessary to support the NRC’s pre-application audit were much greater than originally estimated. These efforts included advance communication and arrangements, site and area tours, travel by technical experts to the site to support the audit, etc.	Additional emphasis, planning, and resources should be implemented to support pre-application interactions with the NRC Staff.
1-28	The division of responsibility (DOR) between the reactor supplier (and its subcontractors) and the utility (and its site characteristics information support contractors) needs to be established early and clearly for each calculation that is a shared responsibility. Some calculations (e.g., offsite doses) need inputs from both sides (source terms from the reactor vendor and meteorological data from the utility), and either side can perform the calculation.	A clear DOR for each calculation is needed to establish the schedules for obtaining needed inputs and performing the calculations.
PART 2 – LESSONS LEARNED FOR AUTHOR AND LICENSING PERSONNEL		
2-1	Although there was an NEI COL Task Force, no NRC or NEI guidance was provided on the format for a COLA FSAR that needs to incorporate a DCD by reference. NuStart guidance on COLA FSAR format was not consistent with Dominion’s format guidance.	Variations in FSAR format cause confusion for the NRC during reviews. The NEI should take the lead in reviewing the various R-COLA formats and S-COLA formats to standardize the best approach.
2-2	The approach to identifying conceptual design information (CDI) in each DCD is not standardized. A COLA FSAR needs to address CDI, but there should not be uncertainty in CDI in the DCD.	Uncertainties in the need for FSAR content due to the extent of CDI in a DCD cause confusion for the NRC during reviews. The NEI should take the lead in reviewing the various DCD formats for identifying CDI to standardize the best approach.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
2-3	On an existing plant site, the reference elevation and plan coordinate datum are established in the design bases documents and UFSAR. New construction is typically developed in the latest datum. Interfaces become an issue and can result in confusion and potential calculation errors and design inadequacies. Further, such issues could lead to use of more than one datum in the COLA and potential errors if a difference in elevations is not appropriately documented and reconciled.	Early identification of vertical and horizontal datum should be established for consistent use throughout the ESP/COLA development. The appropriate vertical datum should be identified for each elevation identified or the consistent use of a single datum ensured, making reference to alternate datum when referring to existing unit elevations as appropriate.
2-4	NRC requests for additional information (RAIs) on COLAs have generated the next level of detail required in a COLA.	An NEI process should be in place to review RAIs against the COLA content requirements in NRC Regulatory Guide 1.206 and identify the next level of detail being required by NRC reviewers for COLAs.
2-5	The ACRS presentation for the R-COLA was supported by subject-matter experts (SMEs) remotely using a conference call setup. Due to technical difficulties, the SMEs were muted and could not be heard when questions were directed to them.	The NRC should allow use of SMEs at remote locations to support the ACRS meetings due to the expense in traveling and the generally short amount of time that their area of expertise is needed at the meeting. Improved controls for audio equipment or upgrading to use of videoconferencing equipment would help to obtain the answers needed from the SMEs in real time and minimize expenses.
2-6	Little guidance was provided on which systems needed P&ID figures or the detail level required for P&ID figures for the systems.	Guidance is needed on which systems (or system classifications) require P&IDs in the FSAR and the level of detail required by system or system classification. This is an issue to be addressed for both DCDs and COLAs.
2-7	Preparation of the North Anna COLA began over 2 years before Regulatory Guide 1.206 was issued in June 2007. Draft Guide DG-1145, Proposed Revision 0 was published in September 2006 and was used until Regulatory Guide 1.206 was issued. Thus, the project encountered numerous issues regarding basic licensing principles, e.g., what information must be submitted to satisfy the regulations and the NRC Staff's review, during the time period from April 2005 through September 2006 when the DG was issued.	This was the result of the project being an industry first-of-a-kind effort in developing a COLA that references an ESP. Future COLA preparation efforts should take into account the schedule impact of changing regulations, standards, and guidance.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
2-8	A common issue found in early section drafts was that descriptions of the same information presented in multiple sections were not consistent—even when originated by the same author. Additionally, there were inconsistencies in descriptions between the FSAR and ER.	Training must be conducted for the author, checker, and licensing review responsibilities at the beginning of the project. The Style Guide must be published prior to any sections being written. Consistency issues and adherence to the Style Guide must be addressed during Author Presentations and pre-job briefings. One of the objectives of the final page-turn review is to check the entire application for consistency.
2-9	COLA changes were submitted to the client for Revision 1. The COLA changes were based on FSAR RAI responses and ESBWR DCD Rev. 5. In some cases, particularly for COLA changes associated with COLA FSAR RAI responses, the COLA FSAR change package mark-ups did not include a corresponding mark-up for the ER. A change package for the ER was submitted at a later time. The adverse impact was COLA changes that resulted in inconsistencies in the application that were not consistently tracked. A re-review of RAI responses and revisions had to be performed to verify consistency in the COLA.	To maintain consistency and accuracy in the COLA, a consistency check between the different parts of the COLA should be performed prior to submitting a revision or RAI response. This would improve the quality of the deliverable as well as decrease hours spent on re-review of similar or related COLA changes.
2-10	No guidance is provided on which structures require fire zone details or FHAs to be presented in the FSAR.	The NRC should provide direction on which site structures (or structure classifications) require fire zone drawings and FHA tables should be included in the COLA FSAR.
2-11	The FSAR indicated that the seismic category I structural fill would be obtained from the hard rock excavated from below the reactor and other deeply buried structures, and then crushed to gravel-sized particles.	Since the fill material would not be available until plant construction, parameters such as shear wave velocity and the relationship of shear modulus degradation and damping with strain had to be estimated, leading to multiple RAIs. Eventually, Dominion committed to obtaining samples of similar rock from a local quarry that would be crushed to a specified gradation (VDOT 21A) and then tested to obtain the required parameters. In a future situation where the fill beneath the site is not available, such testing should be performed on similar materials at the time of the site investigation.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
2-12	Concrete fill will be placed beneath the reactor building to replace weathered rock in situations where weathered rock is encountered at the foundation elevation.	No details of the concrete fill were originally provided in the FSAR, leading to a series of RAIs. In the future, where concrete fill will be placed beneath seismic category I structures, concrete parameters such as strength, shear wave velocity, unit weight, and Poisson's ratio need to be included, as well as a description of the measures to be taken to eliminate cracking due to thermal effects during curing.
2-13	The FSAR stated that structural fill would be tested at least once every 10,000 ft^2 placed.	The NRC Staff prefers that a commonly used standard be the basis for the testing frequency. The 10,000 ft^2 value was later replaced by 250 yd^3 as indicated in Table 5.6 of ASME NQA-1-1994.
2-14	For central and eastern U.S. (CEUS) hard rock sites, the evaluation methodology of Regulatory Guide 1.165 or Regulatory Guide 1.208 leads to high-frequency safe shutdown earthquake (SSE) amplitudes. These high frequency amplitudes are relatively high compared to: (1) lower frequency amplitudes for standard design response spectrum of existing nuclear power plants, and (2) in an absolute sense, the amplitudes predicted by design response spectra of standard shape and anchored to industry-accepted values for a PGA of 0.3g, thought to envelope SSE spectra for most CEUS sites.	The evaluation of high frequency SSE spectra and comparison to standard plant design spectra remains an unresolved industry/NRC issue. The DOE and the Electric Power Research Institute have begun working on a new characterization of the CEUS with guidance planned for issue in late 2013.
2-15	NUREG/CR-6728 guidance was implemented for an ESP application for the first time.	Although NUREG/CR-6728 provided recent advances in methods to select time histories, incorporate site-specific soil/rock column amplification factors, and compute ratios of vertical to horizontal motions at a site, NRC acceptance of the NUREG's methods was not assured when the COLA was prepared. ISG-01 on Seismic Issues Associated with High Frequency Ground Motion, issued on May 19, 2008, which references NUREG/CR-6728, provided additional guidance.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
2-16	Several pre-job briefs for calculations were conducted well in advance of the actual start of the calculation. This was a result of building the schedule to meet the specified end date and then having to make multiple revisions to the schedule to incorporate changing requirements. In a few instances, this resulted in pre-job briefs being scheduled and conducted several weeks before the actual start of the calculation and before the receipt of input data as requested in RFIs. This situation was further exacerbated by the fact that many RFI responses were received late, resulting in an even longer time between when the pre-job brief was conducted and when the calculation actually began. With the creation of an excessive time gap between the pre-job brief and the start of the calculation, some of the benefits of conducting a pre-job brief were lost.	It is recommended that the pre-job briefs for calculations be held as close to the start of the calculation as possible. If there is a planned or unplanned time gap between the pre-job brief and the start of the calculation, then the project should consider holding a second pre-job brief or an informal pre-job brief update near the start of the calculation. Ideally, the pre-job brief should be held after all input data has been received and reviewed. For complex calculations with a large amount of input data and requiring sophisticated modeling, it is recommended that the project consider holding additional interim pre-job briefs as the preliminary modeling tasks are completed. Interim pre-job briefs will provide an opportunity for the team to reevaluate assumptions based on preliminary output. Also, if input data is revised during the origination of the calculation, an interim pre-job brief will provide an opportunity to communicate and discuss any technical issues associated with the calculation.
2-17	ESP and COL projects require extensive subsurface investigations to support the permit applications to the NRC. If the ESP or COL permit application is for a new unit at an existing site, then the Owner will have in-house capability to know and communicate the environmental issues associated with the subsurface work. However, if the subsurface work is for a greenfield site, then the Owner will most likely not have in-house information available that addresses the environmental issues for the work. For example, the Owner would not have readily available information for endangered species, archeological, cultural resource concerns, etc. Applicants for COL projects with a greenfield site should be aware of situations where the environmental conditions at the site need to be investigated before drilling can begin.	The subcontract for the environmental subcontractor's support for a greenfield project (or existing site where the location of the proposed unit[s] has not been previously investigated) should include the scope of work to support the subsurface investigation. The environmental subcontract for ER work should be issued early in the project and should include an investigation for items that may impact the subsurface investigation subcontractor.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
2-18	ESP and COLA require water quality data to develop various sections of the ER and FSAR. Uses of the water quality data include but are not limited to identifying water treatment chemicals, determining cooling tower cycles of concentration limits, and determining discharge stream chemistry. Certain sites may not have meaningful water quality data, including seasonal changes readily available either because they are a greenfield site or because the cooling systems and discharge streams at an existing site are of a design and permitted such that the data is not collected to the level necessary to support evaluations of new units.	Project scoping should appropriately account for the effort and responsibility for providing the information, especially if the effort could result in significant expenditure of hours and cost to the project. Dialogue and interfaces between various stakeholders (e.g., water treatment, mechanical, environmental engineering; utility) need to be initiated during early project planning and reflected in detail in schedule logic.
2-19	The analyses in support of ESP or COLA should consider all federal requirements that could lead to a limitation on liquid discharges from the plant. This includes not only NRC CFRs and Regulatory Guides but also EPA regulations. The North Anna ESP project did not evaluate the release of tritium in liquid discharges for compliance with EPA drinking water standards. Although this compliance is not part of the NRC's review responsibility, the NRC pointed out to Dominion how the North Anna application could be questioned regarding its ability to meet EPA drinking water standard regulations.	Analysis of liquid discharges to meet NRC criteria should include analysis of conformance to EPA drinking water standards. The latter may not need to be reported in the ESP or COLA, but will need to be considered within the project's overall regulatory framework.
2-20	For some subsections of FSAR Section 2.4, Hydrology, where the flooding hazards were identified as low or not contributing to the design basis flood level, the NRC Staff requested additional data on sources of information and how conclusions were reached. This included requests for information on stage storage data for Lake Anna, database searches for seismic seiches and landslides, records of ice jams on upstream rivers, and documentation on the volumes of upstream reservoirs.	Even when it is obvious that a particular flood hazard will not be a factor, information and data sources need to be included in the application to substantiate the conclusions reached. If searches are made that yield no results, the sources searched should be identified with the indication that no information was found (e.g., no seiches were found in the state of Virginia after searching xyz database).

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
2-21	All meteorological data reported in the ER and FSAR was based on data observed at Richmond, Virginia, located southeast of the site. This approach was consistent with the existing North Anna UFSAR. Consequently, the potential ice thickness on Lake Anna and any open water body was calculated using Richmond temperature data. However, an NRC review indicated that using data from another nearby weather station northwest of the site produced a larger potential ice thickness.	Consideration should be given to looking at weather data from other nearby stations when calculating ice thickness (or other weather-based characteristics) and selecting that data which produces the maximum potential ice thickness (more conservative result). Any questions on data sources should be resolved with the NRC during pre-application interactions.
2-22	Conflicting requirements for Regulatory Treatment of Non-Safety Systems (RTNSS), e.g., the ESBWR Plant Service Water System (PSWS) design, resulted in delays in the preparation and completion of R-COLA FSAR sections.	Requirements should be defined and conflicting requirements resolved upfront to ensure that proper SSC design is incorporated in the COLA.
2-23	Bechtel utilized the HEC-RAS computer model to perform the probable maximum precipitation (PMP) runoff analysis for North Anna Unit 3 COLA FSAR Section 2.4.2 to evaluate the potential impacts of flooding at the site. The results of the analysis as well as the conservative assumptions used as input to the model are described in the FSAR. NRC issued an RAI requesting the applicant to provide the HEC-RAS input files and updated HEC-RAS input files used to conduct the FSAR Revision 1 analysis.	COL applicants should provide the NRC with the HEC-RAS input files and updated files used in subsequent COLA FSAR revisions at the time of submittal of the COLA or a revision of same.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
2-24	The Commonwealth of Virginia has issued General Virginia Pollutant Discharge Elimination System (VPDES) Watershed Regulation (9VAC 25-280-10) that severely restricts nitrogen and phosphorous discharges to tributaries that ultimately feed into the Chesapeake Bay. Standard Sewage Treatment Plant (STP) discharge treatment technologies that are routinely employed do not assure compliance with these limits. In addition, these limits essentially rule out phosphate-based corrosion- inhibiting technologies for cooling water systems that ultimately discharge into such tributaries. Compliance with these limits requires the use of low or no phosphate based corrosion inhibiting technologies, use of materials suitable for the cooling water chemistry, and/or mitigating measures being taken to reduce the nutrient impact. Initial design of STP and cooling water/chemical treatment systems for North Anna Unit 3 did not consider the subject regulation requiring reevaluation of the subject systems' design. The new unit designs were based on the existing Units 1 and 2 discharge permit.	Several regions have recently imposed more stringent limits on nitrogen and phosphorous (among others). The design engineer is responsible for proposing a design that meets the discharge permits along with any updated regulations in any location. In many cases, discharges for an existing facility may be acceptable (grandfathered), but the addition of a new facility on the site causes the more restrictive regulation to be invoked. The evaluator of systems and system chemical treatment plans should check current discharge permits as well as updated regulations for the state in which the facility is to be located to ensure that appropriate options are selected for the site.
2-25	Responses to some RFIs underwent revisions numerous times, causing delays to R-COLA section and supporting analysis preparation.	Prior discussions with the responding organizations to clarify intent of requested information and review of draft responses can avoid and save the time needed for revisions to responses.
2-26	The NRC asked for justification for assuming that subsurface conditions within an area of the technology footprint where there were no borings were the same as subsurface conditions in adjacent areas where borings had been made.	Unless good quality borings already exist from prior subsurface investigations, sufficient borings should be performed throughout the technology footprint to ensure that there are no significant unexplored areas.
2-27	Since North Anna was considered a "rock site," the original work plan did not call for running SHAKE analyses in the soil at the site during the ESP stage. This approach was modified during the COL analysis, but the SHAKE analysis used only "best estimate" values of shear wave velocity of the soil and did not provide variation (e.g., 0.67 and 1.5 times the best-fit value). This variation was provided in response to an NRC RAI.	Even for "rock sites," high quality shear (and compression) wave velocity measurements should be performed in both the rock and the soil above the rock. A randomization analysis should be performed to provide sufficient soil and rock parameter values to envelope possible parameter variations.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
2-28	When reporting the values for extreme meteorological conditions, care should be taken that the basis for the number is clearly explained.	The NRC questioned the maximum wind speed information provided because (a) an outdated calculation method was cited, and (b) the greatest of several maximum wind speed data included for comparison was not used. It is important to ensure that the maximum wind speed be reported as the "100-year return value 3-second gust" or the historical maximum, whichever is higher. The "fastest mile wind speed" should no longer be referenced.
2-29	The application review process included a "team review" or "page turn" of the compiled document. In preparing the COLA (either for initial submittal or for subsequent revisions), a final activity in the process is typically a "page-turn" review. During this review, the key stakeholders (from Dominion as well as supporting organizations) closely review the document to make sure it is in its final form, that all comments and questions have been addressed or resolved, and to ensure consistency within the overall document. Attendees at this page-turn meeting are to be intimately familiar with the document being reviewed and are to be prepared to discuss the document and to efficiently perform confirmatory reviews on-the-spot.	This was identified as a **Best Practice** for the project and served to improve the consistency of language and approaches to multiple sections. The page-turn review should not be conducted before open items have been closed or before the document is ready to be considered final. In the page-turn review meeting, it is most helpful to have ready access (preferably electronic) to the other section of the COLA that may be related to the section/chapter being reviewed, and to other COLAs, especially in the same technology.
PART 3 – LESSONS LEARNED FOR DOCUMENT PRODUCTION PERSONNEL		
3-1	Following submittal of more recent COLAs, the NRC has requested electronic versions of certain figures from the Environmental Report in a native file format (e.g., pgn files with associated GIS and metadata) for their use in development of the Environmental Impact Statement (EIS).	The final licensing packages for a section should also include electronic copies of all figures in the native file format. If a section is developed by a subcontractor, electronic copies of all figures should be provided as part of the supplier document submittals.
3-2	COLA content requires that there be multiple authors from multiple organizations. Poor administrative controls can quickly result in loss of COLA content configuration and adversely affect the ability to deliver a quality COLA on schedule.	Lessons learned include rigorous administrative control of the document during COLA development use of a post Rev. 0 issuance process that employs a "living COLA" from a single source.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
3-3	The Writer's Guide and Work Instructions were constantly being updated and new revisions issued. Numerous format and consistency issues arose that caused rework and lost time during the production of the document.	The Writer's Guide and Work Instructions evolved as problems were identified. Future projects should have a Writer's Guide and Work Instructions prepared and authors trained before any sections are written if at all possible. The importance and time required to prepare and issue an effective Writer's Guide and Work Instructions were underestimated. Although easy to say in theory, in practice it is difficult to produce a completely workable Writer's Guide and Work Instructions before starting the project, since the need for changes is identified once the authors start to use the guides. Applicants should review internal lessons learned to develop the most complete instructions possible prior to the start of author section preparation.
3-4	Control of figure content and revisions must be consistent and uniform by all parties to ensure proper document incorporation and consistent use of terminology.	A process should be established for figure management (i.e., revision control and author access) and a mandatory set of typical terminology provided for use in both text and figure content (e.g., Plant North, True North, Grid North, facility names and abbreviations, etc.).
3-5	The convention and mechanics for Reference and Figure call-outs must be clearly established before sections are written.	Considerable time and effort were expended to ensure that text reference and figure call-outs were correct. A fool-proof manual or automatic method should be established before any sections are put into production. Lessons learned during the ESP application were put into practice during the COLA, resulting in much greater efficiency.
3-6	The final electronic format of the application is professional and easy to use.	The practice of preparing ESP and COLAs using Adobe® FrameMaker® (or equivalent) software specifically designed for large document production should be continued. Typical word-processing applications are not up to the task. The project team should include someone who is knowledgeable in the creation of large electronic documents. This was identified as a **Best Practice**.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
3-7	Teleconferencing was used as the primary method for holding Author Presentations and pre-job briefings.	This technique was found to be very effective and resulted in avoiding time-consuming and costly travel for face-to-face meetings. This practice or Web conferencing should be used for future COLAs.
3-8	An eRoom or ftp site was used to exchange and store large electronic files.	The use of an eRoom to exchange and store large electronic files was identified as a **Best Practice**.
3-9	When the COL project started, paperwork was completed in duplicate and sometimes triplicate.	Up-front planning and automation are essential to the efficiency and overall success of the project. A good document control system, as well as a transmittal tool, needs to be implemented at the start of the project.
PART 4 – LESSONS LEARNED DURING COLA DEVELOPMENT WITH AN ESP		
4-1	The key to **"**COLA Development from an ESP**"** is not doing the COLA based on an ESP, but doing an ESP in the first place.	Dominion has long extolled the virtue of doing an ESP first from the perspective of early identification of potential impediments. A more mundane but equally worthwhile benefit is that ESP preparation is an excellent dry run for COLA preparation. It allows the applicant to acquire resources, establish processes and organizations, and develop the skill set necessary to implement the new NRC licensing process effectively.
4-2	The transition process from ESP to COLA is still evolving**.** Understanding the relationship of the ESP to the COLA is one key to deriving benefit. The COLA preparation team must understand what is in the ESP. An individual knowledgeable in the scope of ESP content is valuable in assembling the comparison tables required in the COLA to demonstrate that the technology selected in the COLA "falls within" the limits of the ESP. In addition, the transition from ESP to COLA is also made easier if an Appendix B quality program is used for ESP development.	Dominion included Appendix B, 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" in its ESP application, although some ESP applicants did not include Appendix B. By including the Appendix B quality program, the transition from ESP to COLA avoided additional challenges and backfitting. Future ESP/COL applicants should include Appendix B in the ESP work plan.
4-3	Although the NRC's evaluation of once-through cooling identified small to moderate environmental impacts during the Staff's review of the ESP application, interactions with state agencies brought to light concerns with the initial planned approach of once-through cooling for Unit 3. (Note: Unit	Significant benefits of the ESP process include confirming the original determination regarding the potential suitability of the site, early resolution of siting issues, deferring a technology decision until supported by the business case, and keeping the nuclear option open while monitoring market

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
	4 had always been envisioned to use closed-cycle cooling.) As a result of numerous discussions and consultations, Dominion elected to change the cooling water approach for Unit 3 from a once-through cooling system to a closed-cycle cooling system. The change was implemented through a revision to the ESP application. Although challenging at the time, the ESP process served the beneficial purpose of identifying and resolving a significant concern at an early stage of Dominion's planning for Unit 3. Taken in perspective, the effect on Dominion's cost and schedule would have been significantly more severe had this conceptual design change been made during the COLA process. Because a COLA involves the development of more robust design information compared to an ESP and the commitment of substantially more resources to support, Dominion would have suffered a significantly greater adverse impact to its overall plans for North Anna Unit 3 had this change only been identified and addressed as part of the North Anna 3 COLA.	conditions. The environmental impact reviews performed by the NRC and the state agencies must be closely monitored as there is no assurance that similar conclusions will be reached. Because this issue was identified during the ESP project, the results were used during the R-COLA with no delay to schedule.
4-4	The ESP application process, in conjunction with the PPE approach, allowed Dominion to defer a technology decision until justified by the business case. Dominion did in fact change its original reactor technology selection for the North Anna 3 COLA while the ESP phase was still in process, with a relatively small impact on the Unit 3 program's time line. Dominion subsequently changed its reactor technology selection again in the spring of 2010 prior to submitting Revision 3 of the COLA with relatively small impact expected on the Unit 3 time line.	Significant benefits of the ESP process include confirming the original determination regarding the potential suitability of the site, resolving siting issues early, deferring a technology decision until supported by the business case, and keeping the nuclear option open while monitoring market conditions.
4-5	There is no NRC or NEI guidance on how to identify new and significant information for a COLA ER that is based on an ESP. The process used to identify new and significant information did not account for the short amount of time that had elapsed between approval of the ESP and writing of the COLA ER.	There should be a reasonable amount of time after an ESP is issued before a search for "new" information for time-sensitive key inputs must be conducted. The NEI should take the lead in developing guidance for performing the new and significant information searches.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
4-6	In many cases, the “new and significant process” evaluated the FEIS and ESP application on a statement-by-statement basis. This resulted in piecemeal evaluation of some concepts and evaluation of statements regardless of their ability to be “new and significant,” such as those pointing to figures, tables, sections, etc.	Not every statement in the FEIS and/or ESP application needs to be evaluated against “new and significant.” “Key inputs” would be better identified on the multi-sentence or paragraph basis so that a complete concept can be evaluated instead of a sentence taken out of context.
4-7	An ESP application can be for a specific reactor design or for a range of designs, i.e., a PPE. The PPE approach can be for few or many designs, and can comprise current and/or future generation designs. The more complex the PPE, the more challenging and potentially less definitive the NRC review.	The PPE concept should be retained and supported. The NRC should continue to provide guidance to applicants who wish to prepare and submit ESP applications based on a PPE approach. The DOE should continue to support such an approach as a critical component of the licensing framework for new nuclear plants. During preparation of the COLA (both the R-COLA and now the S-COLA), Dominion learned that not enough conservatism in envelope values was allowed to provide more flexibility in accommodating changes in the cooling tower design. Consideration needs to be given to adding reasonable operating margins to PPE values at the ESP stage by future ESP/COL applicants.
4-8	There is no NRC or NEI guidance on the format for a COLA FSAR that needs to incorporate the content of an ESP application SSAR by reference. COLA FSAR format (principally for Chapter 2) was not consistent between Dominion’s R-COLA and the Grand Gulf S-COLA, both of which were based on ESPs.	Variations in FSAR format cause confusion for the NRC during reviews. The NEI should take the lead in reviewing the various COLA formats for FSAR Chapter 2 to standardize the best approach.

Table 2. Lessons Learned

No.	Background/Description	Lessons Learned
4-9	There was insufficient direction available regarding development of COLA ER Chapter 3, Plant Description, for a site that has an ESP based on the PPE process. By necessity, for a site using the PPE process, limited detail can be provided for site design in Chapter 3. Given the finality of the ESP, questions arose as to how much technology detail was necessary in the COLA ER and whether specific technology parameters needed to be defined.	The NRC needs to clearly define the level of detail required to be addressed in Chapter 3 for technology specific design when an ESP using PPE exists. Because there was no clear definition, and therefore impossible for the authors to determine which information should be included versus which was not necessary, Dominion's section authors laboriously wrote the sections for ER Chapter 3 including all information with specific technology detail and then deleted information repeated from the ESP. Detailed guidance from the NRC will eliminate this duplication of effort.
4-10	The site suitability evaluation with respect to radionuclide transport characteristic as defined by 10 CFR Part 100.20(c)(3) requires the use of observed site specific parameters important to hydrological radionuclide transport (such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest surface body of water) obtained from on-site measurements. Onsite measured values of adsorption and retention coefficients for radioactive materials were not provided in the ESP application, because the assessment of accidental releases of liquid effluents to groundwater was deferred to the COL stage when radionuclide inventories would be known. The NRC identified this issue as an SER Open Item.	For the North Anna ESP, resolution of the SER Open Item could have required Dominion to send soil samples to a laboratory to measure adsorption coefficients. This testing would have been unplanned and would have delayed the NRC review. This issue was ultimately resolved by the NRC identifying a Permit Condition that mandates no accidental radwaste releases to the environment. In preparing the R-COLA, site-specific Kd values were obtained and used. For future ESP applications, to address potential accidental releases of radionuclides into any potential liquid groundwater pathway, site-specific distribution coefficients (Kds) should be determined using representative soil samples for the radionuclides expected to be present in liquid effluents. For COLAs without an ESP, site-specific Kd values need to be obtained with this testing planned for in the schedule.

Table 3. Benefits of the North Anna ESP in Developing the COL Application

Benefit of an ESP	Dominion Experience
Determine potential suitability of the site.	The general suitability of the North Anna site was determined during the site evaluation phase of the project which preceded the ESP work. The ESP preparation process determined that no site characteristics were "show stoppers" for site development before considerable resources were expended to develop a technology-specific design during the COLA development.
Early resolution of siting issues.	The ESP review phase and consultations with state agencies brought to light concerns with the initial planned approach of once-through cooling for Unit 3. Thus, the ESP process served the purpose of identifying and resolving a significant concern at an early stage of Dominion's planning for Unit 3. The effect on Dominion's cost and schedule could have been more severe had this conceptual design change been made during the COL process. Because this issue was identified during the ESP project, the results were used during the R-COLA with no delay to schedule.
Defer technology decision until justified by the business case.	The North Anna ESP application was prepared and approved using a PPE approach which allowed Dominion to select a reactor technology later.
Keep nuclear option open while monitoring and evaluating market conditions.	Although this is a benefit of the ESP process, Dominion moved directly from the ESP phase into the COL phase after having selected the ESBWR reactor technology. Market conditions and other factors led Dominion to not "bank" the ESP, but rather move directly to the COL stage.

5. Insights/Recommendations

5.1 Accomplishments

The purpose of the Cooperative Agreement was to advance the design of a new nuclear power plant technology as well as develop the business case and licensing approach for Dominion to decide to build a plant and obtain NRC approval to construct. Although some of the goals detailed in the Cooperative Agreement were not met, the project as a whole was very successful in advancing the potential for a new nuclear unit to be constructed and operated at North Anna. The Cooperative Agreement also helped to stimulate the entry of multiple vendors into the U.S. commercial market for new nuclear plants.

5.1.1 Meeting of Cooperative Agreement Objectives

Prepare and submit the ESBWR Design Certification application

The ESBWR design activities were removed from this Cooperative Agreement on April 1, 2007, and transferred to a separate Cooperative Agreement between GEH and DOE.

Obtain NRC Design Certification for the ESBWR

The ESBWR design activities were removed from this Cooperative Agreement on April 1, 2007, and transferred to a separate Cooperative Agreement between GEH and DOE.

Prepare and submit a Combined License application for the ESBWR at the North Anna site

In November 2007, Dominion submitted the initial version of the COLA for the ESBWR at the North Anna site. The last revision of the COLA FSAR and Environmental Report based on the ESBWR technology was submitted to the NRC in May and July 2009, respectively.

Obtain NRC approval of the Combined License Application

Approval of the COLA was not accomplished, but the process was "on schedule" at the conclusion of the Cooperative Agreement. The further development of the ESBWR R-COLA is now being led by the Detroit Edison Company for the Enrico Fermi Nuclear Generating Station.

Complete the ESBWR Standardized and Site-Specific Design and other Site-Specific Engineering

ESBWR standardized and site-specific design activities for the GEH scope of work were removed from this Cooperative Agreement on April 1, 2007, and transferred to a separate Cooperative Agreement between GEH and DOE. Site-specific engineering for Unit 3 yard facilities was progressed until Dominion's decision to enter the EPC competitive process. Site separation engineering activities were largely complete at the conclusion of the Cooperative Agreement.

Develop the Business Case Necessary to Support a Decision on Building a New Nuclear Power Plant

Dominion developed the business case for the construction and operation of a new nuclear power plant at North Anna. Although a decision was made to pursue a different technology than the one addressed in this Cooperative Agreement, the business case developed as part of the project facilitated the Dominion decision to remain interested in the development of a new nuclear power unit at North Anna.

5.1.2 Meeting of Cooperative Agreement Terms and Conditions

The Cooperative Agreement included several requirements to facilitate DOE oversight of activities, including quarterly progress reports, quarterly financial status reports, a yearly independent financial audit of Dominion, and special status reports (upon request). Each of these required documents was provided on time and in sufficient detail to meet DOE expectations. Only one special status report was requested by DOE during the Cooperative Agreement. This request was related to concerns raised during review of the initial version of the ESBWR DCD. The special status report was submitted in October 2005.

In addition to required periodic deliverables, DOE and Dominion participated in numerous conference calls (typically biweekly) and in-person meetings to update the status of the project.

5.2 Discussion and Recommendations

To promote a thorough and accurate overview of the work performed, and outcomes achieved by the project, a "compliance scorecard" (see Appendix 5) was developed from requirements detailed in the Cooperative Agreement. The scorecard was completed by several members of the Dominion project management team. Based on the information contained in the completed scorecards, as well as information obtained from project documentation (e.g., quarterly reports to DOE), follow-up discussions were held with Dominion management personnel. This section summarizes opinions regarding the performance of the project and provides recommendations for improvement for similar government-industry efforts that may be undertaken in the future.

Although the Cooperative Agreement did not meet all of the established objectives, it was a success in that it facilitated the likely construction of a new nuclear facility at North Anna within the next decade and stimulated interest by multiple competitive vendors in the U.S. commercial nuclear power market. In particular, the Cooperative Agreement funding advanced the development of the COLA (as an earlier Cooperative Agreement had spurred the ESP process to completion) and development of the business case supporting the decision to construct the new unit. The ESP-COLA framework, coupled with the business case findings, provided Dominion with flexibility to continue forward by switching plans to use the US-APWR technology as it became clear that successfully negotiating an EPC contract with GEH was unlikely until a competition for the plant was conducted. As summarized by the DOE director for light water reactor technologies, Ms. Rebecca Smith-Kevern, in the July 2010 Nuclear Energy Institute newsletter, Insight: "Dominion has an ESP that it got under our program and because of that, Dominion believes the licensing of the new Mitsubishi design is going to be very straightforward and rapid. They don't have to go back and completely redo the environmental report because it was bounded by the ESP. They [NRC] just have to add a supplement to the environmental impact statement." The NP 2010 program was a major contributor to jump start utility interest in new nuclear unit development in the United States. The progress made in development of licensing approaches, reactor designs, and business cases for new nuclear development would likely remain far less advanced without the NP 2010 program. The innovative approach employed by DOE in extending partnership opportunities to utilities for the development of new nuclear units serves as a model for future government-industry cooperative efforts.

The COLA development effort was undertaken after an ESP was obtained from the NRC. It should be noted that the ESP was developed using a "Plant Parameters Envelope (PPE)" approach that defined the physical and technological bounds of the proposed new unit several years before a specific nuclear power plant technology was selected. This approach was useful in allowing generic (i.e., not technology-specific) regulatory and licensing activities to progress concurrent with the utility's evaluation of bids from technology vendors.

The establishment of the ESBWR DCWG by several utilities and GEH in 2006 was reported to be very useful to all parties and consistent with NRC's expectation for licensing new plants under Part 52 of a design-centered review approach. Utilities and technology vendors shared resources, with subject matter experts from different organizations providing input to design and licensing concerns that were expected to be common to all future ESBWR plant operators. A subset of this group, the technical oversight group, which was composed of utilities and GEH, was also developed. The technical oversight group provided a collaborative means of developing and reviewing ESBWR design, where shared plant design and operating plant expertise was drawn upon to improve the overall plant design. A partnership in which utility operating experience is combined with technology vendor engineering expertise is likely to yield more thorough licensing documents, and the DCWG concept promotes this approach. The NRC also benefited from the DCWG organization because it promoted consistency in issue resolution and pending license applications, thereby helping to streamline the future review and approval process.

The Cooperative Agreement concept would likely be improved in future endeavors if a well-established chain of command is detailed among the parties on the industry side of this type of government-industry partnership. From inception of the Cooperative Agreement through March 31, 2007, the engineering design for the ESBWR technology was conducted by GEH through the integrated agreement. From April 1, 2007, ESBWR engineering design activities were conducted under a different DOE Cooperative Agreement established directly with GEH. From the onset of the project, differences in understanding regarding the extent of ESBWR design engineering to be accomplished became evident between Dominion and GEH. Dominion viewed the completion of the ESBWR design to a “ready for construction” level of detail to be a goal of the project. GEH reportedly expressed an understanding that the mandate of the Cooperative Agreement was simply to complete the ESBWR design to a level sufficient for DCD approval. When an unexpectedly large number of RAIs regarding the DCD were issued to GEH from the NRC, it became increasingly challenging for GEH to meet the schedule established for ESBWR design engineering. When the ESBWR design certification tasks were eliminated from the Cooperative Agreement and placed in a newly formed agreement between GEH and DOE in April 2007, additional challenges in coordinating schedules, priorities, and overall project progress developed. Delays associated with ESBWR design engineering negatively impacted progress for site engineering and the development of licensing documents. A well-defined chain of command among the industry participants would likely have resulted in a more unified approach to the project, and additional progress may have been achieved.

If a project similar to this Cooperative Agreement is undertaken in the future, it is recommended that an integrated schedule including direct associations between engineering and licensing tasks be used, as this will help highlight “critical path” items with the greatest potential to cause delays to the project as a whole if not completed on time.

The most significant obstacle to progress noted during the project was the need by GEH to allocate resources away from ESBWR design engineering to address the tremendous number of RAIs from the NRC resulting from staff review of several revisions of the DCD. If a project similar to this Cooperative Agreement is undertaken in the future, increased emphasis should be placed on ensuring the quality and thoroughness of the DCD before submission to the NRC to minimize delays and unanticipated impacts on the schedule. In addition, to avoid overall project delays, contingency plans to add qualified staff to meet both the NRC RAI response time requirements and project schedule requirements should be developed and implemented if conditions warrant.

6. References

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- Regulatory Guide 4.7, "General Site Suitability for Nuclear Power Stations," U.S. Nuclear Regulatory Commission, Revision 2, April 1998.
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- "Report on Lessons Learned from the NP 2010 Early Site Permit Program," Final Report, U.S. Department of Energy, March 26, 2008.
- "Staff's Implementation of Lessons Learned from Reviews of Early Site Permit Applications," Letter from William J. Shack, Chairman, U.S. Nuclear Regulatory Commission, Advisory Committee on Reactor Safeguards, to The Honorable Dale E. Klein, Chairman, U.S. Nuclear Regulatory Commission, November 19, 2007.
- United States Department of Energy, Notice of Financial Assistance Award, Instrument Number DE-FC07-05ID14635. North Anna Construction and Operating License Demonstration Project, Amendments A000 (April 2005), A001 (September 2005), and A002 (April 2006)
- United States Department of Energy, Office of Nuclear Energy. Nuclear Power 2010 factsheet, May 2009 (accessed at http://www.ne.doe.gov/pdfFiles/factSheets/NP2010.pdf)
- United States Nuclear Regulatory Commission, Combined License Application Documents for North Anna Unit 3, August 2010 (accessed at http://www.nrc.gov/reactors/new-reactors/col/north-anna/documents.html)

Schedule Milestones

Date	Description
April 4, 2005	Project start
October 24, 2007	NRC Public Outreach Meeting, Louisa County
November 27, 2007	North Anna ESP issued by NRC
November 27, 2007	Submission 1 of the COLA with Revision 0 of all parts of the COLA was provided to the NRC
November 29, 2007	North Anna Unit 3 (NA3) COLA Orientation presentation to NRC
December 20, 2008	Submission 2 (Non-Public Version) of the COLA and Submission 3 (Public Version) with Revision 1 of most parts of the COLA were provided to the NRC
May 29, 2009	Submission 4 (Public Version) of the COLA with Revision 2 of FSAR and Departure Report was provided to the NRC
July 29, 2009	Submission 5 (Public Version) of the COLA with Revision 2 of the ER was provided to the NRC
	Acceptance Review
December 3, 2007	Acceptance Review Start
January 28, 2008	NRC Docketing Decision Letter was issued and the acceptance review completed
February 27, 2008	Review Schedule Established/Schedule Letter Issued to Applicant
	Safety Review
August 29, 2008	Phase 1 – Requests for Additional Information (RAIs) Issued to Applicant
August 7, 2009	Phase 2- SER with Open Items (incorporating COLA Rev 1) issued
November 4, 2009	Phase 3 – ACRS Review of SER with Open Items Complete
(September 2010)-T*	Phase 4 – Advanced SER with no Open Items Issued
(December 2010)-T*	Phase 5 – ACRS Review of SER with no Open Items Complete
(February 2011)-T*	Phase 6 – Final SER Issued
	Environmental Review
April 16, 2008	Environmental Scoping Public Meeting, Louisa County
September 5, 2008	Phase 1 – Scoping Summary Report Issued
December 19, 2008	Phase 2 – Draft Supplemental Environmental Impact Statement (SEIS) issued to Environmental Protection Agency (EPA)

T* = Target. This table includes milestones that had been targeted prior to the time Dominion announced the change in technology for the North Anna COLA.

Schedule Milestones

Date	Description
February 3, 2009	Public Meeting, Louisa County, to discuss Draft SEIS
March 20, 2009	Phase 3 – End of the Draft SEIS comment period
March 19, 2010	Phase 4 – Final SEIS issued to EPA
	Hearing
	Commission or ASLB hold mandatory hearing
	License
	Commission decision on issuance of COLA
	COL issued by NRC
	Technology Change
May 18, 2010	North Anna COL Technology Change Letter to NRC
June 28, 2010	Submission 6 and Submission 7 of the COLA submitted to NRC
	NP2010 Project Close-out
November 2010	Project summary report issued

APPENDIX 2

Pre-Job Briefings For COL Section Development

Subject	Discussion Topics
1. Approach to Section Preparation	Describe the overall approach to section preparation.
2. Conformance With NRC Regulations and Guidance	Describe conformance with applicable NRC regulations and guidance documents (10 CFR 52, Regulatory Guide 1.206, NUREG-0800, NUREG-1555, other Regulatory Guides, other NUREGs, other documents).
3. Changes/Deviations from R-COLA or DCD	Identify any potential changes/deviations from the R-COLA or DCD content.
4. COL Items and ESP Permit Conditions	Describe the approach, necessary actions, etc., to address each COL item and ESP Permit Condition (if applicable).
5. Links to Other Sections	Identify links to other application sections.
6. Basis/Input Documents To Be Used	Identify documents that are planned to be used as input to the section or supporting analyses and their validity.
7. Lessons Learned from Other ESP Applications and COLAs	Identify pertinent lessons learned from other ESP applications and COLAs and how addressed.
8. NRC RAIs and Questions Pertinent to the Section(s)	Describe pertinent NRC RAIs and questions from other ESP applications and COLAs and how addressed.
9. Data Collection	Describe plans for data collection and identify planned Requests for Information (RFIs). Identify to whom the request will be made.
10. Analyses and Validation Package	Describe planned analyses; describe approach to validation package.
11. Special Challenges/Other Issues	Identify any special challenges or other issues.

APPENDIX 3

Supporting Engineering and Analyses for COL Applications[1]

Mechanical
Siting Study/Report
Water Balance Calculation
Chemical Feed for Raw Water and Cooling Towers
Raw Water/Station Water Pump Calculation
Waste Water Characterization Calculation
Circulating Water System Process Flow Calculation
Circulating Water Cooling Tower Sizing Calculation
Service Water Pump Calculation
Plant Service Water System Cooling Tower Sizing
Plant Service Water Basin Volume Calculation
Plant Service Water System Pump and Pipe Design Calculation
Station Water Storage Tank Sizing
Water Use Diagram
Raw Water/Station Water P&ID
Circulating Water System P&ID
Plant Service Water P&ID
Potable Water System & Sanitary Waste System P&ID
Fire Protection Yard Loop P&ID
Electrical and Switchyard
Switchyard Single Line Diagram(s)
Switchyard General Arrangement Drawing(s)
Transmission Line Map(s)
Civil/Plant Design
Plot Plan
Boring Plan(s)
Site Plan
Construction Facilities/Site Utilization Plan
Site Topography – Pre-Development

[1] *Identified activities are for a COLA based on ESBWR technology. Required analysis and diagrams for a COLA will vary depending on technology, especially in regard to whether the technology is passive or active design.*

Supporting Engineering and Analyses for COL Applications[1]

Preliminary Site Grades to Support Probable Maximum Precipitation (PMP) Calculations
Nuclear Island Excavation Plan and Profiles
Cut/Fill Estimates
Plant Renderings – Visual Study Support
Various Figures to Support COLA Chapters
Nuclear Analysis
Design Basis Accident Dose Analysis
Liquid and Gaseous Effluent Dose Analysis
Construction Worker Dose Analysis
Liquid Tank Rupture Activity Release Analysis
Radiological Impacts of Normal Operation
Environmental
Entrainment/Impingement Calculation
Population Distribution Projection Analysis
On-site Chemical Hazard Calculation - Explosion, Flammable Vapor Cloud, Toxic Chemicals
Nearby (Offsite) Chemical Hazard Calculation - Explosion, Flammable Vapor Cloud, Toxic Chemicals
Road Hazard Calculation - Explosion, Flammable Vapor Cloud, Toxic Chemicals
Railway Hazard Calculation - Explosion, Flammable Vapor Cloud, Toxic Chemicals
Waterway Hazard Calculation - Explosion, Flammable Vapor Cloud, Toxic Chemicals
Pipeline Hazard Calculation - Explosion, Flammable Vapor Cloud, Toxic Chemicals
Aircraft Accident Analysis
Baseline Weather Calculation
Monthly, Seasonal, Annual Mixing Heights, Wind Speed, & Ventilation Indices Analysis
Tornado Frequency Analysis
Severe Weather Calculation
Wind Rose Tabulations
Accident (Short Term) χ/Q Analysis
Normal Release (Long Term) χ/Q & D/Q Analysis
Control Room χ/Q Analysis
Technical Support Center χ/Q Analysis
Validation of Meteorological Data from Onsite Meteorological Tower
Compilation of Hourly Meteorological Data for Submittal to NRC

Supporting Engineering and Analyses for COL Applications[1]

Evaluation of Long-Term Climatic Trends
Seasonal and Annual Cooling Tower Impact Evaluation of Fogging, Icing, Salt Deposition, and Visible Plume
Wildfire Heat Flux Analysis
Design Basis Temperature Parameters
Design Basis Snow Load Parameters
Geotechnical & Hydrological Engineering
Hydrograph Validation
PMP Analysis
Probable Maximum Flood (PMF) Analysis
GIS Data Analysis in Support of Hydrologic Calculations
Dam Break Flooding Analysis
Wave Height and Run-up Analysis
Low Water Temperatures, Ice Thickness, and Ice Effects Analysis
Low Water Analysis
Site Drainage Analysis
Circulating Water Intake Temperature Percentiles
Circulating Water Discharge Outfall Sizing
Circulating Water Intake Structure Hydraulic Design
Circulating Water Blowdown Discharge Structure Hydraulic Design
Circulating Water Makeup Water Pipeline Hydraulic Analysis
Circulating Water Pump Intake Sizing/Hydraulic Design
Circulating Water System Steady-State Analysis
Circulating Water System Transient Analysis
Subsurface Hydrostatic Loading
Contaminant Transport
Update EPRI (1988) Seismicity Catalog
Develop Procedure for Converting Between Moment Magnitude and Wave Magnitude
Shear Wave Velocity of Soil and Bedrock
Develop Rock Response Spectra
Develop Frequency Rock Spectrum Compatible Time Histories
Develop Hi and Low Frequency Target Spectra for Spectral Matching
Select Seed Input Time Histories for Spectral Matching
Develop Spectrum-Compatible Time Histories for Rock Sensitivity Analysis

Supporting Engineering and Analyses for COL Applications[1]

Develop Spectrum-Compatible Time Histories for Site Response Analysis
Rock Column Sensitivity Analysis
Develop Amplification Factors and Sigmas as a Function of Rock Input Motion
Develop Method 2A ASCE FOSID Response Spectra
Develop Vertical SSE from Horizontal SSE
Site Response Analyses of Randomized Rock Profiles
Develop SSE Spectrum
Tabulation of Seismic Source Data
Surface Faulting Field Reconnaissance Report
Source Logic for EPRI-SOG Sources
Develop Updated Rock Seismic Hazard
Replication of 1989 EPRI-SOG Hazard
Develop Geotechnical Engineering Properties and Subsurface Materials
Liquefaction Analysis
Bearing Capacity and Settlement Analyses
Lateral Earth Pressures on Building Structures Analysis
Emergency Planning
Evacuation Time Estimate Analysis

Table of Contents for a COL Application

Section	Title
—	**TRANSMITTAL LETTER**
PART 1	**GENERAL AND ADMINISTRATIVE INFORMATION**
PART 2	**FINAL SAFETY ANALYSIS REPORT (FSAR)**
Chapter 1	Introduction and General Description of Plant
Chapter 2	Site Characteristics
2.1	Geography and Demography
2.2	Nearby Industrial, Transportation, and Military Facilities
2.3	Meteorology
2.4	Hydrology
2.5	Geology, Seismology, and Geotechnical Engineering
Chapter 3	Design of Structures, Systems, Components, and Equipment
Chapter 4	Reactor
Chapter 5	Reactor Coolant and Connecting Systems
Chapter 6	Engineered Safety Features
Chapter 7	Instrumentation and Controls
Chapter 8	Electric Power
Chapter 9	Auxiliary Systems
Chapter 10	Steam and Power Conversion System
Chapter 11	Radioactive Waste Management System
Chapter 12	Radiation Protection
Chapter 13	Conduct of Operations
Chapter 14	Verification Programs
Chapter 15	Transient and Accident Analyses
Chapter 16	Technical Specifications
Chapter 17	Quality Assurance and Reliability Assurance
Chapter 18	Human Factors Engineering
Chapter 19	Probabilistic Risk Assessment and Severe Accident Evaluation
PART 3	**ENVIRONMENTAL REPORT**
Chapter 1	Introduction
Chapter 2	Environmental Description
Chapter 3	Plant Description
Chapter 4	Environmental Impacts of Construction
Chapter 5	Environmental Impacts of Station Operation

A P P E N D I X 4

Table of Contents for a COL Application

Section	Title
Chapter 6	Environmental Measurements and Monitoring Programs
Chapter 7	Environmental Impacts of Postulated Accidents Involving Radioactive Materials
Chapter 8	Need for Power
Chapter 9	Alternatives to the Proposed Action
Chapter 10	Environmental Consequences of the Proposed Action
PART 4	**TECHNICAL SPECIFICATIONS**
PART 5	**EMERGENCY PLAN**
PART 6	**LIMITED WORK AUTHORIZATION (LWA)/Site Redress Plan** – if applicable
PART 7	**DEPARTURES REPORT (VARIANCES & EXEMPTIONS)**
PART 8	**SAFEGUARDS/SECURITY PLANS**
PART 9	**NON-PUBLIC INFORMATION** - if applicable
PART 10	**LICENSE CONDITIONS AND INSPECTION, TESTS, ANALYSES AND ACCEPTANCE CRITERIA (ITAAC)**
PART 11	**REFERENCE MATERIAL**

A P P E N D I X 5

Compliance Scorecard- DOE Notice of Financial Assistance Award DE-FC07-05ID14635

On March 31, 2005, the United States Department of Energy (DOE) awarded Dominion Nuclear North Anna, LLC (DNNA) financial assistance in the form of a cooperative agreement to facilitate a COL demonstration project to further the development of new nuclear plants and to take such actions as may be necessary to lead to a decision by Dominion on whether to build a new nuclear power generation unit at the North Anna Power Station near Mineral, Virginia. The agreement included a number of requirements; this "scorecard" is intended to aid in the assessment of compliance with the requirements.

Scorecard Completed By: ____ Organization: ____

Date (MM/DD/YYYY): ___________

Requirement	**Reference**	**Responsible Party**[1]	**Completed? Y/N**	**Proficiency (5= Highly Proficient; 1= Not Proficient)**	**Comments**
Completion of Responsibilities					
Define approaches/plans, submit plans to DOE for review, and resolve DOE comments	*Part V, 8(b)1	DNNA			
Review and concur with project work plans and deliverables within 30 days after receipt	*Part V, 8(a)1	DOE			

APPENDIX 5

Requirement	Reference	Responsible Party[1]	Completed? Y/N	Proficiency (5= Highly Proficient; 1= Not Proficient)	Comments
Manage and conduct the project activities, including providing the required personnel, facilities, equipment, supplies and services	*Part V, 8(b)2	DNNA			
Coordinate with DOE management and operating contractors on activities THAT may be performed under their contracts that are related to the project	*Part V, 8(b)3	DNNA			
Conduct program review meetings	*Part V, 8(a)2	DOE			
Attend program review meetings and report project status	*Part V, 8(b)4	DNNA			
At the annual project review meetings, provide progress status/issues and present the detailed work plan/budget requirements for the following year	*Part V, 8(b)4	DNNA			
Participate in DNNA progress meetings and conference calls	*Part V, 8(a)2	DOE			

APPENDIX 5

Requirement	Reference	Responsible Party[1]	Completed? Y/N	Proficiency (5= Highly Proficient; 1= Not Proficient)	Comments
Submit technical project deliverables and resolve DOE comments	*Part V, 8(b)5	DNNA			
Notify DOE when decision is reached to proceed from Phase 1 to Phase 2 of project	*Part V, 8(b)6	DNNA			
Ensure the intended results are achieved from this nuclear power plant licensing demonstration project	*Part V, 8(a)3	DOE			
Promote and facilitate technology transfer activities, including dissemination of program results	*Part V, 8(a)4	DOE			
Collaborate to jointly develop the DOE Interface and Oversight Agreement to implement the principles of DOE Order 413.3	*Part V, 8(a)5 *Part V, 16	DOE/DNNA			

APPENDIX 5

Requirement	Reference	Responsible Party[1]	Completed? Y/N	Proficiency (5= Highly Proficient; 1= Not Proficient)	Comments
Include an acknowledgement of federal support and a disclaimer in the publication of any material, copyrighted or not, based on or developed under the project	*Part V, 11(b)	DNNA			
Obtain a yearly audit from an independent auditor in accordance with the requirements in 10 CFR 600.316 (applies for each year DNNA expends $500,000 or more in a year under federal awards)	*Part V, 20	DNNA			
Obtain any required permits and comply with applicable federal, state, and municipal laws, codes, and regulations for work performed under the award	*Part V, 12	DNNA			
Comply with intellectual property provisions applicable to the award	*Part V, 13	DNNA			

APPENDIX 5

Requirement	Reference	Responsible Party[1]	Completed? Y/N	Proficiency (5= Highly Proficient; 1= Not Proficient)	Comments
Obtain DOE approval in advance of changing designated key personnel or participating organizations	*Part V, 18	DNNA			
Obtain DOE approval on all subcontracts or subagreements associated with the award with a value greater than $5 million, including all options and/or modifications thereto	*Part V, 21	DNNA			
Submit continuation application documents at least 90 days before the end of any budget period	*Part V, 14(a)	DNNA			
Adhere to the lobbying restrictions described in the award document	*Part V, 15	DNNA			
Manage confidential or proprietary business, technical or financial information in accordance with the Trade Secrets Act	*Part V, 22	DOE			

APPENDIX 5

Requirement	Reference	Responsible Party[1]	Completed? Y/N	Proficiency (5= Highly Proficient; 1= Not Proficient)	Comments
Process any request for release of confidential or proprietary business, technical or financial information consistent with the Freedom of Information Act and DOE FOIA regulations	*Part V, 22	DOE			
Submit deliverables in a timely manner (i.e., in accordance with the schedule established in the award)	*Part III	DNNA			
Meet or exceed Cooperative Agreement time milestones	*Part III	DNNA/DOE			
Fulfillment of Cooperative Agreement Objectives					
Prepare and submit the ESBWR design certification application	*Part III	GEH via DNNA before 4/1/2007; GEH after 4/1/2007			

APPENDIX 5

Requirement	Reference	Responsible Party[1]	Completed? Y/N	Proficiency (5= Highly Proficient; 1= Not Proficient)	Comments
Obtain NRC design certification for the ESBWR	*Part III	GEH via DNNA before 4/1/2007; GEH after 4/1/2007			
Prepare and submit a COLA for the ESBWR at the North Anna site	*Part III	DNNA			
Obtain NRC approval of the COLA	*Part III	DNNA			
Complete the ESBWR standardized and site-specific design and other site-specific engineering	*Part III	GEH (technology) and DNNA (site-specific)			
Develop the business case necessary to support a decision on building a new nuclear power plant	*Part III	DNNA			

*DOE Notice of Financial Assistance Award, North Anna Construction and Operating License Demonstration Project, Instrument Number DE-FC07-05ID14635, Revision A001

[1]DOE= U.S. Department of Energy; DNNA= Dominion Nuclear North Anna, LLC; GEH= General Electric-Hitachi Nuclear Energy, Inc.

APPENDIX 5

Please provide general comments on the North Anna COL Demonstration Project (What worked well? How might the process be improved? How successful was the project in advancing the goals of the NP 2010 program?)

Appendix B:

NuStart Energy Development, LLC. NP 2010 COL Demonstration Project Report

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Department of Energy

Nuclear Power 2010 Program

NuStart Energy Construction and Operating License Demonstration Project

Cooperative Agreement DE-FC07-05ID14636

Final Report

6/27/2012

Table of Contents

Purpose of the Project Participants' Reports and General Guidelines

The purpose of this report is to discuss the status, performance and experiences gained while implementing NuStart Energy Development, LLC's (NuStart) Construction and Operating License (COL) Demonstration Project under the Department of Energy's (DOE) Nuclear Power 2010 (NP2010) Program.

For this report, NuStart is following the outline provided by the DOE. NuStart understands that DOE will use the information and data from each of the four participants' reports, two utility COL projects and two reactor vendor design certification and design finalization projects, plus follow-up interviews of key personnel, as appropriate, to form the basis of an integrated Department's NP2010 Construction and Operating License (COL) Demonstration Project Close-out Report. This report approach is similar to that used on the Early Site Permit Demonstration projects. NuStart further understands that each of the industry participants will have an opportunity to review and comment on the department's integrated COL report prior to issuance.

The following sections include questions that have been provided by DOE to help identify specific information that the Department believes important. NuStart has incorporated language from the DOE report guidelines, shown in italics, to aid compliance with the Department's request.

I. Executive Summary

This report provides a final summary of the status, performance, and lessons learned to date for the NuStart Construction and Operating License Demonstration Project (Cooperative Agreement DE-FC07-05ID14636) under the DOE's NP2010 program. NP2010 was initiated in 2002 and is a joint government-industry effort intended to support the near term deployment of new nuclear plants.

NuStart is a consortium of ten industry utility members and two reactor vendors created in 2004 which was selected to receive an award from DOE under NP2010. Under the cost-shared, cooperative agreement arrangement with DOE, NuStart's two main objectives are to 1) demonstrate the untested regulatory processes associated with 10 CFR Part 52 by obtaining a Construction and Operating License (COL) from the Nuclear Regulatory Commission (NRC) and 2) support the standardization and finalization of selected reactor vendor technology designs.

The NP2010 Program has exceeded the expectations of the industry. NuStart has meaningfully contributed to the success of NP2010 as indicated by the following:

- NuStart formed the AP1000 Design Centered Working Group to further the NRC's new "one issue, one review, one position" standardization approach to reduce costs, resource needs, and schedule impacts for both the NRC and applicants. The NuStart approach was held by the NRC as the model for other reactor technologies to emulate and led development of the form and content of COL applications.
- A key concern of the industry on nuclear projects has been the uncertainty of the NRC regulatory process. As a result of experience with the reference COL applications (such as the AP1000 R-COLA) obtained through NP2010, the risk of that regulatory process has been reduced and to date, 18 COL applications have been submitted to and accepted by the NRC.
- NuStart has achieved its program objectives on schedule, paving the way for the initial four U.S. based AP1000 reactors in 2016-2019 (two each at NuStart member's Southern Vogtle and SCANA Summer sites).
- DOE's cost share at $41 million of the NuStart specific scope's total $125 million spending to date has resulted in a 33% matching rate rather than the program target 50% due to additional investment by industry. The $125 million does not include investments made by individual NuStart members for their company-specific COL projects. Inclusion of these costs would indicate even further leveraging of the DOE cost share.
- NuStart has strongly encouraged design and licensing standardization among its members and the reactor vendors to improve designs, reduce costs, and reduce time to market.
- Working with NEI and NRC, NuStart has helped to establish review processes and procedures needed to make Part 52 implementation a reality.

NuStart also has some “lessons learned” that may be of use to future DOE programs:

- Goal alignment early on is critical to the various stakeholders working together well in the long term and showing the flexibility and will to overcome unexpected challenges.
- Cost sharing at a meaningful level is essential to that goal alignment. Awardees must have significant “skin in the game”.
- Carefully written award Part III scopes are important elements for goal alignment. This was especially important as the original NuStart and Dominion NP2010 awards were restructured to break out the reactor vendors into separate awards. This led to less cooperation between NuStart and the reactor vendors that was overcome largely on the strength of the revised Part III scopes and implicit sanctions from the DOE for failure to perform.
- DOE should consider structuring its future award funding distributions to achievement of program milestones rather than a simple matching of industry investment. The Program encountered a problem with a reactor vendor who was reluctant to continue performance on DOE objectives once DOE funding had been exhausted.
- DOE can take on a substantial role as liaison between industry and the NRC on matters such the need for cost and schedule information from the NRC to program awardees.

Without NP2010, industry would have been unable to respond as quickly to incentives in the Energy Policy Act of 2005 and would be less prepared for a nuclear renaissance. Had it not been for low priced shale derived natural gas and a lack of a national energy policy, particularly with respect to carbon emissions, that renaissance would likely be much more active than it appears to be today. However, because of NP2010, industry is better prepared to advance new nuclear generation, should the nation call on us to do so.

II. <u>Introduction</u>

The purpose of the Nuclear Power 2010 COL Demonstration projects was to conduct a pilot demonstration of the previously unused Construction and Operating License (COL) application and review process under regulation Title 10 Part 52. Under these projects, the industry recipient implemented a plan to obtain NRC approval and issuance of a COL for an advanced nuclear power plant. The demonstration projects involved initiating a COL for a new, standardized reactor technology at a specific reference site, thereby simplifying the licensing process for subsequent COL applicants. In addition, the original scope also included the certification of the selected nuclear plant design and completion of the First-of-a-Kind Engineering (FOAKE) for a standard plant. This scope of design certification and design Finalization (FOAKE) was later removed from the COL projects into separate reactor vendor projects.

This report provides a final summary of the status, performance, and lessons learned to date for the NuStart Energy Construction and Operating License Demonstration Project (Cooperative Agreement DE-FC07-05ID14636) under the DOE's NP2010 program.

The NP2010 program, announced in 2002 to support the deployment of new nuclear plants, is a cost shared, joint government-industry effort intended to identify sites for new nuclear power plants, develop and bring to market advanced nuclear plant technologies, and demonstrate the untested regulatory processes associated with 10 CFR Part 52. The accomplishment of these program objectives is designed to pave the way for the near-term construction of new advanced light water reactor nuclear plants in the United States, leading to increased energy independence, energy diversity, and cleaner air.

The NuStart LLC is currently comprised of ten utility companies (Detroit Edison, Duke Energy, EDF International North America, Entergy Nuclear, Exelon Corporation, Florida Power & Light Company, Progress Energy, SCANA Corporation, Southern Company, and Tennessee Valley Authority). The NuStart consortium includes NuStart LLC and two reactor vendors (GEH and Westinghouse). Both NuStart LLC and the NuStart consortium were created in 2004 for the purposes of 1) demonstrating the untested licensing process by obtaining a COL from the NRC and 2) supporting the standardization and finalization of the selected reactor technology designs. The consortium approach allows cost and risk to be spread over multi-companies while promoting industry standardization, sharing, and cooperation. The organizational structure of NuStart is laid out in detail in NuStart Project Instruction PI-001 – the NuStart Energy Organization Plan, which established the organizational framework necessary for the day-to-day management and operation of NuStart. Please refer to Appendix I (NuStart PI-001 - Figure PI-001-1) and Appendix II (NuStart PI-001 - Figure PI-001-2) to see NuStart's organization charts.

III. COL Demonstration Project

This section documents the goals, objectives, activities and events of NuStart's COL Demonstration project from development stages through successful NRC COL application submittal and post-submittal activities. It provides a comprehensive summary of the demonstration project addressing accomplishments, cost, schedule, and other pertinent factors per the Federal Assistance Reporting Checklist and Instructions (DOE form F 4600.2) in addition to answering specific questions itemized below.

It considers the entire duration of the COL Demonstration project, discusses reactor vendor involvement, including the transition to a separate cooperative agreement, and changes in lead COL reference application plant.

Questions on Construction and Operating License Demonstration Project

1. NP2010 COL Demonstration Project Purpose & Achievements

Describe how your project supported, achieved or otherwise satisfied the primary goals and objectives of the Nuclear Power 2010 program that you were expected to accomplish. Please address the following additional questions in your description. Include solutions to issues raised under the section "Lessons Learned".

a. *In your opinion, did the purpose of the NP2010 Program COL Demonstration projects satisfy a clear need or shortcoming in the nuclear community? Were the NP2010 program goals and objectives satisfied by the activities and results of the COL Demonstration projects?*

The NP2010 Program exceeded the expectations of the industry. Prior to the NP2010 Program, the regulatory uncertainty associated with licensing a new nuclear plant was viewed as one of the top risks facing a nuclear investment. This risk has been mitigated somewhat because of the work performed by the various parties under the NP2010 Program. To date, 18 COL applications have been submitted to and accepted by the NRC. Further, the NRC has published and maintained milestone schedules for the individual licensing actions.

The NP2010 Program prompted the formation of NuStart, a special purpose entity established to respond to the solicitations offered by the NP2010 Program. NuStart created the motivation, forum, and infrastructure that resulted in unprecedented industry cooperation and landmark achievements in the area of new plant licensing. The work done under the NP2010 Program positioned the industry to respond promptly to the incentives set forth in the Energy Policy Act of 2005.

Overall, the activity on new plants is far greater than what was envisioned when the NP2010 Program was envisioned. One of the goals of the NuStart consortium was to demonstrate the new licensing process by obtaining a COL. It was hoped that within a few years of receipt of the reference COL, members would use their NuStart experience to prepare and submit their own COL applications. The actual scenario is that NuStart members and other applicants submitted follow-on applications within months instead of years after the first application. Much of this timing is attributable to the eligibility dates contained in the Energy Policy Act for certain financial incentives.

NuStart's commitment to design standardization and the associated approach for developing a reference COL application prompted the NRC to develop the Design Centered Working Group (DCWG) concept. This concept endorses the notion of "one issue, one review, one position." The NuStart approach of insisting not only on technical design standardization, but standardization of the associated licensing documents that reflect the design has resulted in regulatory efficiencies not anticipated by the industry.

b. *What specific and existing problems, interests, and/or needs did the COL demonstration projects and NP2010 as a whole address? Are there outstanding industry issues, problems or barriers to nuclear plant deployment that should have been addressed through the program?*

The fundamental basis for the regulatory uncertainty was that the Part 52 licensing process was untested. Accordingly, one of the NuStart objectives was to demonstrate the process by preparing and submitting a COL application. In parallel with the industry work to prepare the application, NuStart worked through NEI to participate in the NRC development of the associated guidance and rulemaking for the new process. The need for consistency of public policy between industry and NEI is vital for discussions with government.

NuStart led the industry in developing the form and content of a COL application. NuStart shared this information with applicants of other technologies so as to ensure a common approach. Specific deliverables from NuStart under the NP2010 Program include:

- Introduced the concept of a Standardization Matrix where each subsection of the COLA was dispositioned as one of the following: Incorporate by Reference from DCD, Standard among all applicants, Standard with some site-specific, or Site Specific. This document continues to serve as the governing document for various strategic licensing decisions. The Standardization Matrix is used by each NuStart member for the ESBWR and AP1000 designs, UniStar for the US EPR design, and Mitsubishi for the APWR design.
- Developed the Writers' Guide which established the form and content of the COL application as well as the notations necessary to facilitate the NRC review under the Design Centered Review Approach. The Writers' Guide has been used by each NuStart member for the ESBWR and AP1000 designs, UniStar for the US EPR design, and Mitsubishi for the APWR design.
- Developed NuStart Task Plans for Site Selection, COLA Development, and Quality Assurance.
- Developed detailed NuStart Project Instructions to address the procedures for development of the R-COLAs. Example areas covered by Project Instructions include:
    - COLA Review Process
    - Change Control for COLA Information
    - DCD and COLA Configuration Management
    - RAI Response Processing
    - Records Management
    - Document Control Practices

In addition to the COL work, the NuStart consortium served as the forum for utilities to provide design input to the reactor vendors. This forum provided an efficient and effective mechanism to tap into the extensive operational experience of the utilities. On occasion, NuStart provided senior reactor operators and other subject matter experts to the vendor facilities to provide requested input. The focus of the NuStart Engineering Team was that the design be standard, and that it reflect the lessons learned from the current operating fleet. The NuStart Licensing Team provided a consistent review of the regulatory impact of the emerging designs, and provided in depth review of the vendors' DCD submittals. NuStart received very favorable comments from the NRC regarding the coordination between the DCD and the R-COLA and between the R-COLA and the S-COLAs. This coordination contributed to review efficiency by the NRC staff.

The NP2010 Program stopped short of construction which would have further addressed the handling of design changes during construction and provided a full demonstration of the ITAAC process.

An area that remains as a potential barrier to nuclear plant deployment is the demonstration of economic viability for the construction of a new plant in a de-regulated market. In addition to licensing and construction costs, low natural gas prices and carbon legislation issues are factors that will impact whether new nuclear plants can be economically competitive.

c. *Describe any flaws in the COL demonstration projects or the NP2010 program design that may have limited the program's effectiveness or efficiency. Include in the Lessons Learned section with proposed solutions.*

The difficulties in licensing the initial wave of new plants are to be expected given that the industry and staff are working through Part 52 for the first time. Because of the industry commitment to standardization, most of the challenges should be one-time occurrences. The Bipartisan Policy Center examined the licensing process and concluded that all parties are acting appropriately and in good faith to resolve any problems. Please refer to Appendix III (BPC Letter from Meserve to Jaczko dated April 6, 2010) for more detail.

The reactor vendors struggled with understanding the level of detail required by the NRC to support a DCD review. Ultimately, the NRC staff needs were satisfied, but in many cases, this required iterations of submittals. Subsequent DCD applicants benefitted from the work done by GEH and Westinghouse in establishing expectations regarding level of detail.

The other difficulty is the continuing changes to the reactor design and their impact on the pending NRC approval of the DCD and COLAs. This is most relevant to the AP1000 design which is significantly further along with the design finalization effort. Although a path forward has been developed by NuStart and Westinghouse, the number of post COL changes is higher than what was anticipated. Nevertheless, it is still preferable to address the majority of design changes early in the development process as opposed to resolving them during the construction phase.

Regarding implementation of the NP2010 Program, noted opportunities include the implementation of the award restructuring and the pacing of vendor funds. Each of these is discussed in the sections below.

d. *Were the COL Demonstration projects and/or NP2010 program appropriately structured to efficiently address the program's purpose and goals? How could program resources have been more effectively targeted to achieve needed results?*

The program resources were appropriately structured. An opportunity for improvement exists with the timing of disbursement of the vendor funds. When the program was established, each vendor provided an estimate of total project cost. This formed the basis for the DOE long term budget request. The plan was to disburse DOE funding at a 50% cost share level throughout the completion of the vendor work. However, the actual vendor spend rate was higher than expected and costs associated with both design certification and design finalization are significantly higher than those estimated. The result is that DOE funding was exhausted before the vendors completed their respective scope of work. For the Westinghouse project, this does not appear to be an impact because Westinghouse is continuing with project completion at its own expense. It is unclear to NuStart at this point when GEH will complete the design finalization of the ESBWR. A program improvement would have been to pace the disbursement of the vendor funds so as to ensure commitment by the vendors to compete the planned scope of activities.

e. *How effective is the use of a "cooperative agreement" approach involving cost-shared arrangements between DOE and industry versus a contract or grant?*

The use of a cooperative agreement was an acceptable approach and most likely avoided unnecessary administrative burdens associated with either a contract or a grant. However, the DOE restructuring of the initial awards to NuStart and Dominion to establish separate awards to NuStart, Dominion, GEH, and Westinghouse did more harm than good. The intent of the award restructuring was to further lessen the administrative burden of Dominion and NuStart by having the DOE directly award funds to GEH and Westinghouse. The restructuring was not intended to impact the working relationships between the utilities and the reactor vendors; however, this was an unintended consequence. GEH leadership at the time of the restructuring misinterpreted the restructuring as relieving them from accountability to NuStart and Dominion. Additional effort was required to ensure that GEH provide necessary reporting metrics so as to monitor progress. Current GEH management is supportive of the need to share status information with the utilities.

2. Project Execution

Provide a complete description of each phase of your COL demonstration project from development of the COL application through submittal to the NRC and the review process to date. Identify continuing tasks and expectations if the COL Demonstration project is not complete at the time the report is submitted. Upon completion of the project or end of the cooperative agreement activities, an addendum or update will be provided addressing any further activities or accomplishments since the initial report. Discuss the major activities undertaken at each stage and significant results achieved. Address key accomplishments in terms of the program's goals and objectives. Please address the following additional questions in your description.

The fundamental objectives of the DOE's NP2010 program were to demonstrate the regulatory process for licensing new plants and to complete the final design for the selected reactor vendor technologies. The accomplishment of these program objectives will facilitate the construction of advanced, light-water reactor nuclear plants in the United States. Construction of new nuclear plants would address increasing concerns over air quality and climate change, reduce the supply pressures on natural gas and other energy sources, and provide a source of plentiful, reasonably priced, dependable and low carbon energy to supplement the current baseload capacity.

NuStart's key accomplishments in support of the NP2010 program objectives include:

- Receipt of the AP1000 reference COL by Southern Nuclear Company for Plant Vogtle Units 3 & 4 on February 10, 2012
- The development, submittal, and acceptance of COLAs by the NRC for both reactor vendor technologies
- Significant cooperative process development with the NRC on the DCWG and review procedures
- A relative cost share amount by the DOE of less than 50% for NP2010 scope items, demonstrating financial commitment to the project
- DCD support provided to keep COL issuance on schedule
- Performing reviews and other analysis necessary to support design standardization and finalization

Please refer to the monthly or quarterly progress reports submitted to DOE for more detail on specific project issues and accomplishments.

a. *Provide a brief summary of the history of your participation in the NP2010 program with significant milestones and current project status.*

DOE Award milestones and scheduled completion dates are summarized below. The milestones reflected below are as shown in Part III of the NuStart Cooperative Agreement. Effective with DOE Award Amendment A017 milestones 31-35 have been superseded and milestones 36-59 have been added to the table, replacing existing milestones. Per discussion with the DOE milestone 54 was removed. Historical milestones can be viewed in previous monthly progress reports issued to the DOE.

Award MS	Milestone Description	Target Completion Date	Scheduled Completion Date
1	GE Submit ESBWR Design Certification Application	8/24/05	8/31/05A
2	Project Review Meeting with DOE senior management prior to end of CY 2005 to be held in Washington, DC area	12/31/05	1/20/06A
3	Westinghouse receives AP1000 Design Certification	12/31/05	12/30/05A
4	COL Preparation Contractor(s) Selected	12/31/05	11/17/05A
5	Records Management Program Multi-year Work Plan Developed	12/31/05	12/31/05A
7	DOE Acceptance of the Cost and Schedule Performance Baselines	12/16/05	11/18/05A
8	Complete DOE external Independent Review of the Cost and Schedule Performance Baselines	4/3/06	12/9/2008A
9	Final DOE concurrence on the Cost and Schedule Performance Baselines	7/7/06	12/9/2008A
10	Complete Royalty Agreements between Reactor Vendors and DOE	9/39/06	Removed from Project Scope
11	Design Selected for the COL Application Submittal to NRC	1/31/08	Removed from Project Scope

12	Construction Decision for the Selected Design	1/31/08	Removed from Project Scope
13	Construction decision review meeting with DOE senior management to be held in Washington, DC area	Target CY 2008	Removed from Project Scope
14	Rx Vendors Submit Comments on Construction RFP	2/15/07	GE – 2/15/07A WEC – 2/23/07A
15	NRC Inspection of COLA Prep QA Program	2/28/07	7/30/07A
16	ESBWR DCD Rev 3 (Less CH 19) Submitted to NRC	2/28/07	2/22/07A
17	ESBWR DCD Rev 3 Notification of Submittal to NRC	3/2/07	3/2/07A
18	ESBWR DCD Rev 3 CH 19 Submitted to NRC	4/30/07	4/30/07A
19	WEC Submits Electronic AP1000 DCD Rev 15	3/15/07	4/27/07A
20	WEC Submits 4 Tech Reports to NRC	3/30/07	3/30/07A
21	AP1000 COL NRC Inspection of the Application Preparation Q. A. Program	8/31/07	8/3/07A
22	AP1000 Design Control Document Departures Report Completed and to The DOE for Review	8/28/07	8/28/07A
23	AP1000 Seismic Source Characterization and Ground Motion Analysis Complete And Draft to DOE.	5/24/07	8/28/07A
24	AP1000 Final Draft FSAR to NuStart Members for Integrated Review	9/30/07	8/28/07A
25	AP1000 Final Draft ER to NuStart Members for Integrated Review	9/30/07	8/28/07A
26	ESBWR COL NRC Inspection of the Application Preparation Q. A. Program	8/31/07	9/14/07A
27	ESBWR Final Draft FSAR to NuStart Members for Integrated Review	10/31/07	11/26/07A
28	ESBWR Final Draft ER to NuStart Members for Integrated Review	10/31/07	11/26/07A

29	COL Application Submitted to the NRC	1/31/08	AP1000 – 10/30/07A ESBWR – 2/27/08A
30	GE ESBWR Design Certification Granted	6/30/08	Removed from Project Scope
31	COL Granted	6/30/11	Superceded by A017
32	COL License Transferred as Applicable	9/30/12	Superceded by A017
33	Phase 1A PSER and RAIs Complete	8/29/08	Superceded by A017
34	EIS Phase 1 Scoping Complete	9/10/08	Superceded by A017
35	SR Phase 1B Draft Input Complete	11/6/08	Superceded by A017
36	VEGP (Vogtle Electric Generating Plant) LOLA (Loss of Large Area) Security Submittal	5/29/09	5/29/09A
37	VEGP Cyber Security Submittal	7/31/09	7/31/09A
38	Complete R-COLA Transition Agreements	7/31/09	7/24/09A
39	NUPIC (Nuclear Procurement Issues Committee) Audit of WEC – NuStart Support	7/31/09	7/31/09A
40	NUPIC QA Audit of NuStart	9/30/09	10/15/09A
41	TVA Completion of Hydrology Work on Violations from QA Inspection of Hydrology Modeling	12/31/09	12/31/09A
42	Complete R-COLA Transition to VEGP & Transfer of NuStart BLN Data to TVA	1/08/10	1/08/10A
43	NRC Issues VEGP SER (Safety Evaluation Report, the standard content carrier) with Open Items	2/26/10	12/2/10A
44	Resolve WEC DCD (Design Control Document) Open Items	3/15/10	11/23/10A
45	ACRS Sub-committee Review of SER with Open items Complete	3/31/10	12/16/10A
46	PwC Audit of NuStart for Calendar Year 2009	3/31/10	5/3/10A

47	Resolve All COLA Standard Content Open Items	4/15/10	12/2/10A
48	"Standard Content" Departure Report (#6)	2/6/11	1/31/11A
49	VEGP Advanced SER (No Open Items)	10/25/10	12/2/10A
50	AP1000 DCD Final SER	12/27/10	8/5/11A
51	"Standard Content" Departure Report (#7)	12/30/10	12/14/11A
52	PwC Audit of NuStart for Calendar Year 2010	3/31/11	6/24/11A
53	R-COLA Final SER Issued	4/12/11	8/9/11A
55	AP1000 DCD Rule Issued	8/18/11	12/30/11A
56	VEGP EIS Final	9/30/11	3/18/11A
57	VEGP COL Issued	10/31/11	2/10/12A
58	PwC Audit of NuStart for Calendar Year 2011	6/29/12	5/15/12A
59	NuStart Closeout Completed	6/29/12	6/30/12

b. *Outline the significant obstacles faced in developing the COL application and related design certification, particularly with regard to budget and schedule.*

During the development of the COL Application, NuStart ran into several obstacles that challenged the schedule and the budget. The most notable was outdated NRC guidance. This was recognized early on by the industry and the NRC; however, the development of guidance such as RG1.206 required significant effort. Essentially, there was a dual path effort where NuStart was developing the application while working with the NRC on development of RG 1.206. While NuStart could have been more efficient by waiting for the guidance to be completed, the schedule could not support that approach. Therefore, NuStart developed the application in parallel using industry expertise combined with Draft Guidance (DG-1145) from the NRC. This DG was an early draft of the RG1.206 document and governs the content of DCD/COL applications. The final working draft of RG1.206 was issued approximately 6 months prior to the application being submitted. Because of this work around, NuStart naturally encountered some areas of rework. The initial scoping and contract with the COLA contractor did attempt to factor in the evolving regulatory environment; however, this factor ultimately did not account for the total budget impact.

Another obstacle faced in the development of the COLA had to do with work associated with the Environmental Report. The original Environmental Report assumptions were built around the licensing basis of Units 1 & 2 at Bellefonte. The COLA contractor had planned to use much of this information with few exceptions, thus requiring limited new effort. Expectations and regulatory guidance changes over time combined with limited back up information required additional work in order to complete the COLA, impacting both project costs and schedule.

c. *Discuss the COL review process and your interaction with the NRC. Include a discussion of the "design centered working group" and "reference COLA" approach.*

Within NuStart, two DCWGs were represented. The ESBWR DCWG included Entergy, Exelon, and Detroit Edison as COL applicants, joined by the Dominion team (not part of NuStart). By coincidence, all of the applicants for AP1000 combined license applications had joined NuStart by 2005. As part of the original organization of the NuStart AP1000 licensing team, each of the associated utility members was represented on the DCWG.

The number of AP1000 applications was significantly larger than that of any other reactor technology. This experience base within the NuStart and AP1000 communities, plus the indicated interest of the AP1000 applicants to work together, resulted in NuStart being prominent in discussions between the new-reactor utilities (via the NEI COL Task Force) and NRC staff. In the latter part of 2005, NEI met with the NRC staff concerning the number of applications the staff was about to receive. In an ongoing quest for increased efficiency of the licensing process, the COL Task Force (represented in large part by NuStart personnel) participated in discussions of a proposed approach to common reviews for similar applications. While the initial reaction at this meeting was mixed, the NRC staff introduced the "one issue, one review, one position" concept and formulated the "design-centered review approach" concept. In May 2006, the NRC Staff issued Regulatory Information Summary 2006-06, New Reactor Standardization Needed to Support the Design-Centered Licensing Review Approach, requesting new plant applicants to declare their intent with regard to standardization of COL applications.

The NRC staff's DCRA was intended to promote use of "one issue, one review, one position" to maximize review efficiency in all applicable situations. Conceptually, a single technical review for each design issue could be used to support DC rulemaking along with the numerous, standardized COL applications. Decisions applicable to the R-COLA would be valid for all S-COLAs that referred to the standard. Considerable savings in cost and schedule could be achieved by S-COL applicants using a high degree of standardization, thus encouraging the adoption of the standardized design and application.

The process was challenged when there was inconsistency in NRC position alignment between reviewers on specific technical issues between the DCD and the COLA reviews. Not having common reviewers sharing a single position and interpretation on a topic during both DC and COL reviews resulted in an inefficient use of NRC and NuStart resources.

Following the issuance of RIS 2006-06, the AP1000 DCWG was quickly formed within NuStart, utilizing a team structure essentially replicating that of the NuStart organization. Since that time, the design-centered approach, and the NuStart AP1000 DCWG in particular, has been held up by the NRC staff as the model of applicant interactions. Prior to issuance of the RIS, NuStart had pioneered the concept of explicit annotations to designate FSAR content as "standard," or identical across all AP1000 applicants, and the concept of "me too" notification letters to NRC staff, confirming the acceptance by each subsequent applicant of responses to NRC requests associated with standard content. One clear indication of the success of NuStart was the seamless transition of the AP1000 reference COLA from Bellefonte to Vogtle. The success of a cohesive DCWG continues today, and is expected to continue by way of common management of standard content and program into the operating phase of the associated reactors.

Early on, NuStart interactions with NRC were frequent and beneficial. Interaction dropped significantly once both sides became involved in specific COLA activities, but has picked up again during AP1000 Licensing Finalization. The drop off was a natural consequence of the period during which intensive reviews were underway, leaving limited NRC staff available to meet and take part in the discussions of topics identified by NuStart. The NRC was not receptive to talking about topics considered to be pre-decisional; NuStart was looking for feedback, which the NRC was not always ready to provide. NuStart believes that the NRC staff's reticence to review Technical Reports (TRs) on the design certification delayed the NuStart schedule by more than one year.

Early communication with the NRC greatly reduced response time on emergent issues. Learning about these topics via NRC electronic requests for additional information (ERAIs) and through Tuesday morning status calls with the NRC enabled the DCWG to learn more quickly about and respond to new issues. Making the ERAI process public and keeping it up to date has been extremely beneficial. Inconsistent application of the process, particularly at NSIR with regard to keeping standard questions on the R-COLA, and with the Environmental staff's refusal to use the system, has introduced some difficulties. Other projects and offices not currently utilizing the ERAI process could benefit greatly from it.

Public meetings and calls were beneficial. The NRC was initially resistant to more interactions, but the meetings allowed all interested parties the opportunity to officially discuss and work through technical issues so that issues could be resolved promptly. Quarterly meetings with divisional Directors were envisioned to provide insight on the areas of concern of the Directors and their staff. Though the meetings did provide beneficial information, they were held only sporadically and did not have the frequency requested by NuStart to truly be valuable by promoting active communications at all levels between the NRC and industry.

The distribution speed of information from the NRC is an area for development. There is a need for a mechanism for when there is information to be transmitted to industry, but not enough information for a full day's meeting agenda. The time it takes for an ISG to be distributed has been an issue. Many of the topics where discussions were requested with the NRC were delayed until the staff was able to put a draft ISG together. A faster method used to issue a draft ISG would start the discussions sooner and could accelerate the resolution of issues.

Despite the need to switch the AP1000 R-COLA, the reference plant approach is working out well for both reference and subsequent plants. Changing the reference plant from TVA Bellefonte to Southern Vogtle was not ideal, and managing the shift entailed some issues, but the move was necessary as the initial choice of reference plant did not support the construction schedule of some S-COLAs. Limitations in NRC resources caused delays to the process when the demand for NRC reviewers exceeded available staff. The rate at which the NRC received submissions of R-COL and S-COL applications may have led to difficulties in reviewer resource planning, challenging the staff's ability to maintain the documented review schedules. A major advantage of the reference plant review approach is that S-COL applicants are experiencing reduced effort and costs for COLA creation and reduced total NRC COLA review fees. Efficiencies and processes demonstrated by the reference plant approach should be applied post-COL and NP2010 (such as for the Small Modular Reactor effort) in order to overcome limited resources and achieve schedule requirements.

d. *What were the difficulties in coordinating the review of a COLA in tandem with the design certification? Discuss the issues and alternative approaches that utilities should consider.*

There were both advantages and disadvantages in coordinating the review of the COLA in tandem with the design certification. The primary advantage was that the COL applicant was able to negotiate with the DC applicant to resolve many COLA issues within the DCD (e.g., elimination of unnecessary COL items and resolution of some programmatic issues). Another advantage was the ability to work with the DC applicant to improve the quality of the DCD to optimize operability and maintainability, and to develop a clear and concise licensing basis for the new unit. Pursuing the DCD amendment in parallel with the COLA allowed COL information items and design changes to be addressed without the considerable costs associated with addressing them in the individual COLAs.

The biggest disadvantage of the COLA and DCD reviews occurring in tandem was the potential for the DC schedule to negatively impact the COLA schedule. Since a COL cannot be issued before the Design Certification, the COL applicant's schedule is completely dependent on the Design Certification schedule. With the reactor vendors no longer sub-awardees to NuStart, the main course of action available to the utilities is to reasonably assist in the resolution and minimization of issues contributing to DC delays. Reactor vendors typically provided the NRC with a minimum of information that would usually prompt the NRC to push for more detail.

Another significant disadvantage of the reviews in tandem was that of COLA configuration management. For a COLA that was incorporating by reference a DCD that was constantly being revised, the sheer volume of work required to maintain awareness of applicable DCD RAI responses and vendor interactions with the NRC on issues of importance to the COL applicant was considerable. This volume of work could have been greatly reduced if the applicant had been dealing with a design of greater maturity.

Some difficulties during the review were the result of NRC resource limitations. Instances when demand for staff reviewers exceeded available resources slowed the process. Inconsistency in NRC position alignment between reviewers on topics between the DCD and the COLA reviews led to conflicting messages and inefficient use of resources. The reviews were impacted by not having common reviewers necessarily taking a single position and a similar interpretation of issues between design and implementation reviews.

e. *Discuss interactions with other stakeholders and their impact on successful execution of the demonstration projects.*

NuStart relied on assistance of its members' government affairs representatives to frequently communicate with members of Congress and their staff regarding the progress of the NP2010 Program and the basis for each year's budget request.

f. *Describe your experience to date during the NRC COLA review process. What level of effort was required to address post-docketing tasks? Was there a need for adjustments to the resources initially designated to these tasks?*

The level of effort required to address post-docketing issues was initially focused on answering a large number of RAIs in a very short period of time. This was complicated by the absolute necessity for all applicants of a particular technology to collaborate on RAI responses since the S-COLAs would ultimately incorporate or endorse most of the R-COLA responses. From a project management standpoint, this process was made more difficult because it had to be accomplished in a "virtual" environment via teleconferences with team members across the country and sometimes across the world, with many participants in different time zones. The level of effort required to support DCWG meetings, NEI working group meetings, NRC public meetings, and NRC site visits and audits was significant and required adjustment of resources to ensure that key team members were available for important face-to-face meetings. In order to manage logistics and to reduce the amount of information that needed to be submitted on the docket, several teams set up "reading rooms" at remote locations where NRC personnel could review pertinent information on a schedule that suited their needs. Contractors had to constantly juggle resources so that key subject matter experts that were working on several different projects could be made available when required.

3. Cost, Schedule and Project Management Controls

Discuss the project management approach used in your project, including interactions with DOE. Address cost and schedule status as required by the federal reporting guidelines, including actual versus budgeted costs and respective cost sharing, milestones, completion dates, and variances. Please address the following additional questions in your description.

Throughout the life of the project, NuStart Management has strived to uphold several key concepts in its approach to project management. Among these was a desire to maintain a high level of flexibility with regards to DOE requirements, requests, and interactions, as well as the ability to quickly adapt to changes in NuStart scope and situation. Further, NuStart strove to maintain an open and collaborative working relationship with all NP2010 participants. Finally, and perhaps most important, was the preservation of goal congruence among the NuStart Member companies and with the Reactor Vendors. These concepts were essential to meeting project goals in a program environment set up with cooperative agreements, especially given the lack of contractual requirements or sanctions.

a. *Describe your experience with the DOE required Earned Value Management System and its effectiveness for this type of project.*

In accordance with NP2010 program requirements NuStart implemented an EVMS system to facilitate appropriate project controls on schedule and cost, including associated reporting to the DOE. In support of the overall EVMS several tools were selected. Specifically, Primavera's P3 (and later P6) scheduling software was chosen to manage the cost and schedule baselines. This software was found to be adequate; however, it was discovered that the program did not properly perform cost escalation. Given this, an extensive database was set up in Microsoft Excel to act in concert with P3 to control NuStart's cost baseline.

i. How was the cost-schedule baseline established?

NuStart's cost and schedule baselines were developed through collaboration of Subject Matter Experts (SMEs) using the NRC's COLA review template. Based on previous experience with Early Site Permits (ESPs) and similar efforts, it was possible to incorporate a high level of detail into the initial COLA preparation phase of the project. The second phase of the project, which encompassed review of the COLAs by the NRC and NuStart's support thereof, was initially less well defined. This was due in large part to the first of a kind nature of the project and use of the NRC's untested Part 52 licensing process.

ii. *Was the work breakdown structure (WBS) adequately defined, and did it provide for effective DOE management control? Should WBS have been defined differently?*

The Work Breakdown Structure (WBS) established by NuStart to document the scope of work managed under the project was well defined to support required DOE reporting and work/cost management. In addition, it provided a framework for the tracking and reporting of the many cost sharing and DOE approved scope changes that were encountered during the course of the project. While the WBS and associated reporting and cost tracking concerns evolved over the course of the project, it is unlikely that the WBS could have been defined in a more efficient manner without foresight of the specific project changes that occurred.

iii. *How effective were the cost control program and its budget tracking activities for reporting budget information? Was the frequency and required level of detail optimal for this type of project?*

Due to the number of internal and external stakeholders, contractual relationships, funding sources, and cost sharing agreements associated with the project, the reporting requirements imposed upon NuStart were extensive. To accommodate that, and in addition to the aforementioned cost database, additional Excel databases were developed to track and control actual cost data and accrual information, budgetary forecasting, and to calculate EVMS data, among others. Those controls saw significant evolution during the life of the project.

With the exception of special reports, NuStart provided monthly and quarterly project status reports, as well as quarterly financial reports to the DOE. This frequency of reporting and the level of detail included was appropriate for the type of project; however, the quarterly project status reports were considered to be somewhat redundant given the monthly reports. Status calls were also provided weekly during periods of peak project activity, and were later reduced in frequency to monthly, which provided a bi-monthly update in combination with DOE's participation in NuStart's Management Committee meetings. Finally, face-to-face reviews were held with DOE every 6 months.

One observation on reporting and the NP2010 program is that the award budget period duration being divorced from the calendar year by one month was an inconvenience, causing the need for reporting on different bases dependent upon the stakeholder. A calendar year basis for award funding would have been preferred.

b. *How effective were the performance measurement baseline (PMB) and the budgeted cost for work scheduled (BCWS), the budgeted cost of work performed (BCWP) and the actual cost of work performed (ACWP) tools for cost and schedule reporting? Was the frequency and required level of detail optimal for this type of project? Discuss your interaction with DOE project monitors, including periodic reporting requirements, meetings, or other such interactions.*

Due to the first of a kind nature of this non-construction project, EVMS was not a particularly useful tool for the project. EVMS variance analysis did provide some indication that specific project activities were deviating from the baseline and that change requests needed to be considered. However, project costs were actually managed using variances to each NuStart Management Committee approved annual budget. EVMS statistics were calculated primarily to satisfy DOE requirements. Additional Excel databases developed by NuStart proved essential to meeting DOE reporting requirements, some of which represented an administrative challenge to the project. Two examples of such challenges stand out:

The first involved a variance between the initially agreed upon DOE cost share of 50% of approved scope and the actual funding available which represented an actual cost share of approximately 34%. At DOE's request both of these sets of numbers were tracked and reported on at both 50% and 100% bases, including variations thereto. Providing this tracking, and accommodating the associated information requests which were numerous throughout the first phase of the project, added to the complexity of both EVMS calculations and reporting.

The second involved a DOE requirement that the project budget not include a management or contingency reserve. Based on this, NuStart was forced to use a series of adjustment factors to apply its contingency funds across project activities based on probabilistic risk, effectively incorporating the reserve into the overall baseline budget. As risks were reassessed over the life of the project, this necessitated that the management reserve be recast and reincorporated into the baseline on a regular basis. This requirement added a level of administrative burden that would otherwise have not been required outside of the NP2010 program.

Additionally, an issue was encountered involving NuStart's relationship with the NRC and the agency's reluctance to provide regular and updated schedule status information. Due to this fact and the sizable percentage of NRC related costs and activities in NuStart's schedule, the accuracy of the EVMS data (and especially the BCWP) associated with NRC activities was challenged. NuStart attempted to compensate for this lack of updates by progressing the schedule as level of effort, using best available information provided by SMEs involved in the review process; however, there were periods during the life of the project that a schedule update was not published by the NRC for over a year.

c. *Please provide a breakdown of your costs for each phase or activity of the demonstration project. Include the application development process, support for application review questions/issue resolution, design certification support, NRC fees, and project management. Provide a comparison of original cost and schedule estimates with the actual project cost.*

NuStart selected the Westinghouse AP1000 and the GEH ESBWR as its preferred technologies. The original strategy was to select a single site and prepare two COL applications for the same site, one for each technology. NuStart would then conduct a down selection process and submit the COL application for the selected technology. This original approach was revised early on in the project to the "two sites, two technologies" approach. Under this revised strategy, NuStart selected a separate site each for each technology, with the intent of preparing and submitting both COL applications. The Site Selection process spanned from approximately November 2004 through its conclusion in February 2006. Ultimately TVA's Bellefonte site was selected for the AP1000 COLA and Entergy's Grand Gulf site was selected for the ESBWR COLA.

Following site selection, Enercon Services, Inc. was selected in March 2006 as the engineering contractor for both COLAs and preparation of both COLAs began. That effort encompassed the majority of work for Phase I of the project. Preparation of the Bellefonte COLA was completed and submitted to the NRC on October 30, 2007 and docketed on January 18, 2008. Preparation of the Grand Gulf COLA was completed and submitted to the NRC on February 27, 2008 and docketed on April 17, 2008. A number of change requests were approved for both COLAs, adding scope and cost. Despite the additions, both COLAs were submitted to the NRC on or prior to their original schedule dates, (though not prior to the revised target submittal date in the case of the ESBWR).

Both COLAs experienced an increase in NRC fees during Phase I due to the NRC's sufficiency review, which was not included in the original budget. Additionally, NuStart incurred substantial NRC fees for the AP1000 due to the review of Westinghouse Technical Reports (TRs) that were processed on the Bellefonte docket. At that time there was no license amendment rule, preventing changes past AP1000 DCD Revision 15. NuStart originally agreed to assume responsibility for TR related costs to allow design changes to continue in pursuit of a final design. However, once the license amendment rule was issued, allowing work on DCD Revision 16, the mounting costs and open ended nature of the TRs led to NuStart's transferring those costs back to the Westinghouse docket.

Effective April 1, 2007, the DOE restructured NuStart's Award to remove the then sub-awardees GEH and Westinghouse, who received their own individual Awards. This was done primarily to streamline the administration associated with the overall effort. While that simplification was realized, it also had side effects in that there were no built in requirements for the Reactor

Vendors to support NuStart. Despite that fact, issues encountered between NuStart and the vendors were not extreme and all NP2010 participants continued to support each other.

A number of changes have impacted the project, both from a schedule and cost perspective. Dominion had originally designated the AECL Advanced Candu Reactor (ACR) 700 as its selected technology; however, it later switched to the GEH ESBWR design. Dominon's North Anna site was eventually designated as the ESBWR R-COLA, primarily in response to DOE funding decisions. This made the Grand Gulf COLA an S-COLA, introducing cost savings, but also schedule dependencies associated with Dominion. Another effect of the designation was that DOE only continued to fund standard content work for the Grand Gulf COLA. This continued through the end of DOE Budget Period 3 (November 30, 2007), after which all Grand Gulf ESBWR COLA work was removed from DOE approved scope.

Dominion and NuStart continued to work closely together with GEH on the ESBWR In December of 2007 NuStart membership saw two changes with the departure of Constellation and the addition of Detroit Edison. One aspect of Detroit Edison's admission to NuStart was that 50% of its capital contributions to NuStart would be shared with Dominion to support funding of common ESBWR related work. In January 2009, Entergy informed the NRC that they were suspending both its Grand Gulf and River Bend COL projects. This decision by Entergy followed a similar decision by Exelon to abandon the ESBWR technology. Eventually, Dominion changed technologies again, leaving Detroit Edison as the sole ESBWR COL applicant, and therefore the designation of the Detroit Edison Fermi application as the ESBWR R-COLA.

Beginning in the second quarter of 2009 and substantially concluding on January 8, 2010, the AP1000 R-COLA was transferred from TVA's Bellefonte to Southern's Vogtle site. This transfer introduced cost savings to the project as NuStart is only supporting the NRC's review of standard content portions of the COLA.

Finally, on February 25, 2010, NuStart officially suspended its ESBWR COLA activities. Detroit Edison continues to pursue a COLA for its Fermi site as the ESBWR R-COLA; however, it is not managed or funded by NuStart. NuStart continues to monitor GEH's ESBWR Design Finalization effort through GEH participation in NuStart Management Committee meetings in support of Detroit Edison's role as the ESBWR R-COLA. Both of these changes represent cost savings to NuStart.

NuStart is currently in Phase II of the project, which involves both supporting the NRC review of the AP1000 R-COLA and Westinghouse Design Finalization. This phase of the project will run through NuStart's projected dissolution date of June 30, 2012.

Project management and licensing support for the NuStart COLAs is supplied by a combination of Excel Services contractors and in-kind support. Additional licensing and engineering support is provided by Enercon on an as needed basis.

NuStart support of Westinghouse AP1000 Design Standardization and Finalization activities spans a period from June 2006 to date. NuStart support of the corresponding GEH activities for the ESBWR spans a period from May 2006 to date. The original budget for both of these activities originally included contracted support; however, this was later revised to include only in-kind services. That support was substantially underreported by the industry and amounts reflected in the table below are not reflective of industry efforts.

NuStart project management, not including management of the COLA projects, is supplied through a combination of contractors and in-kind services. Costs to date total $3.6 million.

As noted above, available DOE funding to cost share NuStart activities is less than the originally envisioned 50%. Additionally, NuStart cost and scope have increased over time, due in large part to changes associated with either support of the reactor vendors' designs or directly related impacts to COLA work. While the majority of those changes were considered to be within DOE approved scope, additional funding from the DOE was not available thus requiring increased industry funding. As reflected in the table below, to date DOE funding of the overall NuStart project cost has been approximately 33%. DOE funding of approved NuStart scope is approximately 40%.

Costs associated with the activities discussed above are provided in Table 1.

Table 1

	Baseline Scope	Final Scope	AP1000	ESBWR	Total
NuStart					
Administration					
Contractor	$ 7,338,687	$ 7,915,065			$ 7,915,065
In-kind	$ 8,977,218	$ 7,661,014			$ 7,661,014
Total Administration	$ 16,315,905	$ 15,576,079			$ 15,576,079
Site Selection & Construction RFP					
Contractor	$ 357,536	$ 1,629,014			$ 1,629,014
In-kind	$ 102,514	$ 300,339			$ 300,339
Total Site Selection	$ 460,050	$ 1,929,353			$ 1,929,353
Phase I - COLA Preparation					
Application Preparation	$ 32,176,858	$ 35,208,535	$ 19,026,937	$ 16,235,764	$ 35,262,701
In-kind	$ 444,386	$ 2,023,287	$ 1,732,274	$ 209,960	$ 1,942,234
NRC Fees	$ 3,180,173	$ 199,961	$ 1,416,437	$ 221,850	$ 1,638,287
Sufficiency Review	$ -	$ 2,086,090	$ 2,086,090	$ 1,355,958	$ 3,442,048
Technical Reports	$ -	$ 5,870,197	$ 5,870,196	$ -	$ 5,870,196
Management	$ 1,893,858	$ 3,213,510	$ 1,849,563	$ 1,530,682	$ 3,380,245
Other	$ 37,270	$ 633,748	$ 301,485	$ 300,000	$ 601,485
Total Phase I	$ 37,732,545	$ 49,235,328	$ 32,282,982	$ 19,854,214	$ 52,137,196
Phase II - COLA Review					
NRC Review Fees	$ 45,745,733	$ 32,213,652	$ 17,576,127	$ 3,135,814	$ 20,711,941
NRC Review Support Costs	$ 8,678,525	$ 11,639,838	$ 7,192,257	$ 2,533,230	$ 9,725,487
NS Cost Share of DCD Review Fees	$ -	$ 4,500,002	$ 4,500,000	$ -	$ 4,500,000
In-kind	$ 443,134	$ 6,673,529	$ 8,547,338	$ 148,751	$ 8,696,089
Management/Other	$ 1,911,856	$ 5,620,193	$ 7,534,731	$ 438,832	$ 7,973,563
Total Phase II	$ 56,779,248	$ 60,647,213	$ 45,350,453	$ 6,256,627	$ 51,607,080
Design Standardization/Finalization					
Contractor	$ 2,143,335	$ -			
In-kind	$ 1,073,850	$ 4,391,821	$ 3,032,952	$ 649,594	$ 3,682,546
Total Design Standardization/Finalization	$ 3,217,185	$ 4,391,821			$ 3,682,546
Total NuStart Specific Costs	**$ 114,504,933**	**$ 131,779,794**	**$ 80,666,387**	**$ 26,760,435**	**$ 124,932,253**
DOE Reimbursement			**$ 36,028,179**	**$ 4,975,574**	**$ 41,003,753**
% Funded by DOE			**44.66%**	**18.59%**	**32.82%**
Reactor Vendors					
GEH	$ 124,301,813	$ 124,301,813	$ -	$ 54,250,467	$ 54,250,467
Westinghouse	$ 402,000,000	$ 402,000,000	$ 104,769,592	$ -	$ 104,769,592
Total Reactor Vendor Costs	**$ 526,301,813**	**$ 526,301,813**	**$ 104,769,592**	**$ 54,250,467**	**$ 159,020,059**
DOE Reimbursement			**$ 52,384,796**	**$ 23,606,710**	**$ 75,991,506**
% Funded by DOE			**50.00%**	**43.51%**	**47.79%**
Total Project Costs	$ 640,806,746	$ 658,081,607	$ 185,435,979	$ 81,010,902	$ 283,952,312
DOE Reimbursement			$ 88,412,975	$ 28,582,284	$ 116,995,259
% Funded by DOE			47.68%	35.28%	41.20%

Notes:

1) NuStart baseline costs are as originally provided in the October 2010 Interim report, Actual costs are as of project completion.
2) Reactor Vendor baseline and actual costs are provided as of the Award Restructure on April 1 ,2007.
3) Total NuStart Specific, Reactor Vendor and Project costs reflect actual costs excluding DOE reimbursements.

d. *Provide project schedule information including planned versus actual for key events and activities in the project. Define the milestones achieved and those that weren't and why.*

Provide the durations and man-hours required for the key activities of the project. Provide a graphical timeline for the project.

From a schedule perspective, there are several key activities that are of particular note. During Phase I, submittal and docketing of the COLAs stand apart as the most significant milestones, originally scheduled for January 31, 2008.

Submittal of the Bellefonte AP1000 COLA took place on October 30, 2007 and was docketed on January 18, 2008. That effort spanned the period May 2006 through January 2008.

Submittal of the Grand Gulf ESBWR COLA took place on February 27, 2008 and was docketed on April 17, 2008. Submittal was delayed due to the late completion of certain COLA sections by GEH, which subsequently delayed review and incorporation of the material by the ESBWR DCWG into the North Anna and Grand Gulf COLAs. That effort spanned the period May 2006 through April 2008.

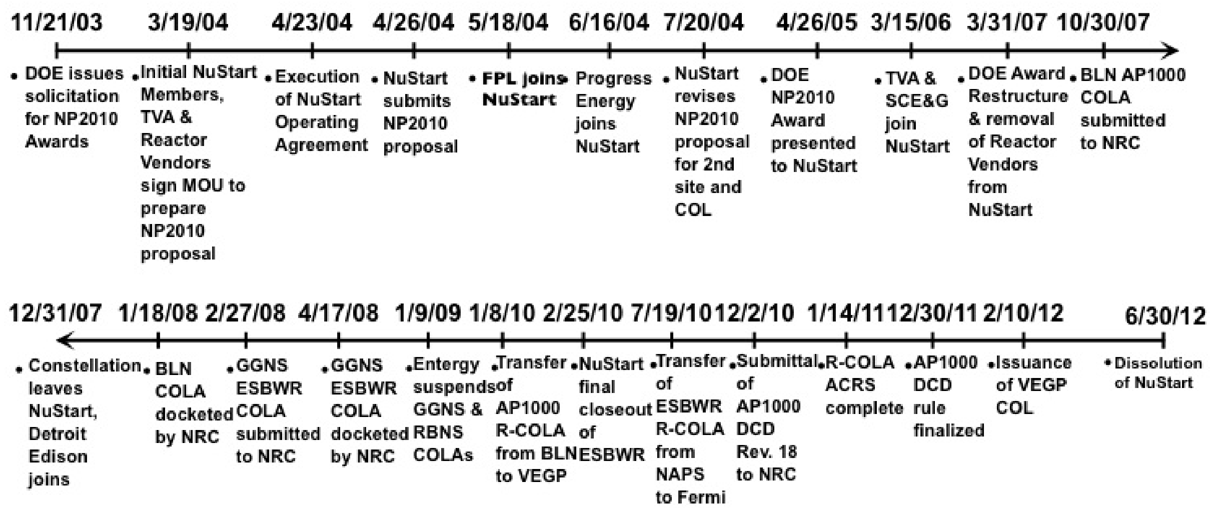
Manhours associated with the activities discussed above are provided in Table 2.

Table 2

	AP1000	ESBWR	Total Manhours
NRC Review Support			
Contractor	1,287,850	126,691	1,414,541
In-kind	24,689	2,193	26,882
Total NRC Review Support	1,312,539	128,884	1,441,423

Notes:
1) Manhours were not consistently reported by all NuStart Members for in-kind support.

The majority of the early milestones within Phase II have been completed as scheduled through the beginning of 2010. In 2010 many of the milestones have experienced slippage due to delays in Westinghouse completion of associated work. Issuance of the Vogtle COL, perhaps the most significant milestone of Phase II, occurred in February 2012. A timeline is provided below.



e. *Elaborate on the primary reasons for major COL revisions and their impact:*

i. *Summarize each COL revision's intent and the reason it was submitted*

ii. *How did these changes impact the COL review schedule?*

iii. *How did changes affect related DC submittals or application schedules?*

iv. *In retrospect, were there any ways to have achieved better schedule results?*

Due to the increased scope of design work from Westinghouse, the number of changes necessary to incorporate the moving target of the DCD into the COLA increased over time. This directly impacted not only the level of effort required on the part of NuStart, but also the frequency of COLA revisions processed and submitted to the NRC. In retrospect, the amount of design work completed by Westinghouse and their interactions with the NRC were less efficient and motivated than desired. Ideally, the design would have been completed prior to development of the COL application.

f. *Discuss the effect of funding variability on the schedule.*

i. *Identify the primary drivers for any major cost increases.*

ii. *How did funding changes impact the COL schedule?*

iii. *What could have been done better?*

g. *Define issues/approaches, including impacts as a result of the reactor vendor, that affected the planned outcome, schedule or costs on the COL Demonstration projects and what if anything should (or could) be done in the future to reduce any negative impact of those issues.*

Overall, the post DCD Revision 15 design work previously mentioned was one of the primary drivers for both schedule delays and cost increases to the NuStart project. Additionally, the design content freeze at DCD Revision 18 had the effect of moving design issues into COL space and transferred the associated costs to the COL applicants. While there were proven benefits and synergies recognized by the simultaneous review of the DCD and COLA, this review also resulted in an increased level of schedule complexity and cost increases.

4. <u>Projected Plant Costs</u>

Discuss how the COL Demonstration project and the associated reactor vendor Design Certification and Design Finalization projects were expected to affect or did affect the forecasted cost of a new nuclear plant. Provide a current estimate of plant costs based on the technology and site within the COL application.

a. *Based on the current status of COL and design certification applications and first-of-a-kind (FOAK) design development, please provide the latest plant construction cost estimates for planned reactors including capital costs, owner's costs, finance costs, etc. A range, bracketed high and low estimates is acceptable.*

b. *Define how the plant cost estimates have changed over the time of COL application processing and what the major contributors were to the cost changes. Address whether the efforts of the NP2010 Licensing Demonstration projects and the reactor vendors Design Certification & Finalization projects had any bearing on the plant cost estimates or the ability to forecast them. Address any lessons and solutions in the "Lessons Learned" section.*

All activities associated with issuing, obtaining, and analyzing an RFP (request for proposal) to determine nuclear power plant construction cost data were removed from the NuStart project scope of work after completion of the initial drafts. This was mainly the result of minimal comments received from the reactor vendors on those drafts, despite an extended period provided to them for such review. Current cost estimates of plant costs, based on proprietary vendor information, are the property of the individual utilities and are not for public report by NuStart.

IV. Overall Lessons Learned and Experience

NuStart understands that DOE is interested in lessons learned on the COL demonstration projects and the overall NP2010 program, particularly in two areas: 1) improvements in the COL and certification regulations and licensing process; and 2) improvements that DOE should consider for future engagement with industry in programs such as NP2010.

Provide a complete description of the lessons learned during the COL Demonstration project and potential solutions in these two distinct areas:

1. *Interaction with the Nuclear Regulatory Commission, their regulations and regulatory processes; interactions with the Nuclear Energy Institute or other industry organizations. Include any lessons learned from the reactor vendor partnerships or separation of the reactor vendors from the COL cooperative agreements.*

NuStart established the agenda for the industry on new nuclear plant initiatives and appropriately involved NEI for generic issues across reactor vendor technologies. The NuStart Licensing Team was the primary contributor to the NEI COL Task Force. Similarly, the NuStart Management Committee members comprise the majority of the utility participants on the NEI New Plant Working Group. These interactions ensured that the generic issues raised by NuStart were appropriately addressed by the larger community. At the start of the NP2010 Program, the only active utilities were Dominion and the NuStart members. As more utilities elected to pursue COLs, NEI was effective in creating the forum for addressing the generic issues. NEI has been successful in improving the clarity for ITAAC closure letter level of detail and the construction inspection process. In response to NuStart’s efforts to accommodate ongoing changes to the design, NEI was helpful in implementing the NuStart concept of the “design freeze point.” The NuStart work prompted NRC issuance of the Interim Staff Guidance-11. NuStart is currently working with NEI and the NRC staff to address changes during construction which are the design changes that need to be implemented after the design is frozen for purposes of initial licensing.

The DOE’s separation of the reactor vendors from the original NuStart award coupled with the creation of separate awards for the reactor vendors was intended to reduce the administrative burden on all parties. This decision separated the COL projects into four individual cooperative agreements: two separate COL demonstration project agreements (Dominion and NuStart) and two reactor technology development program agreements (GEH and Westinghouse).

The award restructuring released NuStart from the administrative burden of responsibility for the pass-through of DOE reimbursement funding to GEH and Westinghouse, but also had a negative effect on the responsiveness of GEH to NuStart and Dominion. GEH management at the time indicated that they were no longer accountable to the utilities since they were now a direct recipient of a DOE award. This mindset challenged the utilities' ability to obtain accurate design finalization reporting status from GEH. The lack of GEH's commitment to finish the ESBWR design in accordance with the original schedule contributed to the decisions by Exelon, Entergy, and Dominion to abandon the ESBWR technology. As stated previously, current GEH management is supportive of the need to provide timely status information.

A strong, carefully crafted Part III scope of work in the reactor vendor awards from the DOE has helped NuStart maintain some leverage over Westinghouse on cooperation with NuStart without the need to resort to more divisive methods of issue resolution. Future DOE award restructurings should have clear language built into the Part III scopes of work that make certain that the objectives and responsibilities put forth in the original award are unchanged post-restructuring. This language will ensure that necessary work products are delivered by awardees as required and can help avoid conflicts between parties.

2. *Interactions with DOE including the DOE program or procurement functions including how the program or project was solicited organized and procured, funding allocation, cost and progress reporting requirements etc.*

   In particular, DOE would like the COL Demonstration Project participants to address the following:

   a. *Discuss the impact on the demonstration project that the lack of design certification and design finalization and the incomplete FOAKE status may have played. Would it have been preferable to complete more design work up front, prior to DC application and COL application submittal?*

The COLA process and schedule would be greatly simplified by having an approved Design Certification at the time of COL application, however the advantages, including the ability to resolve many COLA issues within the DCD and being able to work with the DC applicant to improve the quality of the DCD, would be lost. On balance, the parallel DCD/COLA reviews had a positive impact on the quality of the DCD from a customer/operator standpoint. Since the first Design Certifications were issued without significant operator input, significant revisions to the DC were required to address operability, testability, maintainability and programmatic issues. Although the AP1000 DCD was to be built from industry input, in the form of the utility requirements document (URD) put together jointly with the Electric Power Research Institute (EPRI), many important decisions were still made solely by Westinghouse, despite the utilities more significant operating experience. As a result of this, ITAAC, rework, COL placeholder items, and other potential cost and schedule impacts will be pushed to the applicants for closure at an unknown cost. Increased cooperation between vendors and industry in working together on DC prior to COL application submittals could reap the greatest benefits without the rework and other potential cost and schedule risks associated with the parallel reviews.

The lack of the design certification and especially an adequate amount of design finalization likely had an effect on the commercial implication of the design selected. The lack of these design details made it extremely difficult for the vendors to provide detailed cost estimates that in some cases were felt to be necessary before a mutually acceptable EPC contract could be negotiated. One of the more significant lessons learned from the use of Part 52 is that commercial negotiations for any specific nuclear project need to proceed well ahead of the development of the COLA. Without such consideration, potential customers may find themselves in a situation where significant capital and effort have been spent developing and seeking approval for a COL that can only be used for one design thus resulting in a very weak commercial negotiating position with the selected reactor vendor.

b. *Should the sequence of NP2010 project awards have been handled differently with regard to choosing a reactor technology (e.g., parallel COL/DC reviews versus completion of certification first)?*

The sequence of NP2010 project awards was handled appropriately with regard to choosing a reactor technology. It is important for DOE to encourage competition and improvement, rather than narrowing down the technology options and selecting a winner. Including multiple vendors whose designs are based on extensive and proven technologies that conform to utility requirements will increase the success rate of a program.

c. *How closely did demonstration project performance meet goals specified in the project plans? What caused any differences or delays?*

NuStart was able to meet its goals despite limited control over many aspects of the DCD process and NRC review of both the DCD and R-COLA.

d. *Please explain any other significant issues that occurred during the NRC review that impacted the effectiveness of the demonstration project (e.g., change in designated lead plant, level of utility commitment, uncertainties in the regulatory process, and uncertainties in funding). How can these factors be dealt with more effectively in the future?*

There were a number of challenges and issues that occurred during the NRC review. Most of them were unanticipated because of the first-time nature of the processes NuStart was testing.

Goal alignment among NuStart members, DOE, and the reactor vendors, along with program and funding flexibility enabled NuStart to deal effectively with challenges arising from award restructuring, changes in detail and requirements of the NRC review process, design certification issues and member project construction schedules.

Resolution of issues is often a two-way conversation, and absent the sort of credibility that NuStart and the AP1000 DCWG have built over several years, getting the “other side” (in this case, the NRC staff) to readily accept “our” (in this case, the DCWG’s) approach to resolution may be difficult, particularly if the proposed approach is perceived to be controversial. The keys to success here are: thoughtful engagement and credible spokespeople and SMEs; identification and use, to the maximum practical extent, of meaningful analogs/precedents; and non-confrontational escalation of issues that do not receive prompt resolution.

The transition of the reference plant from Bellefonte to Vogtle was initially felt by many to be challenging but ultimately proved to be readily achievable as a result of thoughtful dialog and a rational, logical approach among all stakeholders. The change was made as a function of business need in order to align NRC resources for standard content review to an application with specific near-term construction plans. The transition of reference plant activities from Bellefonte to Vogtle completed this change in designation while ensuring efficient use of NRC resources. Structurally, the change of R-COLA is undesirable and managing the shift is difficult, but if the initial choice of a reference plant has obstacles that may delay the NRC review and issuance of the COL, it is worth it. Site specific issues (such as hydrology at Bellefonte), number and extent of contentions, and state regulatory issues are some examples of factors that may necessitate a change in reference plant.

With NRC review fees at $29,149,817 out of the $110,985,683 total NuStart project costs to date, the ability to forecast costs and achieve schedule milestones has been difficult as the NRC is outside of the control of NuStart. As compared to other entities that NuStart pays for services (such as NuStart’s contractors), the regulator has no obligation to provide NuStart with information necessary to reasonably forecast cost and schedule for the project. The result has been a reduced certainty by NuStart in the budgeting of future costs and schedule details going forward. As cost and schedule information is supplied frequently to the DOE, there may be a desire for the DOE to play a larger role and act as a liaison between the NRC and award recipients in order to facilitate the availability of this critical information.

The level of utility commitment within NuStart was generally very good. Early in the project, the challenge was the level of time and effort required to reach consensus among a large, diverse, and opinionated group of licensing and engineering professionals on issues of critical importance (and sometimes not-so-critical importance) to the project. Goal and financial congruence within the consortium is essential so that all members are motivated to work together when unexpected issues arise. It is also necessary to get as many members actively participating in order to achieve successful results.

It would be best for a utility and its selected reactor vendor to have an appropriate level of commercial agreement, up to and including EPC contracts, supporting a particular nuclear project before commencing significant licensing efforts seeking approval and issuance of the COL. A contractual commitment would help to define roles and responsibilities for handling unexpected issues and challenges that may arise.

Uncertainties in the regulatory process were greatly ameliorated by the revision of Part 52 and the development of RG 1.206, in addition to the DCWG approach and frequent, high-quality interaction with key NRC staff. However, the industry is still dealing with uncertainties, e.g., seismic reviews, security rules, change process, limited work authorization (LWA) activities, and DAC. Uncertainties also remain relative to the schedule and level of effort required for NRC review of COL applications. The number and type of questions asked by NRC staff in RAIs still varies depending on individual NRC reviewer experience and mindset. COL applicants have received a significant number of RAIs that should never have been asked, i.e., the questions should never have made it through NRC technical branch managers, Project Managers and the NRC's General Counsel office.

Uncertainties in the regulatory process will be tested by the second wave of applicants. To the extent that these applicants adhere to the principles of standardization, it would be reasonable to expect that very few new design questions will arise during the review of their COLAs. The extent of "generic" design questions that come from the NRC staff will be a direct measure of regulatory certainty or uncertainty. Thus the second wave of applicants is important to proving that regulatory certainty has been achieved within the Part 52 process.

Regulatory certainty has been the watchword of the industry throughout the NP2010 program; while regulations and guidance have, at times, been dynamic, there are only a few instances where uncertainty has significantly increased. Some of those examples are significant, though, as indicated by the following sub-items:

<u>Extent of design completion:</u> the NRC staff will say, accurately, that the more complete a design is, the easier it is to review. This is obvious, but not as straightforward as it may seem. The fact is that the level of detail "required" to review a design is subjective. Further, expecting a vendor to completely finalize a design without a paying customer is ambitious, as is expecting a customer to take a chance on an incomplete design. This is a true balancing act that could benefit from additional attention by DOE on similar initiatives going forward.

<u>Parallel DC (or DCA) and COLA reviews:</u> much has been made of COL applicants' suggested overuse of the regulation, with some NRC staff claiming industry is not using the regulation in the way it was intended (i.e., DC and ESP followed by COL). The fact is, though, that the regulation has proven to be remarkably robust in dealing with various permutations (a testament to the rule authors), and it is tough to try and argue that the way we have implemented the

regulation is not more efficient than the originally intended sequence, at least for the “first wave” of applicants.

LWA and unintended consequences: we argued for changes to the LWA rule, and the NRC staff accommodated our request. Those changes were not accompanied by careful enough consideration – by NRC staff or applicants – of changes to guidance. As a result of these changes, and changes to the definition of “construction,” uncertainty in this area actually increased somewhat. This included changes in how other agencies interact during the NRC review.

A suggestion for managing these types of issues in real time is to establish a more structured risk management regimen and more structured process for identification, resolution, and documentation of issues. The flip side of this recommendation is to avoid over-bureaucratizing of such a process.

Below is a summary of other lessons learned during the COL Demonstration project previously discussed in the sections above.

- Goal alignment early on is critical to the various stakeholders working together well in the long term and showing the flexibility and will to overcome unexpected challenges.
- Cost sharing at a meaningful level is essential to that goal alignment. Awardees must have significant “skin in the game”.
- Carefully written award Part III scopes are important elements for goal alignment. This was especially important as the original NuStart and Dominion NP2010 awards were restructured to break out the reactor vendors into separate awards. This led to less cooperation between NuStart and the reactor vendors that was overcome largely on the strength of the revised Part III scopes and implicit sanctions from the DOE for failure to perform.
- DOE should consider structuring its future award funding distributions to achievement of program milestones rather than a simple matching of industry investment. The Program encountered a problem with a reactor vendor who was reluctant to continue performance on DOE objectives once DOE funding had been exhausted.
- DOE can take on a substantial role as liaison between industry and the NRC on matters such the need for cost and schedule information from the NRC to program awardees.
- The use of a cooperative agreement approach can help to avoid unnecessary administrative burdens associated with either a contract or a grant.
- Early communication with the NRC greatly reduced response time on emergent issues.
- The consistent and public use of the electronic RAI process has been extremely beneficial and could benefit other agencies and future projects.

- Efficiencies and processes demonstrated by the reference plant approach could be applied post-COL and NP2010 in order to overcome limited resources and achieve schedule requirements.
- The award budget period duration being divorced from the calendar year by one month caused the need for reporting on different bases dependent on the stakeholder. A calendar year basis for award funding is strongly preferred.
- Due to the first of a kind nature of this non-construction project, EVMS was not a particularly useful tool.
- Completion of design prior to the submission of the COL application is preferable.

V. Insights/Recommendations

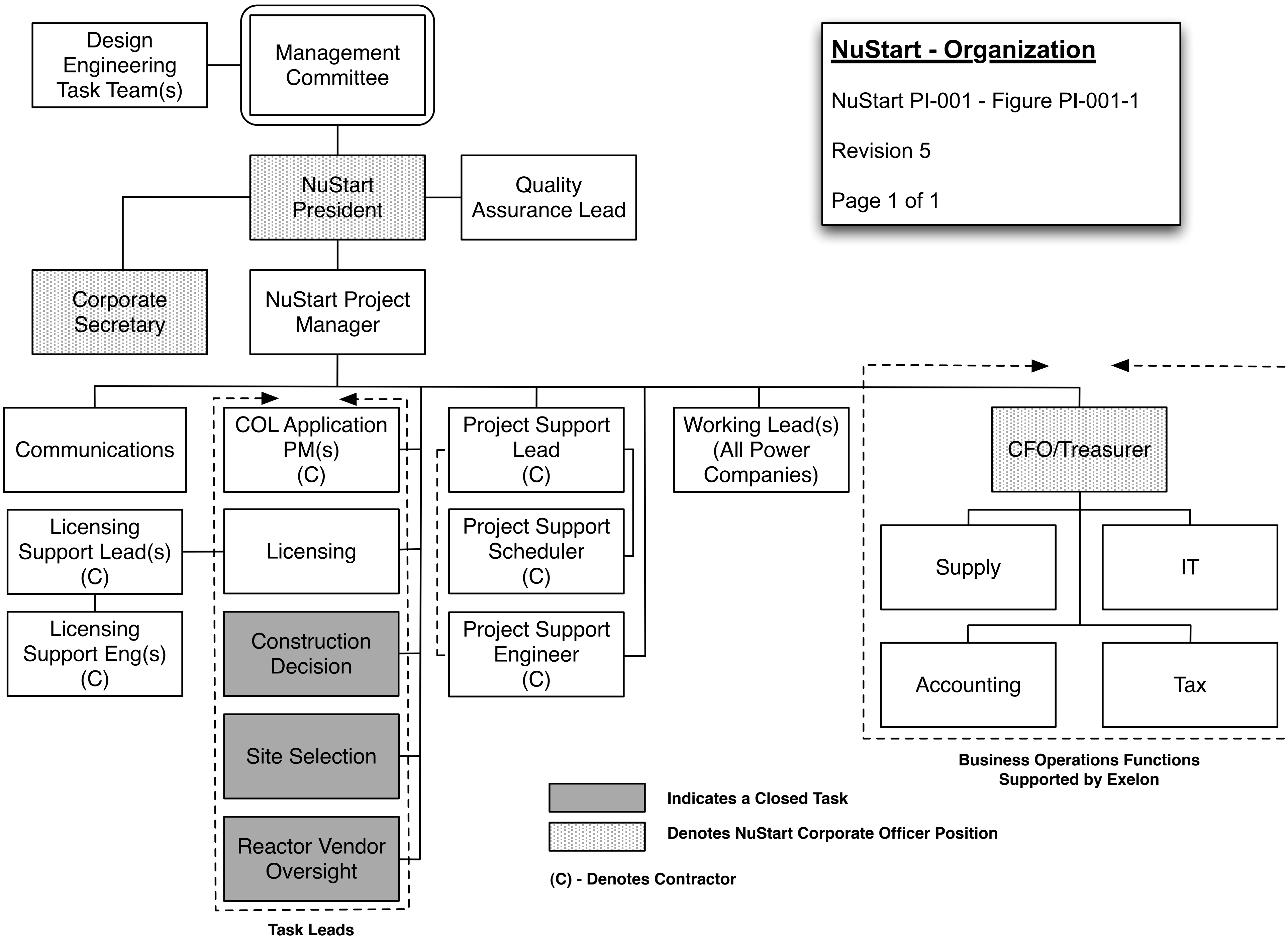
Please provide general comments on the effectiveness of the Demonstration Projects, specific experiences involving implementing processes for COL application and design certification development and review, and recommendations for future DOE sponsored projects of this type or similar industry projects could be implemented more effectively. Please use this section to discuss any other relevant information that the industry participants feel is pertinent and useful.

Demonstrating Projects and DOE/government funding can selectively accelerate the future. Cost sharing at a meaningful level is also vital to goal alignment between DOE and award recipients. Without NP2010, industry would have been unable to respond as quickly to incentives in the Energy Policy Act of 2005 and would be less prepared for a nuclear renaissance. Had it not been for the recent discovery of low priced shale derived natural gas and the lack of national energy policy with respect to carbon emissions, that renaissance would likely be much more active than it appears to be today. However, because of NP2010, industry is better prepared to advance new nuclear generation, should the nation call on us to do so.

VI. Appendices

Provide detail data, schedules or other pertinent information in appendices as appropriate.

Appendix I – **NuStart PI-001 – Figure PI-001-1**



NuStart - Organization
NuStart PI-001 - Figure PI-001-1
Revision 5
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Design Engineering Task Team(s)
Management Committee
NuStart President
Quality Assurance Lead
Corporate Secretary
NuStart Project Manager
Communications
COL Application PM(s) (C)
Project Support Lead (C)
Working Lead(s) (All Power Companies)
CFO/Treasurer
Licensing Support Lead(s) (C)
Licensing
Project Support Scheduler (C)
Supply
IT
Licensing Support Eng(s) (C)
Construction Decision
Project Support Engineer (C)
Accounting
Tax
Site Selection
Reactor Vendor Oversight
Task Leads
Business Operations Functions Supported by Exelon
Indicates a Closed Task
Denotes NuStart Corporate Officer Position
(C) - Denotes Contractor

Appendix II – NuStart PI-001 – Figure PI-001-2

NuStart - Integrated Project Team

NuStart PI-001 - Figure PI-001-2

Revision 5

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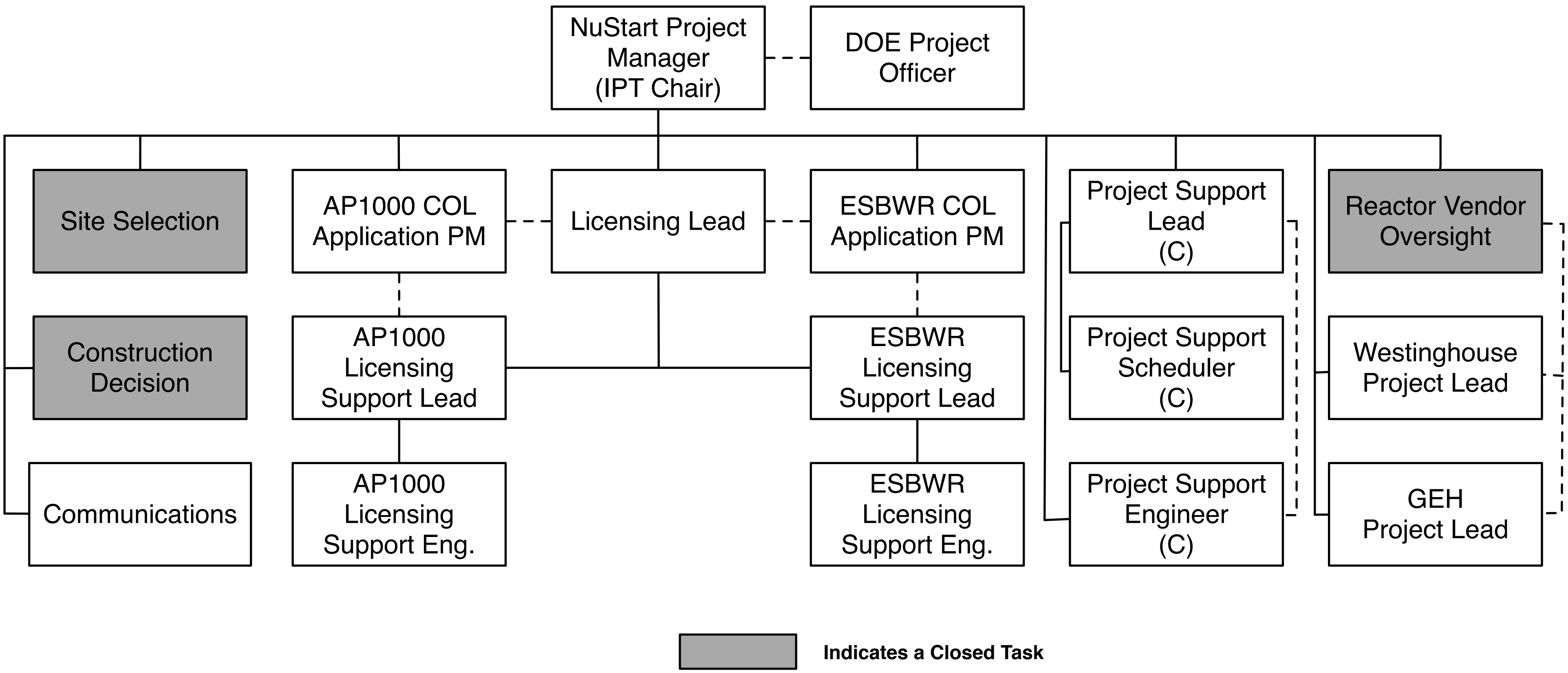

Appendix III – BPC Letter from Meserve to Jaczko dated April 6, 2010

April 6, 2010

Gregory B. Jaczko
Chairman
Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Dear Chairman Jaczko:

We are writing in response to your request that the Bipartisan Policy Center conduct a review of the NRC licensing process for new reactors. You asked that we examine whether there have been unnecessary delays in the licensing process for new nuclear plants caused either by the NRC or by the nuclear industry. In short, we did not find any evidence that either the NRC or industry has needlessly delayed or extended the licensing process. You also asked for a report on any findings and recommendations to improve the process going forward. This letter constitutes our response to your request.

To accomplish this task, we interviewed NRC staff and former NRC commissioners, representatives of reactor vendors, applicants for Combined Operating Licenses (COLs), nuclear engineering firms, and representatives of environmental and other organizations that have actively engaged in the licensing process. We also hosted a half-day forum to which we invited a broad group of stakeholders to discuss issues raised during the individual interviews and to elicit additional views and comments.

General Themes/Issues

In summary, we found that, while many of the stakeholders have encountered some problems in maneuvering through the licensing process, there was a near-unanimous view that all parties have acted appropriately and in good faith to resolve any problems. The NRC was not seen to have needlessly delayed or extended the licensing process. Based on our interviews, we believe that the difficulty of obtaining financing is a bigger obstacle to nuclear plant construction at the moment than licensing issues.

Nonetheless, a number of suggestions were made for improving the process going forward that we found to be well grounded and reasonable so we mention them in this report. In particular, the parties hope and expect that the lessons learned in the processing of the initial applications will result in changes that will improve the process and make it more transparent and efficient. Given the NRC's performance to date, we expect that this will be the case.

The licensing process for new reactors that is now underway has been a learning experience for all involved. Indeed, the NRC has confronted an unprecedented challenge in processing the initial applications. The licensing system embodied in Part 52 of the NRC's regulations had envisioned that applications for COLs would reference designs that had been certified and sites that had the benefit of early site permits. It was anticipated that, with these pieces in place, the review process for COLs would be simplified and relatively straightforward. As it happened, numerous COL applications were filed in parallel with applications for certified designs. The staff thus had the challenge of dealing simultaneously with a large number of overlapping applications that were filed pursuant to an entirely new and largely untested licensing regime. This was further complicated by the fact that new-plant licensing at the NRC has been dormant for many years and needed to be resuscitated. And, at the same time, the NRC was undertaking the hiring and training of a large cadre of new employees and managers, while industry was simultaneously rebuilding its staff. Overall, we believe that the NRC staff has done a remarkable job under trying circumstances. Many stakeholders commented on the high level of commitment demonstrated by the NRC staff to resolve disputes in a fair, consistent, and clear manner.

It was also clear from our interviews, however, that there has on occasion been some miscommunication between NRC staff and applicants, leading to some confusion and delay. Much of the confusion can apparently be traced to misunderstandings as to NRC expectations in regard to the level of detail required in applications. Since the licensing process is new, successful templates by which an applicant can measure its filings do not yet exist. This has put the applicants (and interveners) in a difficult position when applications had to be supplemented as the process has moved forward. Some industry representatives acknowledged that they have not always been able to respond to NRC staff's Requests for Additional Information (RAIs) in as timely a manner as they would like –the responses can on occasion require significant time and effort -- and they also accept some responsibility for past miscommunications. In our judgment, many of these issues should resolve themselves as all sides gain more experience. The Commission and NRC staff should also strive to provide clear guidance to applicants to minimize delays caused by miscommunications as subsequent applications make their way through the process.

Design Certification

The current Design Certification (DC) process has proven cumbersome, in large part because of the parallel submission of COL applications referencing a design then undergoing review for certification. As noted above, efficiencies would have been available if the design certifications had been completed before the NRC was required to process the COL applications referencing that design. The simultaneous processing of DC and COL applications has created some uncertainty arising from the interplay between the two processes. This put interveners in a difficult position by forcing them to monitor multiple proceedings. Nonetheless, all parties appear committed to make the best of the situation. These issues should resolve themselves when the current design certifications are completed and subsequent COL applications reference certified designs.

Scheduling certainty and clarity of NRC management expectations are critical for the vendors. Some vendors believe that the NRC staff has not been consistent over time in the detail that is expected from the vendor. We were told that there have been situations in which different reviewers have caused confusion by applying different standards for review. Indeed, some vendors have complained that issues that were believed to have been resolved were subject to reopening as different reviewers became involved. We conclude that the Commission should focus its attention on providing clear guidance on the level of design detail and analysis that is expected in applications. We understand that the NRC staff is paying attention to this issue, and we bring it up here because we believe that this is an area where a continuing active focus by the Commission and NRC management is warranted.

Ensuring a sensible path forward for future reactor design modifications was also an issue of concern for some stakeholders. There is an inherent tension between the policy goals of, on the one hand, building a standardized fleet of new reactors and, on the other hand, ensuring that modifications based on experience with a design are applied so as to improve safety and environmental performance. We understand that at least one design center has created a committee to look at the issue of how best to incorporate new technology changes into future reactor construction. We believe this is a sensible step and the Commission should closely monitor progress to ensure that there is a transparent and efficient methodology to achieve an appropriate balance between these two important goals.

Combined Operating License

Although there have been occasional “bumps in the road” in the processing of COL applications, the fact that problems have surfaced was neither unexpected nor have the problems proven insurmountable. The general sense is that the NRC staff has generally worked with the applicants in a direct way to resolve issues in a timely fashion. Because there has not yet been a successful application that has gone through the entire process from beginning to end, applicants have no model upon which to base their submissions. Both applicants and the NRC are learning as the initial applications are processed. Not surprisingly, there on occasion have been differing expectations as to what is required. Once the process has run its course a few times, we expect that many of these issues will resolve themselves.

Nearly all the applicants indicated that certainty in scheduling is more crucial than speed. Nonetheless, although the Part 52 process largely serves to move regulatory decisions as early in the process as they can reasonably be made, there often are significant expenditures that must be incurred for long-lead-time components before the licensing process has been completed. With hundreds of millions of dollars at stake, even a small delay can have a significant financial impact. Therefore, efforts should be made to avoid unnecessary delays.

Several applicants questioned the need for a mandatory uncontested hearing – a hearing that is held even in the absence of a successful intervention by a party opposing a license

-- at the end of the COL process. They observed that there are multiple opportunities for public involvement and expert review in the current licensing process, and that the mandatory hearing requirement is an anachronism from an earlier age. They noted the public access that is now a standard part of the staff's review of the licensing application and the environmental impact statement and the detailed review that is undertaken by the independent experts on the Advisory Committee on Reactor Safeguards. As a result, they claim that a mandatory uncontested hearing is a duplicative and time-consuming step that serves little purpose. Some intervener groups, on the other hand, point out that the industry has been successful in recent time in rehabilitating public support for nuclear power and that the quickest way to subvert that momentum would be to eliminate the mandatory hearing requirement or to otherwise limit the confidence of the public in the integrity of the licensing process.

We understand that a mandatory hearing on each application for a construction permit is required by the Atomic Energy Act and therefore it is beyond the authority of the Commission to eliminate it. However, even in the absence of a legislative change, the Commission can reduce the uncertainty associated with the duration of the hearing. For example, the Commission might convene a legislative-style hearing to ascertain the sufficiency of the licensing review. Rather than limiting public involvement, a legislative-style hearing might allow appropriate and efficient wide-scale scrutiny to supplement the staff and the ACRS's licensing review. Of course, such a hearing would be in addition to any detailed review of contentions by the Atomic Safety and Licensing Board (ASLB) in cases in which there has been a successful intervention.

Another major issue that was brought to our attention relates to the environmental review process. We understand that, at least in respect to the initial COL applications, the EIS process is currently more advanced than the safety review process. In these cases, any effort to "speed up" the environmental reviews will have no effect on the overall licensing schedule. This may not continue to be the case for other applications in the queue. That is, the time needed for the safety review of subsequent COL applications referencing a certified design will likely be reduced because non-site specific issues will have already been addressed. Thus, the timing of the environmental review may become a critical consideration going forward.

One suggestion offered in our meetings was to allow the filing of contested issues on the draft EIS, instead of waiting until the final EIS to issue. It was argued that such an approach would allow any ASLB hearing to start earlier. However, the draft EIS would have to be of high quality for this approach to be effective and there is no certainty that time would be saved for every application. For example, interveners would retain the right to file contentions relating to issues arising from any changes introduced in the final EIS. And perhaps little efficiency might be gained if the concurrence by other agencies has not been obtained on the draft EIS. Experience going forward should indicate whether such a change in process would be helpful.

Our comment on this point reflects a general rule: the NRC and the other stakeholders should seek to learn from the existing processing of applications and should seek to achieve efficiencies based on that knowledge going forward. The overall aim should be to reduce the licensing burden without affecting the quality, scope or the thoroughness of the review. A commitment to learn from experience should be the guide.

Summary

In sum, we note that there was near-universal respect and admiration for the NRC staff among the stakeholders we interviewed. Although the licensing process is new, both the NRC and the industry have done a remarkable job in very trying circumstances in assuring the thorough and timely evaluation of license applications. The fact that all parties have experienced some problems in navigating the process was to be expected under the circumstances. But it is apparent that all those involved have been diligent in working through the issues in a forthright manner.

The Commission can, and should, continue to exercise clear leadership to ensure that the processing of the applications continues with the same attention to detail and to efficiency as has been the case to date. The Commission should ensure that the lessons learned in the first round of applications are rigorously applied to make the processing of subsequent applications more efficient. We also believe that the changes we outlined above would have a modest, but measurable impact upon the process.

On behalf of the Bipartisan Policy Center, we thank you for giving us the opportunity to assess the progress that has been made in laying the foundations for the deployment of safe nuclear power in the U.S. We commend you for your willingness to invite an independent analysis, as well as for your commitment to ensuring the transparency and integrity of the NRC licensing process. We hope that this review is helpful.

Pete V. Domenici

Dr. Richard Meserve

CC: George Apostolakis, Commissioner
CC: William Magwood, Commissioner
CC: William Ostendorff, Commissioner
CC: Kristine Svinicki, Commissioner

Appendix C:

Westinghouse Electric Company NP 2010 AP-1000 DC Project Report

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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

March 2011

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LIST OF TABLES

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LIST OF FIGURES

LIST OF FIGURES (cont.)

LIST OF ACRONYMS

10 CFR 52	Title 10 Code of Federal Regulations Part 52
AFSAR	advanced final safety analysis report
AIA	aircraft impact accident
ALWR	advanced light water reactor
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CIPIMS	Construction Inspection Program Information Management System
COL	combined construction and operating license
COLA	combined construction and operating license application
DAC	design acceptance criteria
DC	design certification
DCD	Design Control Document
DCWG	Design Centered Working Group
DF	design finalization
DOE	Department of Energy
EIA	Energy Information Administration
EPACT 2005	Energy Policy Act of 2005
EPC	engineering, procurement, and construction
EPRI	Electric Power Research Institute
EVMS	earned value management system
FOAKE	first-of-a-kind engineering
FSAR	final safety analysis report
GSI 191	Generic Safety Issue 191
I&C	instrumentation and control
IHS CERA®	IHS Cambridge Energy Research Associates®, Inc.
INPO	Institute of Nuclear Power Operations
ISG-11	NRC Interim Staff Guidance 11
ITAAC	inspection, tests, analyses, and acceptance criteria
NEI	Nuclear Energy Institute
NP2010 Program	Nuclear Power 2010 Program
NRC	Nuclear Regulatory Commission
NuStart	NuStart Energy Development LLC

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

1. **AP1000** is a registered trademark in the United States, of Westinghouse Electric Company LLC, its subsidiaries and/or its affiliates. This mark may also be used and/or registered in other countries throughout the world. All rights reserved. Unauthorized use is strictly prohibited.

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.

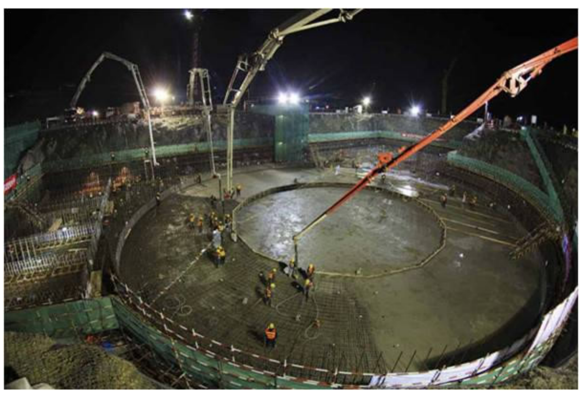

Figure 2. Pouring of First Concrete at Sanmen Unit 2, December 2009

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

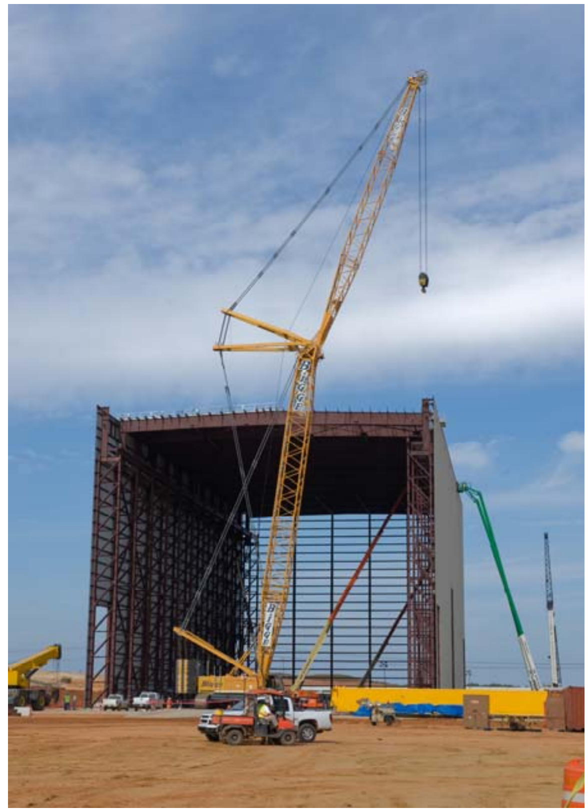

Figure 14. Vogtle Module Assembly Building Construction, November 2010

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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].

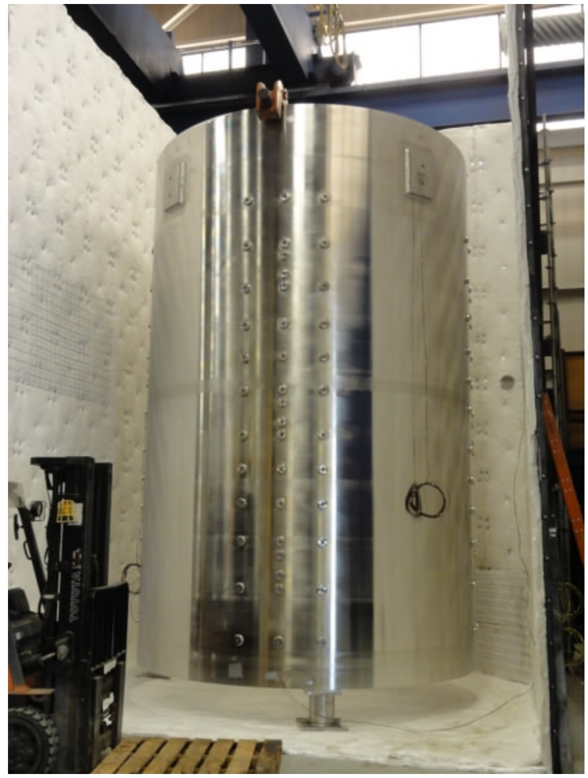

*Figure 16. Manufacture of **AP1000** Core Barrel Assembly in Newington, New Hampshire*

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.

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

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.

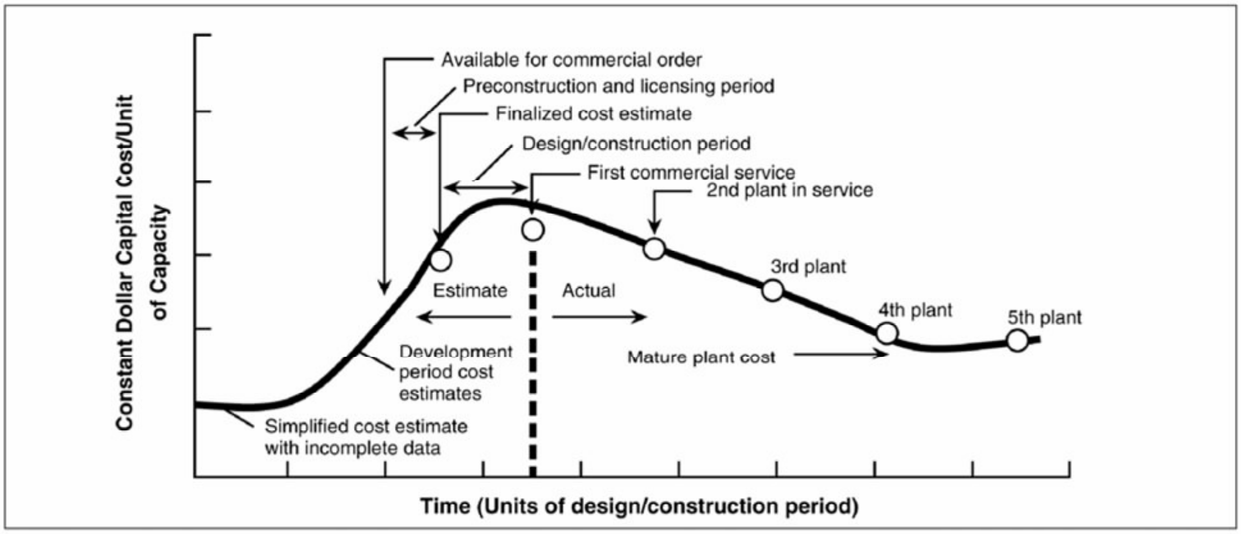

Figure 18. Cost Estimate Curve, Development through Deployment

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

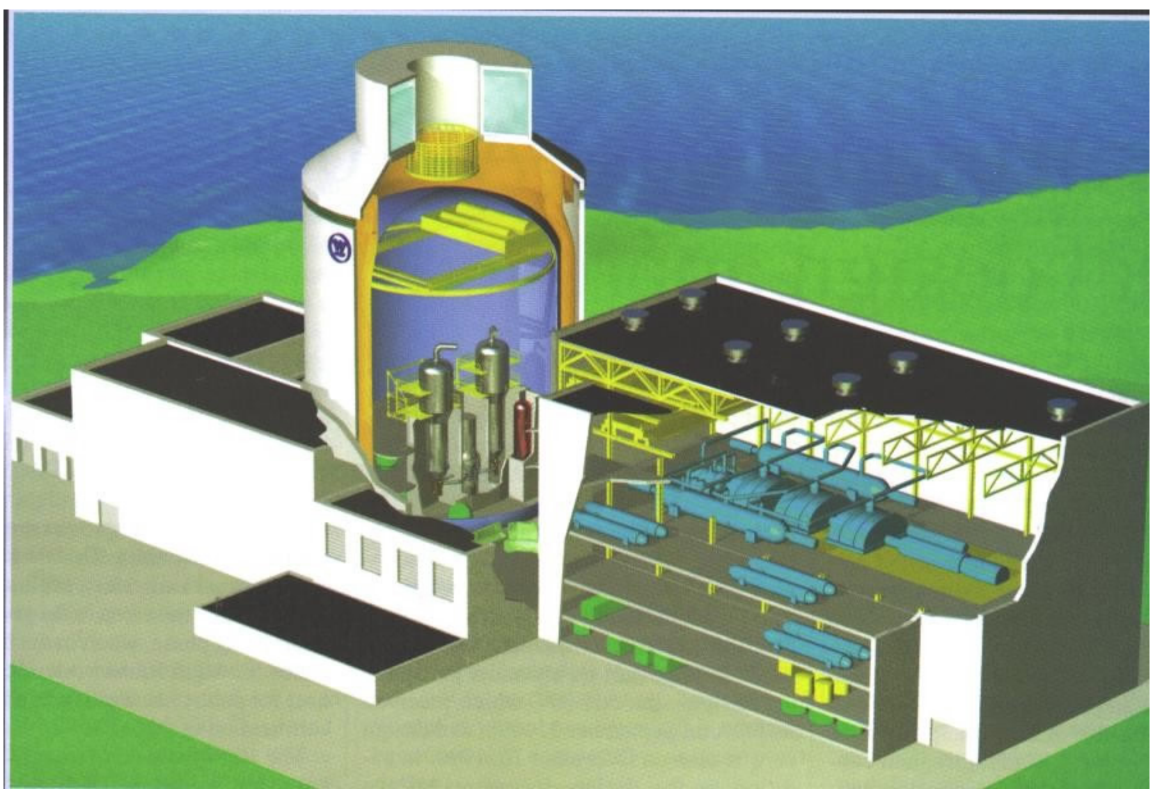

*Figure 19. Cutaway View of **AP1000** Unit*

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.

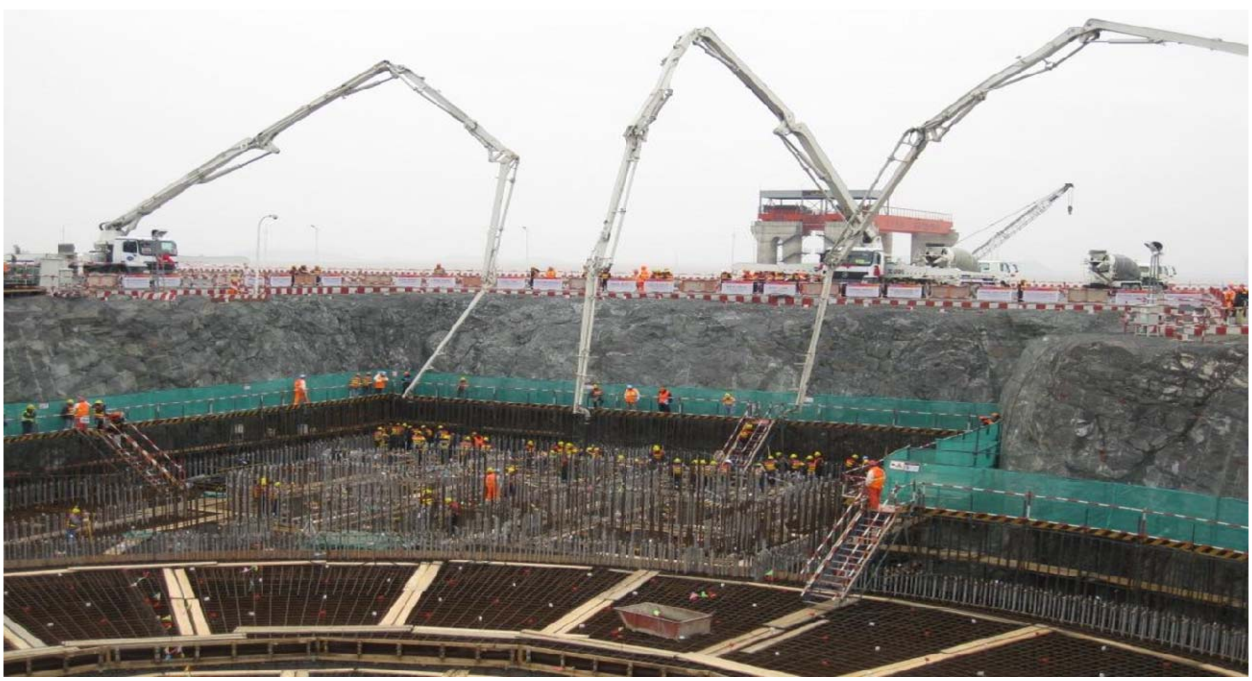

Figure 23. Pouring of First Concrete at Sanmen Unit 1, March 2009

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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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301-415-2956

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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.

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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.

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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).

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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 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

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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.

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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).

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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

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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.

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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.

<u>RECOMMENDATIONS</u>:

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).

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(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

Appendix D:

General Electric – Hitachi NP 2010 ESBWR DC Project Report

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Department of Energy

Nuclear Power 2010 Program

GE Hitachi ESBWR

Design Certification and

Finalization Project

Final Report

DC Applicant Input

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

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Table of Contents

Purpose of the Project Participants' Reports and General Instructions

The purpose of this report is to provide an opportunity for each industry participant (reactor vendor) to discuss the status, performance and experiences gained while implementing their Design Certification and Finalization Project (DC/DF) under the Department of Energy's Nuclear Power 2010 (NP2010) Program. A separate but similar outline is provided to the utilities involved in the NP2010 program to document their activities in the Construction and Operating License (COL) Demonstration Projects.

For those participants whose project is complete or has ended this report will serve as the cooperative agreement final report. For those projects continuing, this report will serve as an interim final report to be supplemented at project completion with an addendum of final results.

Please follow the outlines provided on the following pages. DOE will use the information and data from each of the four participants' reports, two utility COL projects and two reactor vendor design certification and design finalization projects, plus follow-up interviews of key personnel, as appropriate, to form the basis of an integrated Department's NP 2010 Construction and Operating License (COL) Demonstration Project Close-out Report. This report approach is similar to that used on the Early Site Permit Demonstration projects. Each of the industry participants will have an opportunity to review and comment on the department's integrated COL report prior to issuance.

The following sections describe the report input requested directly from each reactor vendor for the DC/DF projects. Questions have been provided to help identify specific information that the Department believes important. Please answer the questions as completely as possible. You are encouraged to elaborate on these questions and raise additional points beyond those listed in order to provide a comprehensive report on your project.

DOE welcomes input and comments from the reactor vendor participants in this report on the support required for the COL projects and NP2010 program as a whole.

I. Executive Summary

Provide an overall summary of the project performance, addressing project organization, scope, schedule and cost. Identify key issues and performance details. Summarize key lessons learned and recommendations for future projects of this type.

This report provides an overall summary of the GE Hitachi Nuclear Energy America (GEH) activities associated with the DOE's NP2010 program, as well as key lessons learned and observations on various aspects of the program implementation. Elements of the report that discuss specifics related to program execution, deliverables, and budget are written in context of the work performed under the GEH direct Cooperative Agreement. More general commentary is provided on the overall program and incorporates GEH's experience as a sub-award recipient under the NuStart and Dominion Cooperative Agreements.

GEH was selected by both NuStart and Dominion as a participant in their respective COL demonstration project cooperative agreements under the original DOE award solicitation. GEH activities under these cooperative agreements were focused on the GEH ESBWR reactor technology. The ESBWR is an advanced Generation III+ reactor design that utilizes passive safety technology and simplification through natural circulation while building on the proven design experience of the GEH ABWR design. The ESBWR was derived from the SBWR design developed in the 1990's with a subsequent scale to produce 4500MWt.

Under the NP2010 program, GEH developed and submitted a Design Certification Document for the ESBWR design and at the time of this writing has received the NRC's Final Design Approval for the ESBWR design and the NRC is in the final steps of issuing the Final Design Certification for ESBWR. In addition to the Design Certification Document, GEH assisted in the development of Reference and Subsequent COL applications for Dominion's proposed North Anna 3 power plant and Entergy's proposed Grand Gulf Unit 3. Other COLs for Entergy's proposed River Bend Unit 3 and Detroit Edison's Fermi Unit 3 were also developed building on the work that was developed under the NP2010 program. In addition to the licensing work, significant design finalization activities and deployment preparation activities were also performed under the NP2010 program. These activities allowed the development of more accurate cost and schedule estimates allowing utilities to more effectively evaluate a project financial pro forma. GEH relied on a team composed of multiple companies to execute the work under the NP2010 program. Key organizations that assisted GEH were URS, Black & Veatch Zachary, EA, Shimizu, and Hitachi.

During the course of the NP2010 program, DOE restructured the Award Cooperative Agreements to include a direct award to GEH for the scope of work related to the ESBWR standard plant design, design certification, and deployment preparation. The scope of work associated with the development of the reference COL remained with the original award recipients.

From a reactor vendor perspective, one of the most challenging aspects of the program was to predict the scope and timeline of the NRC licensing process. The amount of effort originally envisioned and the timeline for completing the NRC review of the ESBWR was significantly underestimated based on the previous GE experience licensing the ABWR design. This challenged GEH's ability to resource detailed design activities to the level originally envisioned under the proposed program funding levels. This was discussed routinely with the DOE and other program participants and resources were consistently prioritized to complete the NRC review and obtain the design certification as the primary goal. The prolonged NRC certification timeline and associated reallocation of resources applied from design finalization caused some frustration between the utility based award recipients and GEH.

The program was highly successful as measured by most respects and has paved the way for deployment of Generation III+ designs. The ESBWR Final Design Approval was issued in March of 2011 and NRC is expected to complete the design certification rulemaking for the ESBWR reactor design by the end of 2012 and the current Reference COL for ESBWR, Fermi Unit 3, is scheduled for issuance by 2013. Unfortunately, economic conditions in the United States have resulted in significant reductions in load growth projections, which, when combined with low natural gas prices, have slowed down many of the utility plans for construction of new nuclear power plants.

II. Introduction

The purpose of the Nuclear Power 2010 COL Demonstration projects was to conduct a pilot demonstration of the previously unused Construction and Operating License (COL) application and review process under regulation Title 10 Part 52. Under these projects, the industry recipient implemented a plan to obtain NRC approval and issuance of a COL for an advanced nuclear power plant. The demonstration projects involved initiating a COL for a new, standardized reactor technology at a specific reference site, thereby simplifying the licensing process for subsequent COL applicants. In addition, the original scope also included the certification of the selected nuclear plant design and completion of the First-of-a-Kind Engineering (FOAKE) for a standard plant. This scope of design certification and design finalization (FOAKE) was removed from the COL projects into separate reactor vendor projects. The scope of those design certification and finalization projects is the focus of this report outline.

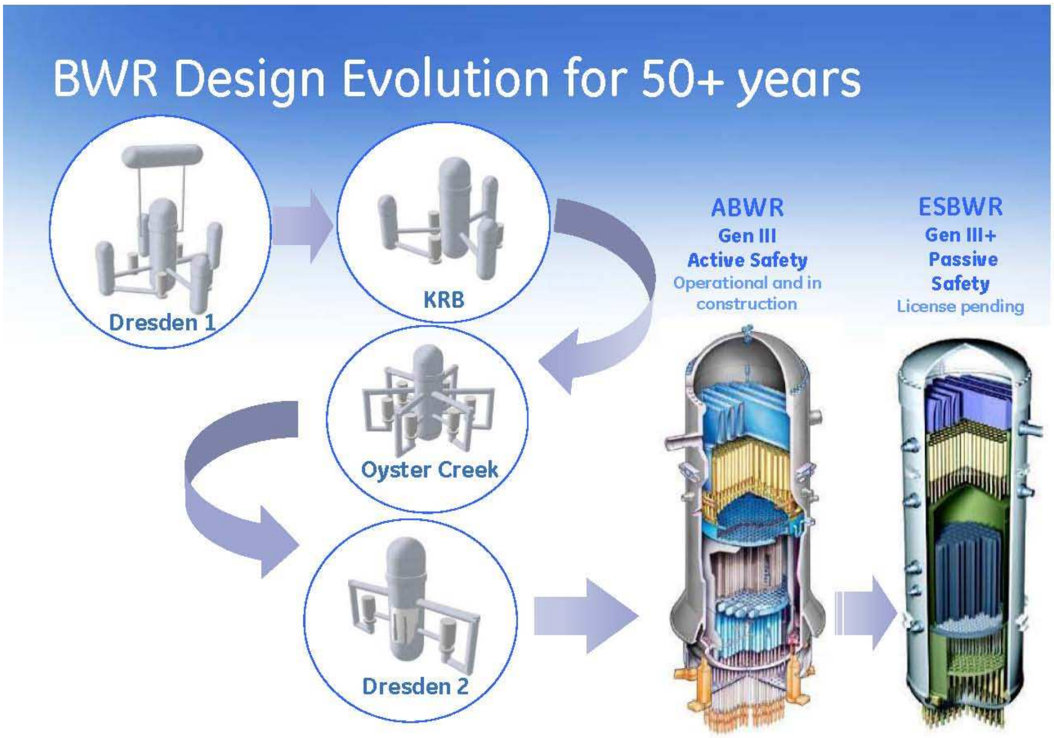
This section should include the scope of the project, the intended purpose of the project, description of your company and project organization, and the rationale for choosing to become a NP 2010 COL demonstration project participant. Describe the separation of the reactor vendor certification and design completion scope from the COL demonstration projects.

This report provides a summary of the key goals and activities associated with the NP2010 program, details regarding the execution of the program, as well as commentary on the effectiveness of various aspects of the program including lessons learned as applicable.

For over 50 years, GE has been in the business of engineering, designing, procuring, manufacturing, and in some cases constructing nuclear power plants for electric utilities on three continents. There are currently 94 BWR plants operating in the world, generating approximately 23% of the world's total electricity from nuclear power. All of these plants trace their origins to the BWR design that GE developed in the 1950s.

In June 2007, GE and Hitachi formed an alliance to better serve the global nuclear industry. The global nuclear alliance formed between GE and Hitachi brings together over 50 years of BWR experience, with a single, strategic vision of creating a broader portfolio of solutions with expanded capabilities for new reactor and service opportunities.

The BWR design has evolved over the years with each change bringing about improvements in safety, simplicity, plant performance, and cost reduction. The ESBWR builds on a long line of proven GEH BWR reactors and provides the latest in Generation III+ reactor technology. ESBWR employs passive safety design features and its simplified reactor design allows for faster construction and lower costs.



Following the Three Mile Island accident in 1979, there was a lot of interest in developing a reactor with passive safety features and less dependence on operator actions. Utilities also took this opportunity to request a reactor which was simpler to operate, had fewer components and no dependence on diesel-generators for safety actions. GE began an internal study of a new BWR concept based on these principles and the Simplified Boiling Water Reactor (SBWR) was born in the early 1980s. Key new features, such as the Gravity Driven Core Cooling System (GDCS), Depressurization Valves (DPV), and leak-tight wetwell/drywell vacuum breakers were tested. As interest grew, an International Team was formed to complete the design, and additional separate effects, component and integrated system tests, particularly of the innovative new feature, the Passive Containment Cooling System (PCCS), were run in Europe and Japan. A Design Certification Program was started in the late 1980s with the objective of obtaining a standardized license, similar to that obtained for the ABWR. However, as more of the design details became known, it became clear that, at 670 MWe, the SBWR was too small to be economically competitive with other utility options for electrical generation. The certification program was stopped, but GE continued to look for ways to make an SBWR attractive for power generation. With European Utility support, the SBWR was uprated gradually to its current power level of approximately 1550 MWe. This was made possible by staying within the Reactor Pressure Vessel (RPV) size limit established by the ABWR, and by taking advantage of the modular approach to passive safety afforded by Isolation Condensers (IC) and PCCS. The ESBWR has achieved its basic plant simplification by using innovative adaptations of operating plant systems, e.g., combining shutdown cooling and reactor water cleanup systems, and combining the various pool cooling and cleanup systems. In addition, several systems were eliminated, e.g., standby gas treatment and flammability control. There is a high confidence that the design is proven because of the following basic approach to the design:

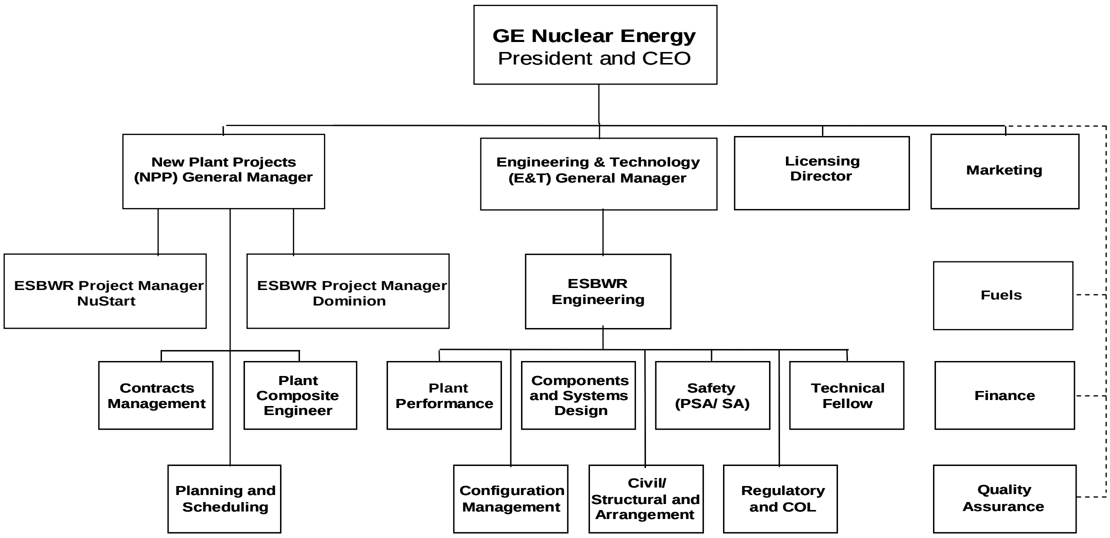
-Utilize BWR features that have been successfully used before in operating BWRs, e.g., natural circulation, isolation condensers.
-Utilize standard systems where practical, e.g. utilize features common to ABWR - vessel size, fine motion control rod drives, pressure suppression containment, fuel designs, materials and chemistry.
-Extend the range of data to ESBWR parameters, e.g. separators, large channel two phase flow, isolation condensers (IC).
-Perform extensive separate effects, component and integral tests at different scales for the PCCS.
-Test any new components, e.g. squib actuated DPVs, IC heat exchangers, wetwell/drywell vacuum breakers.

The ESBWR program, as a result, inherited a technologically rich legacy of design, development and analysis work passed along from the SBWR and ABWR programs. Some systems required duty or rating up-sizing to adjust to a higher power level. Other systems needed an addition of yet another duplicate equipment train. Instrumentation and Control (I&C) were little changed from ABWR. Plant electrical (even though significantly simplified), cooling water, and heat cycle systems benefited tremendously from the on-going systems work underway on all of GE's ABWR design activities.

GEH sought participation in the NP2010 program due to alignment of the NP2010 program goals with the GEH new plant business strategy. Prior to the NP2010 program, GEH had completed the licensing of the ABWR design and had already performed significant research and development of an advanced reactor design that incorporated passive safety features and a natural circulation design. The NP2010 program included goals of testing the NRC's Part 52 licensing process through the development of standard plant designs through the NRC certification process as well as developing Combined Construction and Operating License applications. GEH worked with both NuStart and Dominion in the development of their respective responses to the DOE NP2010 program solicitation. The NP2010 program served as a vehicle that provided unified goals/objectives for the US Nuclear Industry in terms of licensing standardization. As the program progressed, the NP2010 program activities combined with the incentives in the 2005 Energy Policy Act provided a catalyst for significant new plant licensing activities throughout the US nuclear industry.

GEH was selected to participate in both the NuStart and Dominion Cooperative Agreements as sub-recipients. This was a welcome opportunity for GEH, but participating in two separate Cooperative Agreements provided some challenges to administering the program. Much of the work that was being performed by GEH was common between the two Cooperative Agreement Awards. A structure was established within the GEH program implementation that recognized "Generic" project activities that were common to both the Dominion Cooperative Agreement and the NuStart Cooperative Agreement and separate project specific activities that were only applicable to an individual Cooperative Agreement. GEH established separate Project Managers for each of the Cooperative Agreements and maintained separate financial records for each of the projects. The "generic" activities were then applied equally to each of the Cooperative Agreements. This was somewhat cumbersome and complicated by the fact that the two

Cooperative Agreements utilized different Work Breakdown Structures and were tracked in separate schedules. The basic GEH organizational structure is displayed below.



In 2007, DOE restructured the Cooperative Agreements to include separate Cooperative Agreements for NuStart, Dominion, and GEH. The new structure was implemented to provide greater standardization in reactor designs in response to the design centered review approach implemented by the US NRC. In the restructured Cooperative Agreement arrangement, GEH would manage the Certification and Design activities associated with the Standard Plant Concepts under a direct agreement with the DOE. As part of the restructuring, funding for the development of COL content was maintained with the Dominion Cooperative Agreement and GEH provided support to Dominion through a sub-award from Dominion's Cooperative Agreement. In addition to the COL content, additional site specific activities related to the North Anna 3 site were also retained as part of the Dominion Cooperative Agreement. These activities included items such as site specific design and analysis related to geotechnical conditions, site environmental conditions, and site specific yard structure interfaces, etc. Also, site specific deployment planning was also retained as part of the Dominion Cooperative Agreement for activities such as module plans, heavy haul/logistics studies, labor studies, etc. The organizational structure remained essentially unchanged by the Cooperative Agreement restructuring with the exception that the Project Manager position previously assigned to the NuStart Cooperative Agreement was reassigned to the GEH direct Cooperative Agreement with DOE.

In order to implement the program activities, GEH assembled a management team drawn from its staff of experienced project management personnel. Additionally, GEH developed a broad team of resources to execute the project objectives. This team included partnerships with multiple experienced "Engineering, Procurement, and Construction" (EPC) companies to augment the GEH staff in performing plant design and preparation for deployment. The selection of these partnerships was the result of an extensive analysis in which multiple criteria and qualifications were weighted and evaluated. In addition to the EPC companies, the GEH team also included engineering firms with significant design experience including recent design and modularization of power plants in Asia.

The key objectives from the GEH perspective were to complete the certification of the ESBWR, perform sufficient design work to support the Utility COL application and associated NRC review, and to perform additional design work to support deployment planning including cost/schedule development to support utility decisions to build.

III. Design Certification & Design Finalization Project (DC/DF)

This section should document the goals, objectives, activities and events of your specific DC/DF project from development stages through successful NRC DC application submittal and post-submittal activities, along with support you provided to your respective utility COL applicants, as well as the First-of-a-kind engineering and design activities. DOE expects each partner to provide a comprehensive summary of their demonstration project, per the Federal Assistance Reporting Checklist and Instructions (DOE form F 4600.2) in addition to the specific questions itemized below.

Participants should provide as much detail as possible. DC/DF project participants should consider their entire NP 2010 involvement; where applicable, discuss separately your experience as a sub-contractor in the early years of the program and as a prime-contractor in the later years. The following questions should be viewed as minimal guidance to help shape the report.

Questions for Westinghouse and GE-H on DC/DF Projects

1. ***NP 2010 DC/DF Project Purpose & Achievements***
   Describe how your project supported, achieved or otherwise satisfied the primary goals and objectives of the Nuclear Power 2010 program that you were expected to accomplish. Please address the following additional questions in your description. Include solutions to issues raised under the section "Lessons Learned".

The NP2010 program combined with the incentives outlined in the Energy Policy Act of 2005 provided a key catalyst for the Nuclear Industry in the area of new plant development. GEH recognized the value of the NP2010 program, both from a strategic standpoint in shaping customer decisions on new plant technologies as well as from a tactical standpoint to advance the state of the ESBWR through the NRC licensing process and progressing the design and deployment plans to support customer decisions to build.

The following program objectives are provided as described in Part III of the GEH Cooperative Agreement:

> "The objective of this project is to obtain NRC certification of the ESBWR plant design and to complete the engineering and standard ESBWR plant design such that the ESBWR plant is an economically competitive advanced design choice for deployment by U.S. power generating companies. Under their separate NP2010 Program cooperative agreements, Dominion has selected the GEH ESBWR plant as the reference nuclear power plant for a COL application to support deployment of new nuclear generation at the North Anna site and NuStart has chosen the ESBWR plant as the reference nuclear power plant for a COL application to support deployment of new nuclear generation at Entergy's Grand Gulf site. The objectives of this cooperative agreement include GEH support of NuStart's preparation of the Grand Gulf COL application. Support of Dominion's preparation of the North Anna COL application, support of Dominion during NRC's review and issuance of the North Anna COL application, and support of NuStart during NRC's review and issuance of the Grand Gulf COL application are not included in this cooperative agreement.

Consistent with the intent of the original DOE Cooperative agreements with Dominion and NuStart, GEH will coordinate with both Dominion and NuStart to complete the analyses and licensing activities necessary to:

- Complete engineering and NRC certification of GEH's standard ESBWR plant design.
    - Support NRC review of the standard ESBWR plant Design Certification application for Final Design Approval.
    - Support ACRS review, Rulemaking, and ASLB hearings, if any, for the standard ESBWR plant design certification.
    - Complete the First-Of-A-Kind Engineering (FOAKE) for the standard ESBWR plant design to the extent possible under the available, allocated DOE funding.
    - Complete detailed ESBWR plant engineering and design and construction planning to be ready for construction of the standard ESBWR plant to the extent possible under the available, allocated DOE funding.
- Support NuStart preparation and submittal of a COL application for Entergy's Grand Gulf site. This award provides no funding for support to NuStart for activities related to NRC review and approval following submittal to the NRC of the COL application for the Grand Gulf site; however, NuStart will continue to be engaged, along with Dominion, in providing input to GHNEA regarding the development of the generic ESBWR design.
- Support and administer the activities to achieve the project objectives, including:
    - Development and maintenance of detailed work scope and resource loaded integrated schedule that support these Objectives.
    - Preparation and upkeep of Performance Baselines, (cost, technical, and schedule), Work Breakdown Structure (WBS) including WBS dictionary and implementation of an Earned Value Management System (EVMS).
    - Development, implementation, and maintenance of project manuals, policies, and procedures as necessary to ensure work is conducted and meets quality expectations as well as project and NP2010 Program goals and objectives.
    - Apply project control mechanisms to the performance of project activities substantially the same as those project control mechanisms described in the "DOE Interface and Oversight Agreement" between Dominion and DOE, issued June 23, 2005, for implementation on September 30, 2005.

In order to support these program goals, GEH assembled a broad team consisting of GEH resources as well as EPC organizations and other engineering firms with extensive experience in the design and construction of nuclear power plants. The GEH Team implemented the programs, plans, and procedures necessary to execute the project, including, for example:

- Quality assurance programs
- Project organization, responsibilities, and reporting relationships
- Project execution plans
- Budget and schedule controls and processes
- Policies and procedures manuals
- Training and indoctrination program

GEH performed project management and administration activities during execution of the project to support work completion in accordance with the established budgets and schedules. Project reporting was also performed as part of the project management activities. This reporting included

- Monthly EVMS reports
- Quarterly progress reports
- Quarterly financial status reports
- Project status meetings (mid-year reviews)
- Annual continuation applications including budget reports

At the completion of the program, the NRC is in the final steps to issue GEH the final design certification for the ESBWR design. This will be a significant accomplishment and will satisfy one of the key goals of the program. Additionally, GEH supported the development of the Reference COL for Dominion's North Anna site, which was submitted in November of 2008, as well as the subsequent COL for Entergy's Grand Gulf COL. These were the two COLs that were included as part of the original NP2010 program scope. In addition to these two, COL's were also developed for Exelon's Victoria County site, Entergy's River Bend Site, and Detroit Edison's Fermi Site. Subsequent to the submittal of these COL's, all but Detroit Edison have suspended or cancelled their license applications due to various market factors. Had Dominion elected to continue to pursue the completion of their COL, it is expected that they would have received their license before or shortly after the completion of the program. Detroit Edison has assumed the role of Reference COL and at the time of writing this report, Detroit Edison has no open items associated with the NRC's review. According to the latest NRC schedule, the Final Safety Analysis Report for the DTE COL is scheduled for issuance in May 2013. This will represent a second major accomplishment that reinforces the success of the program.

Additionally, GEH developed significant design information for the ESBWR standard plant beyond that which was strictly required for the certification effort. Although the amount of design completed was scaled back considerably in 2009, due to suspension of several key ESBWR customer projects, the capital cost estimates for ESBWR have continued to be refined through the development of additional equipment specifications and design as well as more refined commodity data.

a. *In your opinion, did the purpose of the NP2010 DC/DF Project satisfy a clear need or shortcoming in the nuclear community? Were the NP2010 program goals and objectives satisfied by the activities and results of the DC/DF Project projects?*

The NP2010 program filled a clear need in the industry. The schedule timeline and investment requirements associated with obtaining a design certification are significant. The payback on these investments has a high degree of uncertainty based on future market factors that are difficult to project. Items of uncertainty include volatility of gas prices, uncertainties in energy policy, uncertainty of economic growth and power needs, and uncertainties in regulatory approval timelines. DOE's leadership in promoting standardized design development and support of licensing improved the attractiveness of committing the investment in new plant designs in advance of market certainty.

b. *What specific and existing problems, interests, and/or needs did DC/DF Project and NP2010 as a whole address? Are there outstanding industry issues, problems or barriers to nuclear plant deployment that should have been addressed through the program?*

The primary item that was addressed through the NP2010 program was the uncertainty associated with the part 52 licensing process, both in terms of schedule and effort. Completion of the Design Certification and issuance of a Reference COL will provide significant improvements in the confidence of regulatory timelines.

One key item that has not been demonstrated is what type of review timeline will be required for the nth of a kind COL application. While multiple COL's have been submitted for individual technologies, the review schedule for all COL's has been driven primarily by resource limitations from the NRC associated with multiple concurrent reviews or by delays in Design Certification activities. To date, there has not been a Subsequent COL application that would show what could be expected to be a typical review timeline for an nth of a kind COL application. This will serve as a key variable in evaluation of future programs by utilities considering new nuclear power plant deployments.

Additionally, the NRC review process continues to be a lengthy one and the actual schedule for obtaining NRC design certification is substantially longer than anticipated.

c. *Describe any flaws in the DC/DF Project concept or the NP2010 program design that may have limited the program's effectiveness or efficiency.*

Overall, the NP2010 program was well constructed. One key item that presented challenges to effective program execution was the annual funding nature of the program. Variations in annual funding caused disruptions in the staffing/resource plans which resulted in inefficiencies in the completion of work. It is understood that DOE tried to limit this effect by offsetting the program budget periods from the government fiscal calendar, but the program still had significant uncertainties on an annual basis. Also, the original program structure which placed the vendor's in a sub-recipient role provided some empowerment of the utilities to drive decisions in the area of design certification and key conceptual design inputs. In some cases, utility representatives involved in the technical working groups were driving decisions that were based purely on technical preferences of the operators, but in some cases drove substantial capital cost increases. A specific example is the incorporation of a full bypass condenser design. As the designs evolved, capital costs increased. These cost increases were driven by a combination of design enhancements, changes driven by regulatory requirements, and by increased information as the level of design detail increased. In future DOE programs, consideration should be given to developing a capital cost target for viability of new nuclear plant projects early on in the program based on input from Utilities that are evaluating the technologies as sources of new generation.

d. Were the DC/DF projects and/or the NP2010 program appropriately structured to efficiently address the program's purpose and goals? How could program resources have been more effectively targeted to achieve needed results?

The program structure was appropriate to address the program's stated goals. The restructuring of the Cooperative Agreements was beneficial to reduce the administrative burdens on implementation of the project activities.

One element of the program that caused some contention in the initial phases of the COL development was the lack of definition in the anticipated split between information provided in the COL and information provided as part of the Design Certification. GEH's perspective was that the utilities defaulted to including standard content in the DCD even in some cases when the information seemed to be more appropriately handled in the COL. This disagreement peaked as GEH was trying to "lock down" the content of the DCD in Revision 4 while the COL applicants were preparing Revision 0 of the COL. Based on the cost share nature of the program, both sides had a financial incentive to have the other party address various topics in the associated licensing documents.

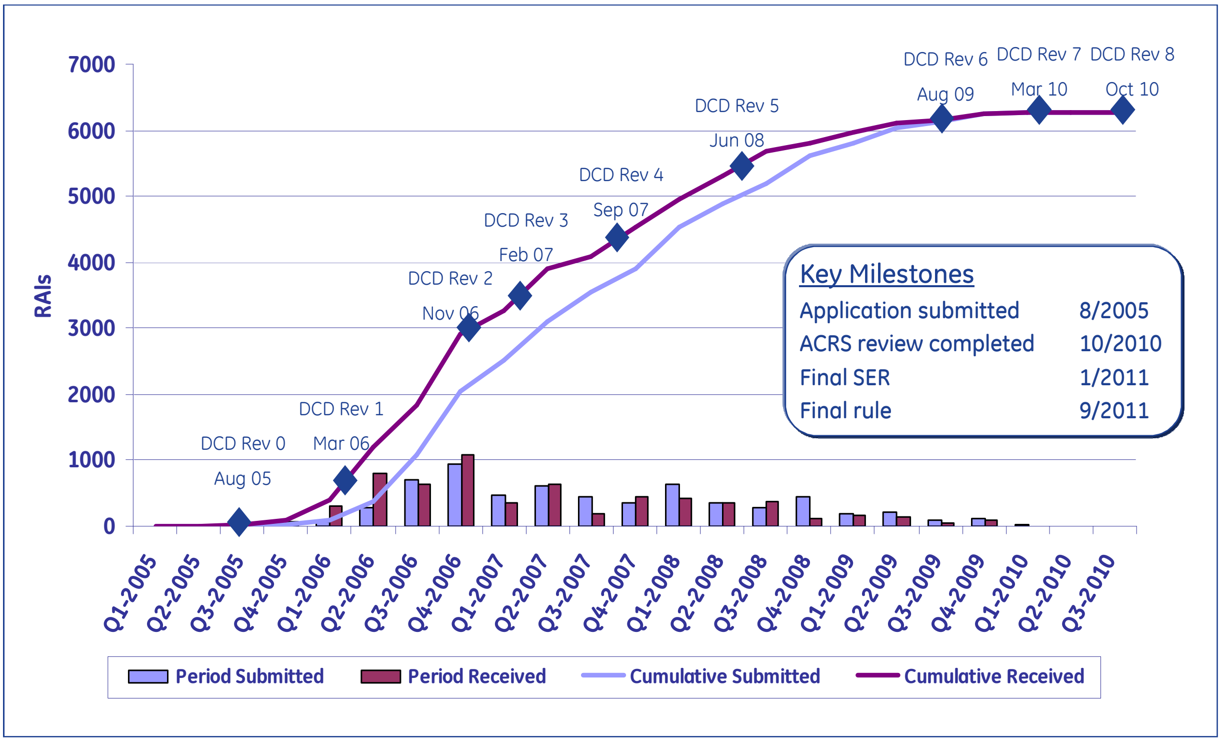
e. How effective was the use of a "cooperative agreement" approach involving cost-shared arrangements between DOE and industry?

The use of Cooperative Agreements was an acceptable method for implementation of the NP2010 program. Unfortunately, due to the FOAKE nature of this program and uncertainties associated with the regulatory review, aspects of this program were difficult to predict in terms of work required. For GEH, the most notable issue was the significant overruns from the original budget in the area of design certification. Based on discussions with the DOE program office, it was agreed that any overruns in design certification would be offset by reductions in design finalization as the program baseline was set with limited opportunity to change. Many of the utility participants expressed dissatisfaction with this concept and wanted the work to progress to the originally planned levels in all areas despite the increases in costs associated with licensing. A different outcome could have resulted if an award instrument other than a cooperative agreement was used.

2. ***Project Execution***
Provide a complete description of each phase of your DC/DF projects from development of the DC application through submittal to the NRC and the review process to date. Identify continuing tasks and expectations if the DC/DF Project is not complete at the time the report is submitted. Upon completion of the project or end of the cooperative agreement activities, an addendum or update will be provided addressing any further activities or accomplishments since the initial report. Discuss the major activities undertaken at each stage and significant results achieved. Address key accomplishments in terms of the program's goals and objectives. Please address the following additional questions in your description.
   a. *Provide a brief summary of the history of your participation in the NP2010 program with significant milestones and current project status.*

GEH prioritized its efforts around completion of the ESBWR Design Certification during the course of the NP2010 program. Overall, the amount of effort required for certification was significantly underestimated and, as the program progressed, it became apparent that there was not a well understood standard for the level of detail to be provided as part of the Design Control Document (DCD) and supporting documentation. This contributed to the larger than expected number of requests for additional information (RAIs) received from the NRC on the ESBWR design. In addition to the uncertainty on level of detail required, the responses to NRC RAIs often did not result in closure of the identified issue. This was caused by a lack of adequate communication between GEH and the NRC. GEH often generated RAI responses that did not fully address the NRC staff's question. Additionally the RAI questions did not always fully capture the NRC reviewer concerns. In the latter case, even if the question was answered fully, often times there was more to the reviewer's concerns than were written in the NRC RAI. In the course of the ESBWR review, GEH provided 6,270 responses to the NRC. These were provided in response to 4,574 RAIs and 1696 supplemental RAIs issued by the US NRC.

A high-level timeline showing the volume of RAIs relative to the timing of the various DCD revisions is shown below:



GEH established a project plan based on its experience in certifying the ABWR during the early 1990s, as the first action under the new regulatory framework set forth in 10 CFR Part 52. GEH estimated that the evolutionary design of the ESBWR would result in approximately 1.5 – 2 times the number of RAIs. Initially, during the NRC review of the ESBWR DCD, GEH and the NRC conducted phone calls for each of the NRC RAIs to ensure both organizations had a clear understanding of the reviewer's question and preliminary strategies to address the review question were discussed. At first, this was effective. However, as the volume of NRC RAIs increased, conducting phone reviews for each RAI became unmanageable.

The volume of RAIs was the most difficult to manage during the period from mid-2006 through early 2008. Additionally, the resolution of reviewer comments and question was complicated further by revised NRC review guidance in March 2007 subsequent regulation amendments related to design certifications and Combined Licenses in August 2007. During this period, the volume of RAIs was very substantial and it was difficult to effectively manage and prioritize the RAI responses based on the high volume of RAIs received and the significant backlog of RAIs awaiting response. Because of this, at times, the NRC reviewer's question was not clearly answered or in some cases, not well understood by the GEH team. In addition, GEH upgraded Tier 1 and its associated inspections, tests, analyses, and acceptance criteria (ITAAC), including Design Acceptance Criteria (DAC), based on revised NRC guidance and increased involvement of the NRC Construction Inspection Program inspectors reviewing ITAAC with a focus on

ITAAC completion. While GEH was challenged by the increased number of RAIs and elevated NRC expectations, GEH recognized that the overall 10 CFR Part 52 process was evolving with the increased number of applications for design certifications and Combined Licenses, and the ESBWR Design Certification review was underway during this period of adjustment on the part of the NRC and the industry.

In 2009, the volume of RAI traffic and the number of unresolved RAIs began to decline to a number that once again could be effectively managed. It also was apparent that some issues would remain in some form of a stalemate without management intervention. GEH created a list of key licensing issues that were reviewed with the ESBWR Design Centered Working Group (DCWG) to establish a recommended closure path and then discussed with NRC staff and management to ensure both sides were in agreement on an acceptable solution. Also, GEH and NRC had elected to share draft FSER material with the ACRS well in advance of the NRC staff's completion of the FSER. This allowed GEH and NRC staff to address ACRS member concerns earlier in the process and facilitated a more efficient ACRS review of the NRC Staffs' FSER with no open items. GEH made a number of compromises during the course of the NRC review in terms of level of detail provided, extent of design commitments, and DAC/ITAAC requirements.

b. *Outline all of the significant obstacles faced in developing the design certification and related COL applications, particularly with regard to budget and schedule.*

As noted above, a major challenge related to the ESBWR Design Certification effort was the evolving nature of the regulations. Topics such as Cyber Security, Aircraft Impact Assessment, Digital I&C and others caused for multiple perturbations in various aspects of the design. Additionally, Regulatory Guide 1.206 was developed and finalized during the review period. This guide provides a description of the expected level of detail for a Combined License application and, thus, relates to level of detail for design certification applications. Because of the lack of precedent for and the nature of Combined License applications under the Part 52 licensing process, there was significant uncertainty with regards to the required level of detail to be included in an application which is submitted concurrent with the referenced design certification application review. Additionally, the ESBWR review was already underway when the NRC began using tools to manage its resources, so GEH and the NRC never shared a fully-developed resource loaded NRC review schedule. Development of such a schedule would not only improve the ability to forecast project durations and costs, but additionally, this tool would also serve to align expectations by both the applicant and NRC on the complexity of a topic, the amount of resources expected to be applied, and a general guideline for establishing planned budgets. The NRC now has experience with a resource-loaded schedule and GEH expects that sharing schedule expectations with applicants will become a fully-integrated part of the review process.

c. *Discuss the DC review process and your interaction with the NRC. Include a discussion of the "design centered working group" and "reference COLA" approach.*

The use of the Design Centered Working Group (DCWG) concept was very beneficial. This concept allowed for all interested parties to evaluate issues and formulate strategies that could be applied to the broad range of potential plants, further enhancing plant standardization. In addition, the forums including all DCWGs provided consistency across the industry on key new topics and regulatory issues. Again, this allowed for all interested parties to collaborate on proposed solutions and generally resulted in commonalities and consistency on various generic topics across the industry. NEI played a key role in industry coordination for the initial wave of design certification applications, as well as the first wave of Combined License applications filed between 2008 and 2009.

d. *What were the difficulties in coordinating the review of a DC (or DC amendment) in tandem with the COLAs? Discuss the issues and alternative approaches that utilities should consider.*

GEH originally intended to finalize the content of the ESBWR design certification before the initial Combined License applications were submitted. Continued necessity for changes in the DCD content challenged the ability to integrate the Combined License Content with the DCD Content. To address this, GEH, NuStart, and Dominion established a collaborative working group with key members of the Combined License project teams co-located with the GEH team. In the end, this resulted in more integrated DCD/ Combined License products because of the amount of interaction with utility representatives when finalizing DCD content, including Combined License action items, DAC/ITAAC descriptions, and other information presented in the DCD.

e. *Discuss your organization's interactions with other stakeholders and the impact on successful execution of the demonstration projects.*

GEH participated in a number of industry groups related to new plant development. The primary industry groups in the US were the various NEI Task Forces and associated management and oversight groups as well as the EPRI Advanced Nuclear Technology program. These groups addressed a number of generic topics and interfaced regularly with the NRC to reach resolution of issues, such as treatment of COL action items, operational programs, and design acceptance criteria. In addition, industry and the NRC established a Design-Centered Working Group (DCWG) concept that allowed issues to be addressed on a technology-specific basis. In the ESBWR design certification application review, the DCWG developed an approach for items such as ITAAC for digital instrumentation and controls design acceptance criteria, site-parameters, radwaste longer-term storage, setpoint control program, and pressure temperature limits report. To further enhance the DCWG concept, potential ESBWR customers assigned an individual to work directly with GEH on a day-to-day basis to provide feedback from an operational and maintenance perspective.

Both the broader industry groups and the DCWG impacted the overall design certification approach, elements of design features, and resolution of issues. Although these interactions may have resulted in some re-work or changes as the NRC review progressed, the ESBWR design has been enhanced to be state-of-the-art, both from a regulatory perspective and from a customer viewpoint. GEH believes that these interactions had a positive impact on successful execution of the ESBWR design certification demonstration project and the associated COL application development and ongoing NRC review.

f. *Describe your experience to date during the NRC DC review process. What level of effort was required to address post-docketing tasks? Was there a need for adjustments to the resources initially designated to these tasks?*

The ESBWR design certification application was submitted prior to NRC establishing an Office of New Reactors, and prior to NRC amendments to regulations and guidance related to the 10 CFR Part 52 process (e.g., 2007 amendment to Part 52; revisions to NRC Standard Review Plan; revisions to numerous regulatory guides, including development of new regulatory guides aimed at new reactor projects; amendments to security regulations; and promulgating new regulations for aircraft impact assessments). Thus, GEH initially underestimated the level of effort that would be involved in NRC review of the application. The application also was submitted before the NRC implemented its resource management program, and the NRC prepared a resource-loaded schedule only after the review was well underway and when GEH and the NRC were well into the "Request for Additional Information" (RAI) process. GEH began the project largely as an Engineering effort, and later expanded support from the New Plant Projects (NPP) and Regulatory Affairs (RA) groups, developing a Project Leadership Team representing Engineering, and RA. By establishing a process for managing the internal process for NRC RAIs, meetings, ACRS reviews, and other regulatory issues, as well as assigning direct interface with the NRC to Regulatory Affairs, GEH was able to reach a point where the project team and the NRC could make adjustments and manage the review schedule more seamlessly.

3. *Cost, Schedule and Project Management Controls*

Discuss the project management approach used on your project, including interactions with DOE. Address cost and schedule status as required by the federal reporting guidelines, including actual versus budgeted costs and respective cost sharing, milestones, completion dates, and variances. Please address the following additional questions in your description.

a. *Describe your experience with the DOE required Earned Value Management System and its effectiveness for this type of project.*
    i. *How was the cost-schedule baseline established?*

ii. *Was the work breakdown structure (WBS) adequately defined, and did it provide for effective DOE management control? Should WBS have been defined differently?*

iii. *How effective were the cost control program and its budget tracking activities for reporting budget information? Was the frequency and required level of detail optimal for this type of project?*

GEH performed project management and administration activities during execution of the project to support work completion in accordance with the established budgets and schedules.

A key element for the effective management of a project is the WBS structure. The WBS provides a common framework for the natural development of the overall planning and control of the project and formed the basis for dividing work into definable increments. The WBS structure implemented for the GEH Cooperative Agreement provided an effective and logical breakout of program activities and was organized around the primary products of the project which were generally aligned with the program objectives.

Originally, while GEH was performing work under two separate Cooperative Agreements, much of the work being performed was considered generic in nature and applied to both cooperative agreements. This presented several challenges as the NuStart and Dominion Cooperative Agreements did not share a common WBS structure. GEH shared a common WBS structure with Dominion and then mapped the GEH/Dominion WBS structure to the NuStart WBS structure for those "generic" or common activities that would be applied to both sub awards. This process was cumbersome and made it more difficult to trend overall program performance. At the current stage in the project with the information available from the experience to date, some potential changes to the WBS may have been beneficial at the level 2 portion of the WBS structure. Two key areas that could have been optimized from a level 2 standpoint were in Design Certification and Design Finalization. In the area of Design Certification, a level 2 structure that revolved around specific licensing products could have been more effective. Examples of Level 2 elements could have been (a) Design Certification Document (b) Licensing Topical Reports (3) NRC Staff FSER (4) DAC/ITAAC. In the area of design finalization, a more meaningful level 2 structure could have implemented various phases of design (i.e. Preliminary, Conceptual, Detailed, etc.), before moving to the level 3 descriptions of system, component, and structure.

The project implemented EVMS in the execution of the project activities as required by the Cooperative Agreement. Although required by the program, the nature of the activities of the NP2010 program did not lend themselves naturally to effective monitoring through EVMS. For example, the volume and timing of the NRC RAIs and the associated GEH effort required to respond, in terms of man-hours, varied greatly by topic. GEH did not find an effective method of laying out a well-defined set of activities that encompassed all of the effort expended to close out the NRC reviewer questions and support the development of the NRC's SER. Therefore, rules of credit for earned value were difficult to establish. This theme continued as the review progressed from NRC staff to ACRS. Again, GEH was not able to find an effective method to make resource loaded schedules that closely modeled the actual effort expended or to make predictive forecasts about the project performance based on observed trends to date.

The restructuring of the program in 2007 created some difficulties relative to the overall program baseline schedule. At the time that the GEH Cooperative Agreement was established, GEH inherited a baseline funding level that was the conglomeration of various portions of two separate cooperative agreements and their associated baseline schedules. At the time of the restructuring, it was already apparent that the original budget levels from the 2005 baseline were not consistent with the level of effort being expended on the licensing process and additionally, as a more detailed understanding of the effort required for detailed design was obtained, it also became apparent that the 2005 baseline funding levels would not be sufficient to complete the detailed design of ESBWR.

The original program baselines were developed in conjunction with NuStart and Dominion through incorporation of GEH inputs on resource estimates for the completion of the program objectives. These estimates were developed using subject matter experts and consultation with various external organizations that were targeted as potential subcontractors for the GEH scope of work under the program. These estimates were developed early in the program and were based on the previous GEH experience with ABWR licensing and FOAKE design work. In the area of design certification, the amount of effort to prepare the original DCD document was well understood. The amount of effort required to support the NRC review and address NRC questions was not well understood. In addition to the DCD submittal, GEH ultimately submitted 56 additional Licensing Topical Reports on a variety of subjects to support the NRC's technical review. In the area of design, industry expectations for the level of design completion were not well defined. Particularly in areas such as I&C design where a significant portion of the I&C design for a given plant is validation and testing of the logic implantation in actual hardware. As GEH refined its estimate for the completion of all design activities to support plant construction and startup, the overall design estimate increased substantially.

b. *How effective were the performance measurement baseline (PMB), the budgeted cost for work schedule (BCWS), budgeted cost of work performed (BCWP) and the actual cost of work performed (ACWP) tools for cost and schedule reporting? Was the frequency and required level of detail optimal for this type of project? Discuss your interaction with DOE project monitors, including periodic reporting requirements, meetings, or other such interactions.*

The Performance Measurement Baselines provided limited value in the licensing and initial phases of the design activities. The licensing activities consisted largely of responding reactively to NRC reviewer questions as the review progressed. This activity was not predictable and comparison of BCWS, BCWP, and ACWP did not provide information that was particularly meaningful. The initial design phase was also driven to a large extent by needs from licensing. For the detailed design portion of the program the PMB proved to be more useful, however, evolving licensing requirements and associated changes in basic design documents caused rework that would not necessarily have been a trigger for a PMB baseline change. Optimally, engineering activities would have been split into a pre-licensing phase and a post licensing phase. Once the licensing basis was established, EVMS metrics would provide valueable performance indicators on the progress of the design finalization activities.

c. *Please provide a breakdown of your costs for each phase or activity of the demonstration project. Include the application development process, support for application review questions/issue resolution, NRC fees, COL application support, design finalization or FOAKE activity and project management. Provide a comparison of original cost and schedule estimates with the actual project cost.*

Program Budget (in thousands)

	2005 Baseline	2008 Rebaseline	Current Approved	Actual to Date
Project Management	$38,497	$44,939	$27,342	$27,166
Financial/Risk/Decision to Build	$9,525	$10,624	$4,952	$6,322
COL (Prior to award restructure)	$1,545	$1,545	$595	$595
Design Certification	$72,528	$90,731	$175,883	$180,483
Initial Submittal	$18,040	$23,585	$17,197	$17,197
Review	$21,692	$22,261	$88,114	$90,872
NRC Fees	$32,797	$44,885	$70,572	$72,414
Design Finalization	$319,266	$389,544	$194,676	$182,475
Deployment Preparation	$33,131	$33,410	$6,823	$6,823
Total	$474,493	$570,794	$410,272	$403,864

d. *Provide project schedule information including planned versus actual for key events and activities in the project. Define the milestones achieved and those that weren't and why.*

The following tables provide the list of key milestones and deliverables as agreed in the Cooperative Agreement

Table 1 – List of Milestones and Deliverables (BP-1)

Milestone Description	Scheduled Completion Date	Actual Completion Date
Task 1 – Project Management and Administration		
Monthly Earned Value Status	Note 1	Note 1
First Quarterly Progress Report	Jul. 30, 2007	Note 2
First Quarterly Financial Status Report	Jul. 30, 2007	Note 2
Continuation Award Application and Annual Work Scope Plan	Aug. 31, 2007	Aug. 31, 2007
Updated Performance Baselines (Cost, Schedule, and Technical) for all budget periods submitted to DOE	Sept. 14, 2007	Note 3
Second Quarterly Progress Report	Oct. 30, 2007	Oct. 30, 2007
Second Quarterly Financial Status Report	Oct. 30, 2007	Oct. 30, 2007
List of Design Finalization Engineering Reports	Nov. 30, 2007	Note 5
List of Licensing Topical Reports Supporting the Design Certification	Nov 30, 2007	Jan 30, 2008
Task 2 – Financial, Legal, & Risk Assessment		
Letter to DOE reporting Completion of Updated Pricing Estimates	Jul. 30, 2007	Aug. 9, 2007
Letter to DOE Documenting Completion of Agreement with NuStart	Jul. 30, 2007	Note 4
Task 4 – ESBWR Plant Design Certification		

	Letter to DOE Reporting Submittal of DCD Rev. 4 to NRC	Oct. 15, 2007	Oct. 15, 2007
	Letter to DOE Reporting Submittal of ESBWR Plant Initial Core Design Licensing Topical Report to NRC	Jul. 31, 2007	Aug. 9, 2007
Task 5 – ESBWR Plant Engineering			
	Turbine Island Power Cycle Optimization Report	Apr. 13, 2007	Apr. 13, 2007
Task 7 – Deployment Preparation			
	Letter to DOE reporting Completion of Conceptual Modularization Plan	Aug. 31, 2007	Aug. 31, 2007

Note 1 – EVMS reports are due 30 days after closing of the GEH accounting month.
Note 2 – The first quarterly financial summary report and project management report were not submitted because the Cooperative Agreement was not finalized until July 30, 2007.
Note 3 – The updated performance baselines were not submitted as scheduled. A revised project baseline is planned as part of the Budget Period 3 Continuation Application after the Task 5 schedule refinement is complete.
Note 4 – The Agreement with NuStart was executed on Feb 26, 2008.
Note 5 – This list of design finalization reports will be submitted after the completion of the Task 5 Engineering Schedule Refinement.

Note 6 – This list of licensing topical reports is contained in Attachment 1.

Table 2 – List of Milestones and Deliverables (BP-2)

Milestone Description	Scheduled Completion Date	Actual Completion Date
Task 1 – Project Management and Administration		
Monthly Earned Value Status	Note 1	Note 1
Quarterly Progress Report	Note 2	Note 2
Quarterly Financial Status Report	Note 2	Note 2
Continuation Award Application and Annual Work Scope Plan	Aug. 31, 2008	Aug. 30, 2008
Task 2 – Financial, Legal, & Risk Assessment		
Letter to DOE reporting Completion of Level 2 Startup Schedule	May 31, 2008	May 30, 2008
Letter to DOE documenting Update of ESBWR Price Estimate	June 30, 2008	Note 3
Task 4 – ESBWR Plant Design Certification		
Letter to DOE Reporting Submittal of DCD Rev. 5 to NRC	March 31, 2008	June 1, 2008
Task 5 – ESBWR Plant Engineering		
Letter to DOE reporting status of system P&ID completions	Nov. 30, 2008	Note 4
Task 7 – Deployment Preparation		
Letter to DOE reporting completion of Initial Construction Execution Plan	March 31, 2007	March 31, 2007

Note 1 – EVMS reports are due 30 days after closing of the GEH accounting month.
Note 2 – The financial summary report (SF269) and project management report are submitted quarterly.
Note 3 – This update was provided as part of the Semi-Annual Review.
Note 4 – P&ID completion status provided as part of the October quarterly progress report.

Table 3 – List of Milestones and Deliverables (BP-3)

Milestone Description	Scheduled Completion Date	Actual Completion Date
Task 1 – Project Management and Administration		
Monthly Earned Value Status	Note 1	Note 1
Quarterly Progress Report	Note 2	Note 2
Quarterly Financial Status Report	Note 2	Note 2
Task 4 – ESBWR Plant Design Certification		
Quarterly RAI status reports (part of management report)	Note 2	Note 2
Letter to DOE Reporting Submittal of DCD Rev. 6 to NRC	Sep. 30, 2009	Sep 24, 2009
Task 5 – ESBWR Plant Engineering		
Letter to DOE reporting completion of updated Composite Design Specification	Nov. 30, 2009	Dec 2, 2009

Note 1 – EVMS reports are due 30 days after closing of the GEH accounting month. Submittal of EVMS has been delayed as a result of the revision of the project baseline for Budget Period 3 and associated adjustments to the EVMS reports.
Note 2 – The financial summary report (SF269) and project management report including RAI status are submitted quarterly.

Table 4 – List of Milestones and Deliverables (BP-4)

Milestone Description	Scheduled Completion Date	Actual Completion Date
Task 1 – Project Management and Administration		
Monthly Earned Value Status	Note 1	Note 1
Quarterly Progress Report	Note 2	Note 2
Quarterly Financial Status Report	Note 2	Note 2
Task 2 – Financial, Legal, & Risk Assessment		
Letter to DOE reporting completion of Internal	August 2010	Sept 30, 2010

Price Estimate		
Task 4 – ESBWR Plant Design Certification		
Quarterly RAI status reports (part of management report)	Note 2	Note 2
Letter to DOE reporting submittal of DCD Revision 7 to NRC	April 15, 2010	April 8, 2010
Task 5 – ESBWR Plant Design Certification		
Letter to DOE reporting completion of the Update to Reactor Pressure Vessel Drawing	August 2010	Sept 30, 2010
Letter to DOE reporting completion of the NPI Design Review and associated follow-up actions	November 2010	November 30, 2010
Letter to DOE reporting that the latest design certification requirements from FSER are loaded into the Requirements Management Tool	March 2011 Note 3	March 29, 2011
Letter to DOE reporting completion of the update to the Category 1 Structure Seismic Analysis	June 2011 Note 3	
Quarterly Design Document Status Reports	Quarterly	Note 2

Note 1 – EVMS reports are due 30 days after closing of the GEH accounting month. Submittal of EVMS has been delayed as a result of the revision of the project baseline for Budget Period 3 and associated adjustments to the EVMS reports.
Note 2 – The federal financial report (FFR425) and project management report including RAI status are submitted quarterly.
Note 3- The due dates for these two deliverables were swapped due to delays in the Seismic Analysis and better than planned implementation of the Requirements Management Tool.

e. *Elaborate on the primary reasons for major DCD revisions or post-docketing design changes and their impact:*
   i. *Summarize each revision's intent and the reason it was submitted.*
   ii. *How did these changes impact the DC review schedule?*
   iii. *How did changes affect related COL submittals or application schedules?*
   iv. *In retrospect, were there any ways to have achieved better schedule results?*

Revision 1 of the DCD addresses topic areas where the NRC determined more information was needed in order to accept and docket the design certification application. This revision allowed the NRC to docket the application and provide a very early estimate of a review schedule.

Revision 2 of the DCD provided additional information, but was not a significant revision.

Revision 3 of the DCD was the first revision that addressed a number of NRC RAIs and GEH design modifications. Revision 4 further revised the design detail and included a significant change to the format and content of Tier 1 and the ITAAC. Revision 5 incorporated a number of RAI responses and reflected interactions with the DCWG and the NRC related to Tier 1 revisions. Revision 6 further advanced the design of the feedwater controls. GEH essentially finalized the DCD content, with a few minor exceptions, in Revision 7 under the NRC guidance for "freezing" the design so that it could finalize its review and the safety evaluation and move into rulemaking. Revision 8 included a more detailed description of digital instrumentation and control based on feedback from the ACRS as to what it deemed necessary. Revision 8 also completed the few remaining items, such as PCCS hydrogen control, aircraft impact assessment, and addressed the few NRC staff and ACRS comments for which GEH committed to make a change to the DCD. Finally, Revision 9 incorporated very minor changes as a result of the NRC inspection of aircraft impact assessment and final audit of the PRA.

Each revision addressed different aspects of the NRC review. Until Revision 7, the NRC was concerned that the revisions could impact its preliminary review results, but once that milestone was reached in March 2010, the NRC and GEH worked diligently to resolve the few remaining technical issues and complete ACRS reviews.

The reference COLA, which was originally based on North Anna-3, is now Fermi-3. The process worked well in that the COLA for the ESBWR relied significantly on the design certification, incorporating by reference most sections of the DCD. Because this minimized the content being reviewed in the COLA proceeding, revisions to the DCD did not significantly impact NRC review of the COLA. The Fermi-3 COLA revision that references Revision 9 did include certain modifications for site-specific items based on final resolution of those issues reflected in the DCD. The COLA review is ongoing and remains on schedule.

In retrospect, GEH submitted the design certification application as a true demonstration project and it evolved as the NRC guidance and regulations evolved, and as the industry became more engaged in the Part 52 process. While this resulted in an extended review process and a number of changes due to the evolving requirements, the NRC has indicated that the ESBWR design certification is an example to the industry on a number of challenging issues.

f. *Discuss the effect of funding variability on the schedule.*
   i. *Identify the primary drivers for any major cost increases.*
   ii. *How did funding changes impact the DC schedule?*
   iii. *What could have been done better?*

The annual funding variability had the highest impacts in the area of design finalization. In this area, GEH employed significant subcontractors where annual funding disruptions could cause significant financial impacts. Additionally, as Design Certification costs increased, less funding became available for design finalization. The DC schedule was not significantly impacted by funding as this remained the highest priority for the allocation of available funds and resources. The DOE strategy for aligning budget periods with an offset from the government fiscal calendar helped to mitigate the annual funding uncertainties. This allowed some buffer between the calendar date for passing a federal budget and the start date of the next budget period. An even better arrangement could have been the alignment of the budget period with the calendar year. This would correspond to the GEH financial calendar and improve the ease of the annual financial planning process.

IV. First of a Kind Engineering (FOAKE)

Please summarize the development first-of-a-kind engineering or design finalization activities for your standardized reactor design. Describe the preparation of the engineering analyses and calculations, design criteria documents, design technical information, and total cost and schedule information.

GEH completed a substantial amount of design finalization activities for the ESBWR standard plant as part of the NP2010 program. The GEH design process for power plant design consists of 3 basic phases of engineering: (a) conceptual, (b) preliminary, and (c) detailed. This 3-phased design approach is a fairly standard engineering practice throughout industry. The GEH engineering activities are based around design deliverables that define the structures, systems, and components that comprise the ESBWR standard plant. The standard plant consists of both the Nuclear Island and Turbine Island. The Nuclear Island consists of the Reactor Building, Fuel Building, Radwaste Building, Control Building, Service Building, and Firewater Storage Complex. The Turbine Island consists of the Turbine Building, Electrical Building, and Ancillary Diesel Building. Additionally, interface requirements for various yard structures was also included as part of the standard plant design. Typical design deliverables include documents such as P&IDs, Process Flow Calculations, Piping 3-D models/Isometrics, Piping Stress Analysis, Component Design, General Arrangement Drawings, Building outline drawings, building seismic analysis, electrical one line diagrams, cable routing diagrams, simplified logic diagrams, detailed logics, cabinet drawings, etc. In addition to the system, structure, and component design deliverables, The GEH design process includes a series of plant level documents that apply to all systems, structures, and components. These include items such as the integrated plant safety analysis, probabilistic risk assessment (PRA), composite design specification, cable separation requirements, cyber security requirements, etc.

The engineering deliverable preparation is sequenced in a logical schedule based on system relationships. The general sequence flows from mechanical system design to structural (civil) design, to electrical system design, to I&C system design. Additionally, human factors engineering and simulation assisted engineering are incorporated into the overall design process. The majority of design requirements are driven from a combination of regulatory requirements and plant performance/safety analysis requirements. These requirements are translated into plant wide requirements, system requirements, and component requirements in a traceable manner.

The intended endpoint of the design finalization activities was not clearly defined at the program outset, but was generally expected to be through conceptual and preliminary design which would include the design up to the point incorporation of data from actual equipment/component procurement. As the program progressed, utility expectations were clearly voiced that the design finalization expectations were completion of all design activities which expanded significantly beyond the program funding. DOE responded with a rebaselining of the program funding levels which were incorporated into the continuation application process in the fall of 2007, although the increased funding levels were not completely realized through the congressional appropriations process. At the end of 2008, market conditions changed, and several ESBWR customers suspended their ESBWR new plant projects including the cancellation of long lead time equipment orders. Based on the uncertainty in customer levels of commitment and associated timing of ESBWR deployments, the ESBWR activities under the NP2010 program were reduced significantly in the area of design finalization with a primary focus on certification of the ESBWR design. At the end of the program, it is anticipated that all key nuclear island systems major turbine island systems will be at the conceptual design completion stage with significantly more detailed design in specific component and system design areas based on the level of detail required to support the DCD and COL licensing efforts.

1. ***To what extent has NP 2010 contributed to your readiness to reach a decision point to build?***

The NP2010 program facilitated significant development in multiple areas supporting effective decision making relative to new build programs. In addition to the demonstration of the licensing process and establishment of the licensed designs, significant design details were developed around major components and system designs. These design details provided updated information for capital cost estimate development. Finally, key activities around deployment planning provided important information to help account for project risk in the areas of supply chain and construction planning.

   a. *How helpful was the NP2010 program in supporting FOAKE activities?*

The NP2010 program was very effective in supporting FOAKE activities. One challenge was the competition between licensing and design for key project resources. Addressing NRC RAIs and developing response materials continued to consume engineering resources longer than anticipated. The additional licensing costs were offset by reducing available funding for design activities during the program, effectively limiting the amount of design that could be performed under the established NP2010 program.

   b. *What level of effort is required to fully develop FOAKE activities? Please explain any impact that FOAKE activities (or lack thereof) had on DC schedule and budget.*

The expected level of design completion at the end of the FOAKE period has a significant impact on the required level of effort to complete the design activities. ESBWR builds on a significant history of testing and conceptual design for the SBWR plant which accounts for a significant amount of design effort. Excluding the effort required to complete the Design Certification, the engineering estimate to complete the standard plant design is estimated between 4 and 7 million man hours depending on the defined endpoint of the FOAKE activities.

   c. *To what extent has your project and the COLA you are supporting been impacted by the relatively immature state of FOAKE and design finalization along with lack of equipment specifications and identified suppliers? Consider the need to rework documents/calculations and the amount and complexity of RAIs generated during review.*

The impact of design maturity on the DC and COL application reviews has varied depending on the specific topic and NRC reviewers involved. The level of detail provided in the initial revisions of the DCD was limited in many cases by available design information. Example areas where level of design detail were challenging are items such as I&C system design products, system control logics for non-safety significant systems, turbine generator, HVAC design to support dose calculations.

2. *Projected Plant Costs*

Discuss how the Design Certification and Design Finalization projects were expected to alter or did affect the forecasted cost of a new nuclear plant. Provide a listing of the main contributors to changes in the plant cost estimate as the DC/DF project progressed. Provide a current estimate of plant costs based on the technology and site within the COL application.

Initial capital cost estimates were developed based on existing data from the ABWR plant design. Adjustments were made and parametric estimating techniques were used to develop initial ESBWR cost estimates. As design detail data became available, the estimate was refined to reflect updated quantities and pricing data from potential vendors. Based on the level of design completion, a significant portion of the capital cost estimate is still based on parametric estimating techniques, primarily in the bulk quantity data. For cost estimating purposes, this also drives uncertainties in labor estimates. Also, in order to reach closure on licensing issues, in some cases, design changes were implemented that raised the plant capital costs which could be considered overly conservative. Examples include addition of shear keys to the reactor building and very robust PCCS heat exchanger designs due to hydrogen detonation concerns and associated modeling techniques.

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a. *Based on the current status of COL and design certification application development, please provide latest plant construction cost estimates for planned reactors including capital costs, owner's costs, finance costs, etc. A range, bracketed high and low estimates is acceptable.*

To be provided separately

b. *Address whether the efforts of the NP2010 Licensing Demonstration projects and the reactor vendors Design Certification & Finalization projects had any bearing on the plant cost estimates or the ability to forecast them. Address any lessons and solutions in the "Lessons Learned" section.*

The NP2010 program resulted in significant improvements in the ability to forecast the estimated capital costs for a nuclear power plant. The design finalization portion of the program brought improvements to the level of detail in equipment specifications, environmental qualification requirements, performance, and sizing requirements. With this data available, vendor quotes had significantly more credibility for incorporation into capital cost estimates. Additionally, as the licensing requirements progressed and licensing requirements were finalized, the ability to obtain quantity take offs for various portions of the design improved. Finally, beyond advancing design, the deployment planning activities resulted in increased supply chain confidence and more accurate bulk commodity cost forecasting.

V. *Overall Lessons Learned and Experience*

Provide a complete description of the lessons learned during the DC/DF project and potential solutions in these two distinct areas:

1) *Interaction with the Nuclear Regulatory Commission, their regulations and regulatory processes; interactions with the Nuclear Energy Institute or other industry organizations. Include any lessons learned from the utility partnerships or separation from the utility COL cooperative agreements.*

The following list provides a summary of key observations and lessons learned from the NRC licensing process, and GEH's experience during the ESBWR Certification:

- Evolving regulatory requirements presented significant challenges and caused rework in many cases. Examples areas where GEH experienced evolving regulatory requirements include: Changes to the Standard Review Plan (SRP), Changes to Reg Guide 1.206, revisions to various Interim Staff Guidance Documents (ISG), Rule changes and new rule implementation such as Aircraft Impact Assessment. Additionally, new standards or expectations for implementation of existing regulations were also challenging. Examples are setpoint methodology and jet impingement analysis methodology.
- Early ACRS reviews were important to allow the ACRS committee members sufficient time to air concerns early in the NRC staff review process. The ACRS subcommittee reviewed the NRC staff's draft safety analysis reports which were originally based on DCD revision 3. Based on this early review, the staff had sufficient time to address the issue as part of their course of review.
- Lack of resource loaded NRC review schedule made it difficult to manage overall program costs and ensure appropriate GEH resources would be available to support NRC review in a timely manner. Sharing of a resource loaded schedule would also align expectations of both organizations about the volume of work remaining to be performed and an estimate of the volume of questions that could be anticipated based on the number of reviewers.
- The Design Centered Working Group provided a good forum to interact with NRC on various topics. Combined DCWG meetings allowed for all technologies to address cross-cutting NRC questions consistently. In addition to the DCWG which was mostly licensing focused, GEH and the utilities also formed a Technical Oversight Group that focused on issues technical in nature. This was also a good forum and allowed GEH to get consolidated industry input on various technical topics related to design.
- The rate at which design advances should coincide with the needs from a licensing standpoint. Sufficient design must be available to provide complete information for the licensing submittals. However, accelerating design before licensing basis requirements have been finalized causes significant rework. A balance must be struck between the level of detail desired by NRC reviewers versus maintaining the licensing commitments at a high enough level to allow the design to flex with components/technology.
- Vendor interactions early in the licensing and design process are critical to ensure that the licensing and design commitments are supported by component technology.
- Developing the DCD content in conjunction with utilities preparing a COL provides a highly integrated package of licensing products. Unfortunately the division of

responsibility between what is provided in the DCD vs. what is provided in the COL is not well defined. This became an area of contention in some cases where the COL applicants wanted topics addressed in the DCD that GEH did not feel were the responsibility of the OEM.

- Managing RAIs becomes very difficult as RAI backlogs grow. The key to efficient RAI response and timely closure is sufficient interactions on various topics beyond strict written responses back and forth.
- Regulatory process makes it difficult to introduce new technology. The level of questioning to prove new technology is adequate from a safety standpoint makes incorporation of these technologies unattractive from a licensing standpoint even if they are better or safer compared to older, previously accepted technology.
- It would be helpful for the NRC to establish a standard review schedule to allow for adequate planning by reactor vendors. Additionally, this would impose some pressure to NRC staff to perform to some schedule accountability.

2) *Interactions with DOE on program or procurement functions including how the program or project was solicited, organized and procured, funding allocation, cost and progress reporting requirements etc.*
In particular, DOE would like the COL Demonstration Project participants to address the following:

The NP2010 program was well implemented by the DOE and provided a broad scope that allowed participants to address many issues critical to successful deployment beyond strictly a demonstration of the Part 52 licensing process. The consortium approach taken by NuStart was beneficial in providing a broad industry perspective relative to new unit issues. From a GEH perspective, one downside of the program structure was the perceived subordinate nature of the reactor vendors relative to utility participants. Clearly the utilities provide the voice of the customer relative to decisions in licensing and product development; however, the program structure may have overemphasized this.

a. *Discuss the viability of initial cost estimates. What is the optimal timing in the project development/contract lifecycle to provide meaningful and accurate construction estimates?*

The initial cost estimates developed for the NP2010 program significantly underestimated the design certification costs. In comparison with the GEH experience with the ABWR certification, the number of questions and level of NRC review was significantly higher. This was compounded by a significant addition of new NRC staff who, in some cases, asked more questions based on a limited depth of experience. GEH's interactions with NRC management were strained early in the Design Certification process. As the project progressed, GEH was able to reduce the backlog of RAIs and focus on timely RAI response submission. Additionally, after Revision 4 of the DCD was submitted, GEH issued a design freeze on DCD content with exceptions only allowed to address errors or NRC RAIs. Establishing the design freeze was crucial to bringing closure to the remaining open RAIs.

In the area of design finalization, utility expectations for level of design completion under the NP2010 program were high. As GEH looked at the volume of design activity to fully incorporate all data from procurement and issue final drawings for construction, the cost estimate for design increased substantially. A more effective manner of establishing program cost estimates could have been to have design activities divided into 2 phases. The first phase would be the conceptual design necessary to complete the design certification. The second phase would include design to a point where a reasonable level of cost certainty could be obtained. The amount of design to achieve a relatively high cost certainty is substantially less than the amount of design required to support construction drawings.

b. *Discuss the impact on demonstration project risk that the lack of design finalization and incomplete FOAKE status may have played. Would it have been preferable to complete more design work up front prior to DC application submittal?*

As described in the previous section, there is a balance between having enough design to support the NRC expectations on level of detail, but not getting so far ahead in design, that there is significant rework if changes are needed to resolve NRC reviewer concerns. For the early submissions of the ESBWR DCD, more design detail would have been helpful in addressing reviewer concerns and providing sufficient level of detail in the DCD.

c. *Should the sequence of NP 2010 project awards have been handled differently with regard to choosing a reactor technology (e.g., parallel COL/DC reviews versus completion of certification first)?*

Both the Dominion and NuStart models had advantages in their forms of implementation. Dominion's model where a single reactor vendor was chosen and they focused their effort on their deployment only provided an efficient model by which they could make decisions unilaterally relative to customer expectations or needs. This autonomous decision making capability provides a level of clarity to a reactor vendor on how to respond to the need. In contrast, the NuStart forum provided a broad industry perspective and provided an opportunity to receive consolidated industry inputs. In both cases, the development of the COL in conjunction with the DCD allowed for a very high level of integration between the two documents and was generally viewed as a positive by GEH.

d. *How closely did demonstration project performance meet goals specified in the project plans? What caused any differences or delays?*

The ESBWR demonstration project will have met the goals of demonstrating the Part 52 licensing process. Additionally, significant design details were developed to support a more thorough capital cost estimate. Finally, the work performed in the area of deployment planning has also proved to be very valuable for responding to customer needs around site planning, permitting, pre-construction work, supply chain strategies, module strategies, logistics, etc. The level of design finalization effort was reduced from the original program spend plan based on levels of customer commitment to proceeding with a new plant project.

e. *Please explain any other significant issues that occurred during the NRC review that impacted the effectiveness of the demonstration project (e.g., change in designated lead plant, level of utility commitment, uncertainties in the regulatory process, and uncertainties in funding). How can these factors be dealt with more effectively in the future?*

The changes in the economic environment in 2008 made a significant impact in the pace at which new plant projects were moving forward. Several potential ESBWR customers suspended or cancelled their plans for ESBWR projects. This had impacts on the rate at which DOE and GEH supported the design finalization activities. Additionally, this change also impacted the priority that the NRC staff gave the ESBWR DCD application. In both the ESBWR and AP1000 design centers, the RCOL changed during the course of the NP2010 program. In the case of the ESBWR, the level of standardization between the various COL applications made for a smooth transition. Most of the RAI's and associated responses provided by the initial R-COL applicant were applicable to the new R-COL applicant after the transition. Additionally, the level of standardization in the COL limits the amount of material provided in the COL that is not merely incorporation by reference of the DCD.

VI. Insights/Recommendations

Please provide general comments on the effectiveness of the Demonstration Projects, specific experiences involving implementing processes for COL application and design certification development and review, and recommendations for future DOE sponsored projects of this type or similar industry projects could be implemented more effectively. Please use this section to discuss any other relevant information that the industry participants feel is pertinent and useful.

Overall, the NP2010 program was a very successful program that benefited the industry greatly. Although the number of utilities moving forward with new plants is significantly less than the number of COL applications submitted, the program provided a great catalyst for the ongoing industry activity. The cost sharing nature of the program promotes effective stewardship of the federal funds while supporting industry growth and development of new innovative products.

VII. Appendices

Provide detail data, schedules or other pertinent information in appendices as appropriate.