1. Introduction

The U.S. nuclear industry is making significant progress toward overcoming technical, financial, and regulatory barriers to deployment of new nuclear power plants. This paper describes the barriers to new plant deployment in the United States and discusses how these barriers are being addressed by the nuclear industry with support from the U.S. government, the Electric Power Research Institute (EPRI), and other organizations.

2. Barriers to deployment of new nuclear plants in the United States

No new nuclear power plant construction projects have begun in the U.S. for decades. The lack of new construction activity has constrained the industry’s ability to support human and capital resources for engineering, manufacturing, building, supplying, and regulating new nuclear power plants. The infrastructure has been downsized to a maintenance level and it will take a significant revitalization effort simply to build enough new nuclear capacity to maintain nuclear’s share of the electricity supply as demand continues to grow. This revitalization effort must overcome the technical, financial, and regulatory barriers that have stymied new nuclear plant construction in the U.S. and will rely on support from international suppliers with recent nuclear plant construction experience.

2.1 Technical barriers

New nuclear plant designs with the potential for near-term deployment have been developed with simplifications and improvements that will allow them to out-perform the current fleet. However, there are many technical issues that must be resolved in order for large scale deployment of new nuclear power plants to be successful. Prospective standard plant designs require further design work and licensing review in order to be near-term competitive options. The industry needs to improve innovative designs and develop opportunities that take full advantage of standardization with the goal of enhancing plant competitiveness. New non-light-water-reactor concepts require further technology development before they can be considered for deployment in the U.S. The industry is still in the process of developing a viable long-term strategy to optimize the nuclear fuel cycle.

2.2 Financial barriers

Models and analysis have shown that a new fleet of plants must rely on standardization and deployment of “families” of new plants in order to be economically competitive. The uncertainty of cost, schedule, staffing, workforce, vendor supplies, construction capabilities, and infrastructure for deploying families of new plants are critical factors in the decision to build the first of a family of new plants. Financing, risk mitigation, government support, and continued strong public support are needed to ensure timely progress on decisions to build the first plant of a standardized design.

2.3 Regulatory barriers

The next generation of new nuclear power plants will be licensed under a new set of regulations, different from the process that was followed for existing nuclear power plants. The new reactor licensing process has three separate phases, Early Site Permit (ESP), Design Certification (DC), and Combined Construction and Operating License (COL). The ESP process allows a company to apply for and obtain
approval for a plant site prior to making a final decision on whether or not they will actually build on that site. DC signifies the NRC’s approval that a specified design meets regulatory safety standards. A COL permits the construction and subsequent operation of a specified design at a specified location. The combination of the license to construct and to operate a new reactor is a key change to the regulatory process compared with the process that was in place when the current fleet of nuclear power plants was licensed.

While the new process is intended to be a major improvement over what was done in the past, it has yet to be fully demonstrated. The licensing process has not yet been shown to be sufficiently workable and predictable to support building a first new plant. Regulatory concerns have been a factor in delaying near-term business decisions to build families of plants.

3. EPRI’s work to address barriers

In order to address technical barriers to new plant deployment, EPRI is working in concert with utilities to upgrade certified LWR designs and obtain certification of new LWR designs. Most of EPRI’s recent work in this area has focused on the Westinghouse AP1000 (AP1000) and General Electric Economic Simplified Boiling Water Reactor (ESBWR) designs. EPRI is working to improve these innovative designs with the goal of enhancing plant competitiveness, particularly by enabling the industry to take full advantage of standardization. EPRI is also working to reduce the uncertainty in the cost and schedule for construction of new nuclear power plants.

3.1 Westinghouse AP1000

The NRC published the final design certification rule for the Westinghouse AP1000 design in early 2006. This certification ensures that applicants for a combined license may reference the AP1000 design certification and can be assured that the commission will treat as resolved those issues settled in the certified design rule. EPRI has worked on projects to further the progress of the AP1000 design toward being implemented through a COL application. In 2005, EPRI’s efforts in support of the AP1000 included tasks related to the construction and startup schedule, the static and dynamic stability of facilities, the containment vessel design, tests and procedures, and human system interfaces.

EPRI’s work to explicitly define the engineering tasks and durations required to satisfy COL information items for both first and Nth plants resulted in an integrated AP1000 master engineering schedule which includes about 3000 activities and is being used to manage continued AP1000 engineering and design development. Efforts related to the seismic stability of the AP1000 buildings are focused on the three approved ESP sites, some of which exceed the ground input spectra for the AP1000 in the high frequency range, EPRI is working to resolve this issue. EPRI is working to resolve this issue. EPRI is supporting a task to demonstrate the methodology required to qualify the AP1000 containment vessel for nozzle loads and assist in definition of a set of loads to be used in the design specification. Westinghouse is continuing to develop the AP1000 startup and preoperational test program, including representative test procedures and EPRI is supporting the effort to provide a description of this program for the AP1000 COL application. This work will continue into 2007. EPRI sponsored a program to develop an AP1000 simulator that was used to perform human systems interface tests modeling four plant systems - the reactor coolant system, the steam generator system, and the normal residual heat removal system. The tests revealed human system interface issues whose resolutions will be incorporated into the design and implementation of the AP1000 instrumentation and control systems and control room.

3.2 General Electric ESBWR

The NRC received General Electric’s application for final design approval and standard design certification for the ESBWR in late 2005. EPRI is providing design certification support for the ESBWR and will support work on design related COL items for the ESBWR.
In 2005 EPRI co-sponsored research on the effects of high temperature on the ESBWR primary containment. Advanced structural analysis results from this work were instrumental in showing that: 1) all thermal stresses within the ESBWR containment are below ASME code allowables, 2) a containment liner design differential pressure of 10 psid was adequate to account for pressure buildup behind the containment liner due to concrete out gassing during extended operation at elevated temperatures, and 3) the thermal duty cycle expected in the ESBWR isolation condenser and passive containment cooling pools over the 60 years of plant operation do not result in structural concrete degradation.

3.3 **Generic technical issues**

EPRI also has recently completed and is continuing projects focused on generic issues for new nuclear plant design, licensing, construction, and operation. These projects have covered seismic design issues, new plant staffing, and COL application content.

### 3.3.1 Seismic issues

The New Plant Seismic Issues Resolution Program (NPSIRP) consists of five seismic technical tasks (performance-based methodology, probabilistic seismic hazard modeling methodology, median ground motion standard deviation, ground motion incoherency, and high spectral amplitudes) that have been structured to develop technical bases documents for updating the NRC’s seismic regulatory guidance (Regulatory Guide 1.165 and sections of NUREG-0800). A sixth task was defined to manage interactions with the NRC staff as required to resolve generic seismic issues in a timely manner and to update seismic regulatory guidance with current technical methods and approaches.

### 3.3.2 New plant staffing

EPRI sponsored a review and analysis of existing staffing studies that may be useful in staff optimization for new nuclear power plants. The review considered whether each model included a functional analysis of individual tasks, covered a full spectrum of nuclear power plant staffing process areas, assumed streamlined organizational approaches and a high level of plant standardization, covered multiple plant operational modes, provided a staff/resource trade-off analysis, and was benchmarked to staffing levels at operating plants. The review also categorized models as either an analysis of staff requirements or a survey of existing staffing, and either a human-systems interface analysis or a judgment on effects of technology efficiencies. Other key considerations in the review were whether a model has potential for fleet deployment business models and if it is currently available as a model for new plant staff optimization planning. While most of the available studies offered some of the characteristics listed, and the combination of the studies covered a wide range of these characteristics, none of the studies addressed multiple plant operational modes, and only one of them is currently available as a model for new plant staff optimization planning. There exists no current platform for staffing analysis that provides a comprehensive basis for staff planning and optimization at new nuclear power plants.

There are significant variations in staffing levels at existing plants as well as in the projections of staffing levels for new simplified designs. The various studies reviewed in this EPRI project generally showed that limited staff reductions at advanced plants could be achieved for single unit sites compared to current plants. Much greater savings could be achieved by deploying a fleet of standardized plants – many of the studies showed significant staff reduction could be achieved with 8-12 plants in a fleet.

EPRI’s on-going work in the staffing area is currently focused on security issues. EPRI will publish a report in 2006 that discusses perimeter intrusion detection issues, technologies, and solutions for nuclear power plants. EPRI is researching technologies such as remote fire weapons, unmanned vehicles, sticky foam (instantly plugs holes in steel doors/walls), and cold smoke (provides vision obstruction). EPRI is also participating in NEI’s New Plant Security Task Force and providing technical support/technology assessments for security review committees working with NuStart and individual utilities.

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3.4 New plant deployment program model

EPRI’s key on-going effort toward overcoming financial and regulatory barriers is its New Plant Deployment Program Model (NPDPM). The new plant licensing and deployment process is a five to ten year activity costing upwards of one billion dollars and requiring coordination with federal and state regulators, designers, engineering architects, and numerous other contractors. Planning is crucial to schedule and budget control, and EPRI is seeking to address the current lack of integrated macro-tools for supporting decision making and planning. The NPDPM is intended to assist near-term utility COL applicants as well as to provide the tools and skills to support larger and longer term needs. The model identifies schedule and resource requirements from the point when a sponsor decides to build a plant through commercial operation. The model includes elements such as initial business case development, site and design selection, input needs starting from ESP and DC, pre-COL application activities, design and site program activities, activities to fulfill requirements set in the COL (e.g., Inspection, Test, Analysis and Acceptance Criteria (ITAAC) verification), activities to construct the plant, and activities to conduct pre-operational testing.

Work on the NPDPM began in 2005, a preliminary version of the model was developed using the Westinghouse AP1000 design as a basis. The preliminary model defined 44 top level (Work Breakdown Structure (WBS) level 1) tasks starting from development of the business plan and concluding with commercial operation of a new nuclear power plant. Among these top level tasks were four milestones: final project decision, COL application submittal, COL issuance, and finally beginning operations. The 2005 effort continued with schedule development and a draft of further task breakdowns for the activities leading up to the COL application submittal milestone. Work in 2006 will focus on developing a full, front-to-back, deployment plan to be reviewed by utility planners with comments being used to update and improve the schedule and incorporate resource information into the plan. Work will continue in 2006 to provide a greater depth of the breakdown of the post-COL application tasks and complete a full base case model, with the base case of a certified design being built on a green field site without an ESP in place. Potential critical path items for the NPDPM include meteorological data collection, seismic characterization, human factors/control room design, major component manufacturing and delivery, ITAAC verification, construction and operations approvals (other than NRC), and permitting, land acquisition, and construction for transmission access.

4. Industry progress with government support

Progress toward overcoming the technical, financial, and regulatory barriers to new plant deployment is evidenced by recent federal legislation, government support of nuclear power initiatives, design development and certification efforts on the part of nuclear power equipment vendors, and industry commitments to prepare licensing applications for new plants.

4.1 Energy Policy Act of 2005

The Energy Policy Act of 2005 offers key financial incentives for new nuclear power plant construction. Production tax credits will provide tax relief equal to 1.8 cents per kilowatt-hour for up to 6,000 megawatts of new generating capacity. These tax credits will be available for the first 8 years of new plant operations. The legislation authorizes loan guarantees for nuclear power and government standby support in the form of risk insurance to cover costs associated with plant start up delays that are beyond the control of plant sponsors. These provisions are focused on the first new reactors of the next generation, it is anticipated that the experience gained during the regulatory and construction phase of the first new reactors will benefit those that enter the market later on. The energy policy act also extended the Price-Anderson Act, continuing no-fault insurance coverage and liability limitations that protect nuclear power plants in the event of an accident until the year 2025.
Table 1  Application Status for ESP and Planned Applications for COL

<table>
<thead>
<tr>
<th>Who</th>
<th>Where</th>
<th>Technology</th>
<th># of Units</th>
<th>When – ESP Application</th>
<th>When – COL Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominion</td>
<td>North Anna Site, Virginia</td>
<td>ESBWR</td>
<td>1</td>
<td>Under review, expect approval in 2007</td>
<td>2007</td>
</tr>
<tr>
<td>Duke</td>
<td>William States Lee, South Carolina</td>
<td>AP1000</td>
<td>2</td>
<td>May go directly to COL</td>
<td>2007 / 2008</td>
</tr>
<tr>
<td>Entergy</td>
<td>River Bend Site, Louisiana</td>
<td>ESBWR</td>
<td>1</td>
<td>May go directly to COL</td>
<td>2008</td>
</tr>
<tr>
<td>Exelon</td>
<td>Clinton Site, Illinois</td>
<td>TBD</td>
<td>TBD</td>
<td>Under review, expect approval in 2007</td>
<td>TBD</td>
</tr>
<tr>
<td>NuStart (TVA)</td>
<td>TVA Bellefonte Site, Alabama</td>
<td>AP1000</td>
<td>2</td>
<td>May go directly to COL</td>
<td>2007</td>
</tr>
<tr>
<td>NuStart (Entergy)</td>
<td>Entergy Grand Gulf Site, Mississippi</td>
<td>ESBWR</td>
<td>1</td>
<td>Under review, expect approval in 2007</td>
<td>2007 / 2008</td>
</tr>
<tr>
<td>Progress Energy</td>
<td>Harris Site, North Carolina Florida (TBD)</td>
<td>AP1000</td>
<td>2</td>
<td>May go directly to COL</td>
<td>2007 / 2008</td>
</tr>
<tr>
<td>S.C. E&amp;G / Santee Cooper</td>
<td>Summer Site, South Carolina</td>
<td>AP1000</td>
<td>2</td>
<td>May go directly to COL</td>
<td>2007</td>
</tr>
<tr>
<td>Southern Co.</td>
<td>Vogtle Site, Georgia</td>
<td>AP1000</td>
<td>TBD</td>
<td>Plan to submit in 2006</td>
<td>2008</td>
</tr>
<tr>
<td>UniStar</td>
<td>Constellation Calvert Cliffs Site, Maryland or Nine Mile Point Site, New York</td>
<td>EPR (design certification in parallel with COL)</td>
<td>TBD</td>
<td>Will go directly to COL, submitting site information early</td>
<td>2008</td>
</tr>
<tr>
<td>NRG Energy</td>
<td>South Texas Project</td>
<td>ABWR</td>
<td>2</td>
<td>May go directly to COL</td>
<td>2007</td>
</tr>
<tr>
<td>Amarillo Power</td>
<td>Vicinity of Amarillo, Texas</td>
<td>ABWR</td>
<td>2</td>
<td>Plan to submit in late 2007</td>
<td>As soon as practicable following ESP</td>
</tr>
<tr>
<td>Florida Power &amp; Light</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>May go directly to COL</td>
<td>2009</td>
</tr>
<tr>
<td>Duke</td>
<td>Davie County, North Carolina</td>
<td>AP1000</td>
<td>TBD</td>
<td>Under Consideration</td>
<td>TBD</td>
</tr>
<tr>
<td>Duke</td>
<td>Oconee County, South Carolina</td>
<td>AP1000</td>
<td>TBD</td>
<td>Under Consideration</td>
<td>TBD</td>
</tr>
</tbody>
</table>

4.2  Department of Energy (DOE) sponsorship

The U.S. Department of Energy (DOE) has co-funded work under the Nuclear Power 2010 initiative to further develop new nuclear plant designs and demonstrate the new plant licensing process. A detailed cost and schedule estimate for building a twin unit Advanced Boiling Water Reactor (ABWR) at a Tennessee Valley Authority site has been completed, and support of new plant licensing is ongoing.

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2 Dominion leads a consortium that also includes three engineering firms. This consortium and the NuStart consortium have received DOE matching funds under the Nuclear Power 2010 Initiative in support of their efforts to demonstrate the COL process.
4.3 New reactor licensing demonstration projects

The NRC is currently reviewing three utility ESP applications. Four plant designs, the AP600 PWR, the AP1000 PWR, the Advanced Boiling Water Reactor (ABWR), and the System 80+ PWR, have been certified by the NRC. The DC application for the ESBWR is currently under review, and four other designs, the ACR-700 CANDU reactor, the U.S. EPR PWR, the International Reactor Innovative and Secure (IRIS) modular LWR, and the Pebble Bed Modular Reactor (PBMR), have been submitted for pre-application review. DC applications are submitted by the reactor vendors who plan to sell the certified designs to utility companies. Several individual utilities and consortia (groups of utility companies and vendors) are planning on submitting COL applications from 2007 to 2009, including consortia that have received DOE co-funding to demonstrate the licensing process. Table 1 provides the details for each planned application.

5. Conclusion

The U.S. nuclear industry has faced technical, financial, and regulatory barriers to new plant deployment that have precluded new plant construction for many years. The industry is working to overcome these barriers with support from the U.S. government, EPRI, and international suppliers. Technical barriers are being addressed by industry research including work managed by EPRI in the areas of seismic evaluation and security staffing. EPRI is also working on a new plant deployment program model that will help to reduce uncertainties in new plant construction cost and schedule. Regulatory barriers are being addressed with industry efforts to demonstrate the new plant licensing process, including three ESP applications under review, four certified designs with additional applications planned and under review, and several COL applications under preparation. These research and deployment activities are expected to lead to new nuclear plant builds in the United States.

6. References