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"Long-Term Strategy for Nuclear Power"

Marilyn C. Kray
Vice President, Project Development
Exelon Corporation

I. Introduction

As the largest U.S. nuclear operator, Exelon Corporation is dedicated to the safety performance of its existing 17 reactors. It is committed to continuous improvement and operational excellence. As one of the largest power producers and wholesale marketers, Exelon is also focused on maintaining the long-term balance between electricity supply and demand. This paper is intended to offer insights regarding nuclear power, within the context of the long-term electricity projections.

The most notable and unrecognized attribute of nuclear power is its environmental benefit. Along with various forms of renewable energy, nuclear power is a carbon-free form of electricity generation. Nuclear power is not based on combustion, so the plants do not produce nitrogen oxides or sulfur dioxide that could contribute to ground-level ozone formation, smog or acid rain. Additionally, nuclear energy does not produce carbon dioxide or other greenhouse gases associated with global warming. The electricity produced by nuclear power plants displaces electricity that would otherwise be supplied predominantly by coal, gas or oil fired generating plants.

Most electricity forecasts predict an increase in the demand for electricity in the coming years. Nuclear power has typically provided approximately 20% of the U.S. electricity supply, despite the steady increase in electricity demand. This gradual increase in nuclear generation has been the result of the nuclear industry's strategy to improve capacity factors[1] and increase rated output[2] of the current fleet of U.S. plants. With these generation expansions already extracted, the current fleet cannot be expected to uphold its current contribution percentage given continuous growth in demand.

Given the environmental attributes of nuclear power and the anticipated demand for electricity, nuclear power needs to remain part of the country's overall generation strategy. Part of this strategy should include the construction of new nuclear generation to preserve the non-carbon emitting portion of total electricity generation. Although Exelon has no immediate plans for building new nuclear capacity, it is taking action to preserve and promote the nuclear option for the future.

II. Reactor Technology

One of the critical factors for the future viability of nuclear power is the readiness of advanced reactor technology. Over the span of the next 50 years, there is an emerging evolution of reactor designs. This evolution starts with the advanced light water reactors (ALWRs) that leverage the operating fundamentals of existing plants in the U.S., and replace many of the active safety components with passive features that rely on laws of nature such as gravity feed, convective heat transfer and natural circulation. The ALWR category includes designs such as the Westinghouse Advanced Passive (AP) 1000, the General Electric Advanced Boiling Water Reactor (ABWR) and the Economic Simplified Boiling Water Reactor (ESBWR). Beyond the ALWRs are the gas-cooled reactors that replace water with helium as the reactor core-cooling medium. The gas-cooled reactors appear to precede what are typically referred to as the Generation IV reactors. Although the lines of distinction regarding the Generation IV reactors are sometimes blurred, the Generation IV International Forum (GIF) has identified six reactors as meeting the specified technology goals. When considering designs for potential investment, the following three factors are considered: operational confidence, licenseability and economics.

Operational Confidence

Any investment in new nuclear technology will need to be accompanied by a high degree of operational confidence. That is, the investment analysis must not only appeal to the financial and risk evaluators, but must also be endorsed by the organization that takes ultimate responsibility in operating the facility. Operational confidence is based largely on familiarity with system designs, including the individual components and their materials, and the basic engineering philosophy governing the design. The more a design departs from proven and familiar technology, the less is its readiness for deployment. Accordingly, some of the more aggressive designs within the family of Generation IV plants are expected to require significant efforts to demonstrate the acceptability of the fuel and materials, as well as a possible prototype or demonstration plant operation before they are commercially deployed. On the other hand, the ALWR category of reactors is considered deployable following approval by the Nuclear Regulatory Commission (NRC).

One of the lessons learned from the existing U.S. fleet is the value of standardization of both design and operating practices. Although a limited number of fundamental designs were constructed, there have been numerous design changes resulting from regulatory requests and owner enhancements. For the next generation of reactors, increased discipline to prevent departure from the standard design would optimize the cost reductions resulting from economies of scale and the performance improvements resulting from the transferability of operating experience and resources. The Exelon Nuclear organization has benefited greatly from its commitment to standardize the operating practices of its 17 units under the umbrella of a common Management Model. The new generation of nuclear operators will need to adopt a similar commitment to operate the next generation of reactors safely and efficiently. The simplified reactor designs are more likely to remain standardized because there are fewer and less complicated systems and equipment for an individual owner to re-engineer.

Licenseability

Just as the future operators must be comfortable with the selected design, the regulatory reviewers of the design must be adequately satisfied. Since a few of the ALWR designs are evolutions of the currently NRC-approved reactors, it is expected that their review process would be shorter than that of other designs. Within the ALWR category is the Atomic Energy of Canada, Limited (AECL) design for the Advanced Candu Reactor (ACR) 700. The ACR 700 uses a light water coolant, but a heavy water moderator. It also employs a horizontal fuel channel designed for on-line refueling. Although these design features may prove to be acceptable to the NRC, they introduce new accident and transient scenarios that will require additional staff analysis to determine their acceptability. This is also similar for some of the gas-cooled designs that employ alternate containment designs based on fuel protection characteristics. Both the gas reactors and most of the Generation IV designs, such as the lead-cooled fast reactor or the molten salt reactor, would require even further NRC staff evaluations first to modify the existing light water-based regulations to make them applicable for the specific designs, and then to evaluate the proposed designs against the new criteria. This insight was gained through Exelon's previous interaction with the NRC staff during pre-application discussions regarding the Pebble Bed Modular Reactor (PBMR). These discussions have ended because Exelon decided to no longer pursue investment in the PBMR as a strategic initiative. The duration and extent of the licensing process are relevant in estimating the time and cost associated with the NRC licensing of the design for inclusion in the overall economic analysis.

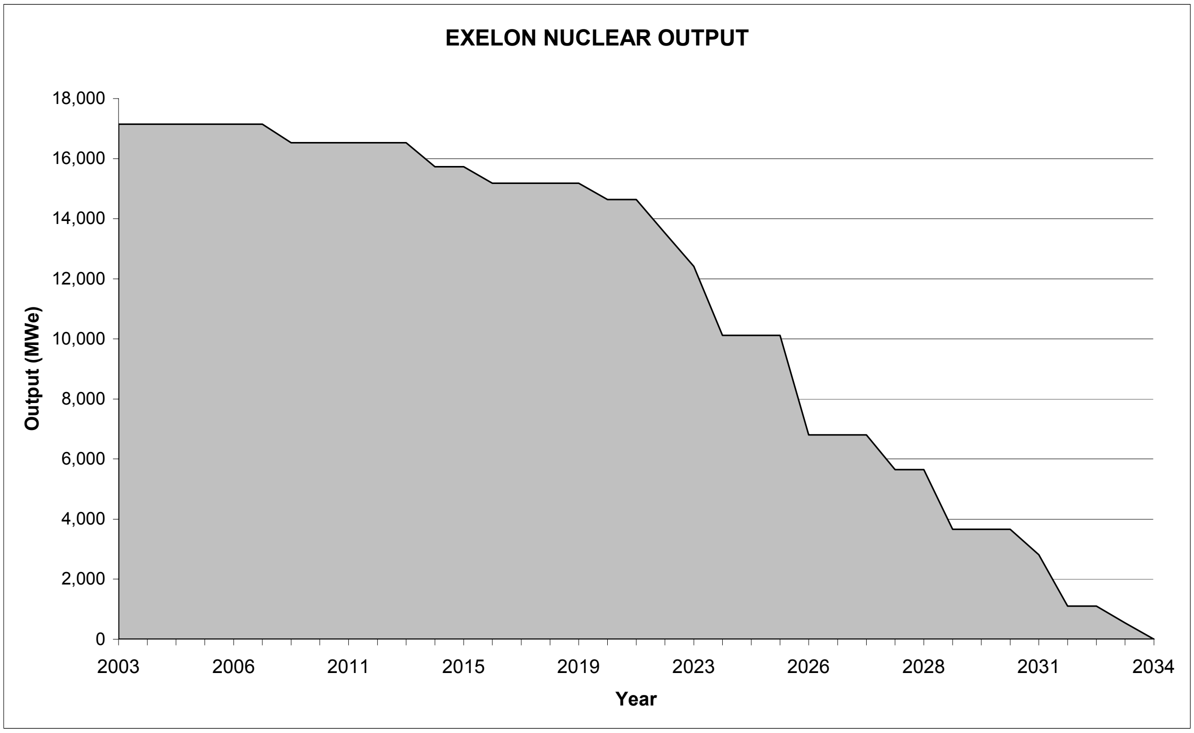
Economics

The industry has informally conveyed an acceptance window of $1000-1200/kwe for the capital cost, excluding financing, for any new nuclear facility. While the reactor vendors have acknowledged this, additional work is needed to confirm that it is achievable. In addition to the construction costs and schedule, confidence is needed in estimating the ongoing operations and maintenance costs, including fuel and staffing levels for the proposed facility. The General Electric ABWR is already operating in other countries. This significantly reduces the uncertainty around many of the economic assumptions. For plants such as the AP1000, which is not yet built, Westinghouse established a Business Plan Team comprised of several power companies, including Exelon, and an architect engineer. The team's goal was to use operational and construction experience to validate the economic data needed to support a detailed business model. It is premature at this time to make construction or operations cost estimates for the Generation IV reactor designs given the state of their design status.

III. Strategic Planning

Licensing timeframes have played a significant role in strategic planning for nuclear power. Nuclear plants have historically been licensed for a 40-year period. This original 40-year term was based on economic and antitrust considerations at the time, and not on limitations of materials or nuclear technology. As such, a licensee can voluntarily request to extend an operating license by demonstrating to the NRC that the plant continues to maintain adequate levels of safety, and this level has been enhanced through maintenance of the licensing basis over the plant's life. Approximately 10 percent of U.S. nuclear plant licenses will expire by the end of the year 2010, and more than 40 percent will expire by 2015.

As stated previously, Exelon currently operates 17 nuclear units, including three units owned through AmerGen. The chart below depicts the approximate gross electrical output of Exelon's nuclear fleet over time, including the curtailment due to license expiration. It includes Exelon's recent success in receiving NRC approval to extend the license for two units, and assumes that the application pending for an additional four units will also be successful. For the remaining units, the chart reflects each unit's current license expiration date, recognizing that license extension decisions for these units will be based on individual cost comparison analyses.



The graph above acknowledges that eventually the current fleet of reactors will retire, although retirements may be delayed by the extension of additional units. It is premature to estimate the amount and type of replacement generation needed. What is evident, however, is that having multiple options available is preferred in order to ensure price competitiveness and fuel diversity. It is hoped that breakthroughs in clean coal technology and renewable energies will be realized in the future. However, it appears realistic to assume that the void created by the nuclear retirements may require some additional nuclear power as the replacement source.

IV. Conditions for New Nuclear Investments

Any nuclear investment made by power companies must be based on a rigorous financial and risk evaluation. Many of the assumptions needed to evaluate a potential nuclear investment have a great degree of uncertainty at this time. In addition to having a passively safe reactor design available, a number of other conditions need to be met in order to enable sound investment decisions for new nuclear plants. The more significant ones are discussed briefly below.

Demand for Power

Many power companies, including Exelon, are operating in a deregulated environment. While there is no longer a need to justify an investment to a public utilities commission by demonstrating that the investment is "used and useful," there must be confidence that a consistent market exists for the resultant product before a firm would invest in new generation capacity. In the case of nuclear power, a reliable demand for baseload capacity must be apparent. The ideal solution may be to have a power purchase agreement in place for the sale of the electricity, at least for the early years of production. In the absence of a power purchase agreement, very high confidence in the projections for demand growth and market prices will be needed to support an investment.

Alternative Fuel Sources

Once the need for additional capacity is established, other fuel alternatives must be considered. Natural gas-fired plants have dominated recent additions to the U.S. generating market, and they are expected to be the primary competition for any advanced nuclear plants. Because fuel costs are the driving component to the total generating costs for natural gas-fired plants, the price of natural gas is critical to the competitiveness of advanced nuclear plants. Even in the absence of carbon restrictions, one reactor vendor has claimed that its advanced design can be competitive at gas prices above $3.50/mmBtu. Exelon preliminary analyses estimate that gas prices consistently above $5 to $6/mmBtu are needed for new nuclear plants to be competitive. Internal modeling of potential nuclear investments also suggest a strong sensitivity to fluctuations in natural gas prices. Increases in the order of $2/mmBtu have a significant impact on the economic returns.

Coal plant investments are somewhat comparable to nuclear investments in that they have similar upfront construction costs and 36 to 48-month construction periods, as opposed to natural gas plants that have cheaper and shorter construction periods. These factors impose a drain on investor earnings as there are considerable expenditures during an extended period with no offsetting revenue stream. For 2002, the average nuclear production costs of 1.71 cents/kWh were just slightly less than those of coal plants which were 1.85 cents/kWh. Where nuclear and coal investments could diverge significantly is in a carbon-constrained regulatory environment. Corporate commitment to environmental stewardship coupled with financial recognition of avoided carbon emissions from nuclear plants would make nuclear power a more attractive investment.

Current Plant Issues

The likelihood of future nuclear investment depends heavily on the performance and issues of the current nuclear fleet. Continued solid industry performance is essential to maintain the confidence of both the public and the regulators. Issues challenging the current plants such as plant security and spent fuel disposal will need to have a clear path to resolution in order to reduce the uncertainty associated with the next generation of plants. With respect to security at nuclear plants, the NRC has issued numerous Orders to its licensees since the September 11, 2001 events. The objectives of these Orders will also be applicable to new plant designs. The advanced reactors will also be required to protect against the NRC-defined design basis threat for the facility.

With respect to spent fuel disposal, the Nuclear Waste Policy Act of 1982 and its subsequent amendments require or authorize the Department of Energy (DOE) to locate, build and operate a deep, mined geologic repository, and to develop a transportation system that safely links nuclear power plants, interim storage facilities and the permanent repository. Yucca Mountain in the Nevada desert was selected as the site for the permanent repository; however, the state of Nevada has objected to this selection, and has aggressively opposed the process set forth to demonstrate the adequacy of the site. Before any new nuclear investments are made, measurable progress will be needed to signal the likelihood of success in establishing the Yucca Mountain site as the final waste repository. Additionally, it should be noted that the Yucca Mountain project is envisioned to be the *first* spent fuel repository. Its capacity was established based on the expected spent fuel from the existing fleet of reactors. Any new reactors will need to re-address the issue of spent fuel disposal, hopefully by leveraging the eventual success of Yucca Mountain.

Regulatory Predictability

A stable political environment and a predictable regulatory process are needed so that licensing costs and duration can be accurately accounted for in investment evaluations. Additionally, the lack of regulatory predictability may adversely impact the financing terms for new nuclear capital projects. The NRC revised its previous process to separate the review of the proposed site from the review of the proposed design. The Design Certification process addresses design adequacy, and the Early Site Permit (ESP) process addresses the adequacy of the proposed site for the reactor. Exelon is one of three power companies who are currently pursuing ESP's for existing nuclear sites, with the intent to "bank" these sites for possible use in the future. The DOE is funding the three ESP projects on a 50/50 cost share basis. The Design Certification and ESP results would then be incorporated into the Combined Operating License (COL) process that authorizes actual construction and operation of a nuclear plant.

With the Design Certification process being exercised by reactor vendors, and the ESP process being demonstrated by three power companies, the component left is the COL process. There are no entities actively seeking a COL at present. To address this gap, the Nuclear Energy Institute (NEI) formed the Advanced Plant Task Force whose objectives include developing an efficient process for the preparation and review of COL applications and developing a predictable process for the construction inspection program. Exelon is an active participant on this task force, which includes frequent interaction with the NRC staff to address the regulatory process issues.

While the results of the Advanced Plant Task Force will be valuable to a future COL applicant, they do not replace the experience gained by the actual preparation and submittal of a COL application. Given the current financial and market environment, there is not a strong incentive for a single power company to be the "first mover" with a new nuclear investment. A group of leading power companies might consider forming a consortium to build and operate an advanced nuclear plant. The goal of this project would be to fully demonstrate the regulatory process as well as validate the construction and operating assumptions. Participation in such a project would require acceptable conditions and returns for the individual power companies.

Environmental Recognition

The environmental benefits of nuclear energy are often mentioned in policy discussions regarding electricity production and the environment, but these benefits are not reflected in any market mechanism that provides financial recognition to nuclear power. These programs were designed solely to achieve reductions in pollution from emitting sources. They do not recognize the role of technologies such as nuclear, hydropower and renewable energy that avoid pollution. In order to preserve the nuclear option, it is necessary to level the playing field for all forms of electricity production. A possible approach to recognizing the environmental benefits of nuclear and other non carbon-emitting forms of generation is to tighten controls for all major pollutants such as nitrogen oxides, sulfur dioxide and mercury; and to adopt controls for carbon dioxide. All forms of generation should be considered in meeting any additional requirements. Implementation of any changes to pollution controls would require a reasonable transition so as to avoid any undesirable supply disruptions.

New nuclear investments also could be encouraged through financial mechanisms similar to those used for other forms of non carbon-emitting generation, such as the existing production tax credit for wind and biomass. Other options include the implementation of an investment tax credit to encourage electricity generation investment by offsetting a portion of the earning dilution typically experienced during construction of capital-intensive projects.

V. Conclusions

Along with other forms of electricity generation, nuclear power is a critical component of the current U.S. energy strategy, providing approximately 20% of the country's electricity. Its unique attributes, highlighted by it being a carbon-free generation source, coupled with the expected increase in demand for electricity suggest that it is a generation option that should be preserved for the future. In order to revive industry investment in new nuclear facilities, actions must be taken now to address and improve upon key areas including reactor design, regulatory predictability and environmental recognition. Some work is in progress by the industry, but ultimate success will require a national energy platform that clearly recognizes the contribution of nuclear power and the actions needed to preserve it.

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[1] "Capacity factor" is defined as the ratio of electricity generated to the energy that could have been generated at continuous full power operation for the stated period of time
[2] "Rated output" refers to the power available at a specified power plant under specified conditions of operation.