Economics of License Renewal in the U.S. – Entergy’s Perspective

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License renewal of operating nuclear power plants in the United States has become one of the most successful U.S. nuclear regulatory activities in the past few years. In 1995, the U.S. Nuclear Regulatory Commission (NRC) published a revised rule in 10 CFR Part 54 that provided the requirements for an operating nuclear plant to seek license renewal. At that time, many people believed that only a select few operating nuclear plants would pursue license renewal and that most plants would operate for no more than 40 years.

By mid-2003, the owners of approximately 52% of the U.S. nuclear fleet of 103 operating nuclear plants have decided to pursue license renewal and more are expected to follow. This change in direction since 1995 can be attributed to the improving economics of U.S. nuclear power plant operation and to the improved regulatory process resulting from the 1995 revision to 10 CFR Part 54.

In 2000, Entergy submitted a license renewal application for Arkansas Nuclear One, Unit 1 (ANO-1). This application was the third to be submitted to the NRC at a time when it was still unclear how successful the regulatory process might be. However, less than 17 months later, in June 2001, the NRC granted a renewed operating license for ANO-1 at a total cost of approximately $11 million.

Due in part to the ANO-1 license renewal success, Entergy now has tentative plans to pursue license renewal for the entire fleet of operating nuclear power plants. Without license renewal, Entergy’s current nuclear fleet capacity of approximately 9,000 MW(e) would begin to decline in 2012. With license renewal, Entergy’s nuclear fleet capacity can remain in place until 2032. This projection does not include the expected improvements in capacity due to power uprate that is currently planned. The combination of power uprate and license renewal will add significant economic value to Entergy’s nuclear fleet.

One of the major factors in strong performance is capacity factor. In 1990, the average capacity factor for U.S. nuclear plants was about 70%. By the end of 2001, the average capacity factor had increased to about 90%. Entergy has done even better in capacity factor improvement. In 2001, Entergy’s nuclear plant fleet had an average capacity factor of 96%. This performance record translates into improved economic status for Entergy’s nuclear plants, which provides further support for making a decision to seek license renewal.

The ultimate decision to pursue license renewal will continue to be primarily an economic decision. If the current positive economic trend for Entergy’s nuclear fleet continues, license renewal for the entire fleet of operating plants is a distinct possibility.

KEYWORDS: license renewal, economics, life cycle management

I. Background

The U.S. Atomic Energy Act of 1954, as amended, provides the authority for the U.S. Nuclear Regulatory Commission (NRC) to issue nuclear power plant operating licenses for periods up to 40 years. This 40-year limitation was based on economic and antitrust considerations, not safety or design concerns. The Atomic Energy Act also included a provision for license renewal.

In December 1991, the NRC published a rule in Title 10, Code of Federal Regulations, Part 54 (10 CFR Part 54) that provided the regulatory basis for nuclear power plant owners to seek license renewal for operating nuclear power plants. Until 1991, the NRC had not identified a need to address the license renewal provision of the Atomic Energy Act. However, by 1991, some of the oldest U.S. nuclear power plants had reached the mid-point of their 40-year operating licenses and license renewal was something worth considering.

The 1991 rule allowed nuclear plant owners to extend the 40-year term for additional terms of 20 years each. It required an applicant to identify “aging mechanisms unique to license renewal” that could affect the safety performance of plant components and structures. During follow-up pilot studies by the nuclear industry to support prospective license renewal applications, it became clear the new rule was more complicated and expensive to implement than necessary. The pilot studies were abandoned and the NRC agreed to revise the license renewal rule.

In 1995, the NRC published a revised rule in 10 CFR Part 54 that provided the requirements for an operating nuclear plant owner to seek license renewal. Based on the original rule published in 1991, the estimated cost just to prepare a license renewal application was about $40 million with an estimated NRC review schedule of about 60 months. Under the revised rule, the estimated cost to prepare an application was reduced to between $10 and $15 million with an NRC review schedule of less than 30 months.

Although the revised rule generated considerable interest
among nuclear plant owners, the decision to seek license renewal was and is fundamentally an economic decision. In 1995 many people believed that only a select few operating nuclear power plants would pursue license renewal and that most would operate for no more than 40 years. The primary reason for this belief was that the cost of keeping U.S. nuclear plants running did not appear to be economically competitive with other forms of electricity generation.

By 1998, the economic conditions in the U.S. were changing dramatically. Electric utility deregulation was moving ahead, the need for electricity was growing, and the operating costs for nuclear power plants were declining. In response to these improving conditions, in 1998 the first two applications for license renewal were submitted to the NRC by Baltimore Gas & Electric for the two-unit Calvert Cliffs nuclear plant and by Duke Energy for the three-unit Oconee nuclear power plant. However, the U.S. nuclear industry was somewhat skeptical that the NRC could complete the license renewal process for these first two applicants in a timely and predictable manner. This skepticism was due to the protracted and unpredictable process used by the NRC to approve the original licenses and the failure of the 1991 license renewal process to be shown workable.

In March 2000, the NRC approved the renewal of the 40-year operating licenses for the Calvert Cliffs nuclear plants for an additional 20 years. Two months later, the NRC approved the renewal of the Oconee operating licenses. These reviews were both completed by the NRC in a timely, predictable, and stable manner.

As of April 2003, the NRC has approved renewal of the operating licenses for 14 nuclear units (capable of producing approximately 12,000 megawatts of electricity) and has applications under review for 16 more units [see Table 1 and Table 2]. Several additional nuclear power plant owners have notified the NRC of their intention to seek license renewal by 2005. This means that the owners of approximately 52% of the U.S. nuclear fleet of 103 operating nuclear plants have decided to pursue license renewal and more are expected to follow. This change in direction since 1995 can be attributed to the improved economics of U.S. nuclear plant operation and to the improved regulatory process resulting from the 1995 revision to 10 CFR Part 54.

II. Economics of License Renewal

Is the decision to seek license renewal in the U.S. purely an economic decision based on the cost of license renewal? Based on recent analysis, more factors need to be addressed, although this is an important aspect of the decision.

When analyzing the economics of license renewal, it is clear that getting 20 more years of operation out of a large base loaded electric generating plant that is “paid for” is well worth the $10 to $15 million cost of license renewal. But if that were the only criteria for seeking license renewal, why aren’t all the operating nuclear power plants in the U.S. working on license renewal? The analysis must consider several other important factors before a decision is made.

The primary question for deciding whether to seek license renewal for Entergy can be summarized as follows:

“Is this nuclear plant capable of making a reasonable return on investment 20 to 40 years from now?”

If the answer to this question is affirmative, then the decision to seek license renewal is a positive conclusion. If the answer to this question is negative, then the decision to seek license renewal is a negative conclusion. However, if
the answer to this question is uncertain, then the decision to seek license renewal is more difficult.

Often the answer to this question is uncertain. As a result, the decision to seek license renewal becomes more difficult. What are some of the factors that can make this decision difficult? One of the most important questions is:

What will the price of electricity be in 20 years for the area where the nuclear power plant is located and what will it cost to produce electricity at the 40 year old nuclear plant?

In many cases, this question has a range of possible answers that include everything from showing the plant will not be profitable to showing that the plant will be extremely profitable. The variables related to this question that need to be considered include such difficult issues as:

- potential and magnitude of major capital expenditures needed to allow the plant to operate for 20 more years,
- price of natural gas or other competing forms of electricity generation in the next 20 years,
- demand for electricity in the next 20 years,
- economic growth of the region over the next 20 years,
- advances in technology for other forms of non-polluting electricity generation in the next 20 years,
- allowance for environmental “credits” to discourage future air pollution,
- support or lack of support from the federal government for the continued operation of nuclear power plants,
- U.S. energy policy or lack of policy,
- public opinion about nuclear power plant operation,
- regulatory environment (NRC, EPA, etc.), and
- many other difficult to predict issues that could impact the profitability of operating a nuclear power plant for an additional 20 years.

Most of these variables require educated “guessing” to come up with an answer and some are highly uncertain. Since many of the answers are uncertain, a significant degree of risk may be involved in reaching a conclusion. As a result, the decision to seek license renewal is often driven primarily by the long-term economic strategy of the organization making the decision, rather than the certainty of an economic analysis. If the economic strategy includes a focus on nuclear power plants as a core competency of the organization, then license renewal is part of that strategy. If it is assumed that nuclear power is going to remain an important part of an organization’s long-term strategy, then license renewal adds value to that strategy.

The following sections will present some of the more important factors that are considered in the decision to seek license renewal. All of these factors have an economic element, but some of them are highly uncertain and the final economic decision is biased by the long-term strategy of the organization.

1. Regulatory Factor

In 1995, when the NRC published the revised license renewal rule, the regulatory environment for license renewal was unpredictable and many nuclear industry representatives were somewhat skeptical that the NRC could complete the license renewal process in a timely and predictable manner. However, following the success of the Calvert Cliffs and Oconee license renewals in 2000, the regulatory process has proven to be reasonably stable and predictable. The NRC schedules for approving license renewal applications have been consistently less than 24 months for the 14 completed license renewals and all indications are that the NRC review schedule will continue to be shortened to 22 months or less due to efficiency gains in the regulatory review process. Figure 1 shows the NRC review schedule for the license renewals completed so far.

![Figure 1 – NRC Review Schedule for License Renewal](image)

The cost of preparing a license renewal application has seen a dramatic improvement. Under the 1991 license renewal rule, a nuclear plant owner would have had to spend an estimated $40 million just to prepare an application. Today’s estimate is roughly one-quarter of that, or less than $10 million, and it is expected that this cost will continue to decline due to improvements in efficiency for the regulatory process. Entergy had costs of approximately $11 million for the ANO-1 license renewal project, which included the cost of preparing the application and the cost of the NRC review of the application.

Separate from the NRC regulatory environment, the electric utility deregulation process in the U.S. is also creating a potentially more positive economic environment for license renewal. A deregulated, competitive electric generating business creates a more powerful business incentive to renew a nuclear plant’s license. Under cost-of-service regulation, a utility’s earnings are based on the regulatory approved rate base – the total investment in plant and equipment. Because a 40-year-old nuclear unit would be fully depreciated, or “paid for” – and thus not part of the rate base – it would have limited earnings potential under a regulated, or cost-of-service, structure. In a deregulated, competitive business, a fully depreciated nuclear plant may be a tremendous asset. It can sell power at marginal cost, which is currently very competitive for a nuclear unit. Such a plant would have a significant profit potential. Entergy has ten nuclear plants, five have a regulated rate structure and five are deregulated [see Table 3].
The current economics of the regulatory factors associated with the NRC license renewal process and the rate regulation environment are favorable for license renewal of nuclear power plants in the U.S. Especially for nuclear power plants located in the rate deregulated regions of the U.S.

2. Socio-Economic Factor

The socio-economic situation in the U.S. has also changed in the past few years such that public opinion is much more positive about nuclear power plants. According to Bisconti Research, Inc., the percent of the U.S. public that favors the use of nuclear energy has risen from 49% in 1983 to a peak level in any survey asking this question since 1983\(^1\). Although socio-economic factors are difficult to quantify in tangible economic impacts, such factors do have intangible impacts that can be significant. A positive public image for nuclear power in general, and for license renewal specifically, creates a favorable economic impact. At present, the socio-economic factor is favorable for license renewal.

3. Safety Factor

Safety remains the top priority for operating nuclear power plants and the safety record of U.S. plants has continued to improve in conjunction with the economic improvements. It is now widely agreed that the top performing plants from a safety viewpoint are also the top performing plants from an economic viewpoint. This close relationship between safety and economics is likely the reason that the positive public perception of nuclear power plant operation in the U.S., and license renewal of nuclear power plants, is experiencing an improving trend.

NRC data on numbers of safety events also shows an improving trend since 1989. Figure 2 is a graph of the number of safety events reported to the NRC from 1989 through 2000\(^3\). This steady trend of improvement corresponds with improving public acceptance of nuclear power.

According to a February 2002 U.S. national survey, 60% of Americans think nuclear plants are safe. The poll found that 66% of Americans favor the use of nuclear energy as one of the primary ways to provide electricity – the highest level in any survey asking this question since 1983\(^3\). Recent polls indicate that 65% of the public believes in the use of nuclear power\(^1\).

According to U.S. Secretary of Energy, Spencer Abraham, in a speech given in February 2002, “... lingering public concerns about the safety of nuclear power plants is an ongoing challenge for the nuclear industry. I think the industry has accomplished the most important work to assure the public – it has operated its plants safely, efficiently, and professionally and earned the trust and respect of an increasing proportion of the public. Recent polls indicate that 65% of the public believes in the use of nuclear power\(^1\).”

Table 3

<table>
<thead>
<tr>
<th>Nuclear Plant</th>
<th>Megawatt Output(^1)</th>
<th>40-year License</th>
<th>Renewed License</th>
<th>Date of Submittal</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANO-1</td>
<td>836</td>
<td>2014</td>
<td>2034(^*)</td>
<td>Renewed</td>
</tr>
<tr>
<td>ANO-2</td>
<td>858</td>
<td>2018</td>
<td>2038</td>
<td>09/2003</td>
</tr>
<tr>
<td>Grand Gulf</td>
<td>1204</td>
<td>2024</td>
<td>2044(^*)</td>
<td>01/2008**</td>
</tr>
<tr>
<td>River Bend</td>
<td>936</td>
<td>2025</td>
<td>2045</td>
<td>01/2008**</td>
</tr>
<tr>
<td>Waterford-3</td>
<td>1075</td>
<td>2024</td>
<td>2044(^*)</td>
<td>12/2007**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deregulated Nuclear Plants (Merchant Plants)</th>
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</thead>
<tbody>
<tr>
<td>Fitzpatrick</td>
</tr>
<tr>
<td>825</td>
</tr>
<tr>
<td>2014</td>
</tr>
<tr>
<td>2034(^*)</td>
</tr>
<tr>
<td>12/2005(^*)</td>
</tr>
<tr>
<td>Indian Point-2</td>
</tr>
<tr>
<td>975</td>
</tr>
<tr>
<td>2013</td>
</tr>
<tr>
<td>2033(^*)</td>
</tr>
<tr>
<td>07/2006(^*)</td>
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<tr>
<td>Indian Point-3</td>
</tr>
<tr>
<td>980</td>
</tr>
<tr>
<td>2015</td>
</tr>
<tr>
<td>2035(^*)</td>
</tr>
<tr>
<td>07/2006(^*)</td>
</tr>
<tr>
<td>Pilgrim</td>
</tr>
<tr>
<td>670</td>
</tr>
<tr>
<td>2012</td>
</tr>
<tr>
<td>2032(^*)</td>
</tr>
<tr>
<td>12/2004</td>
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<tr>
<td>Vermont Yankee</td>
</tr>
<tr>
<td>504</td>
</tr>
<tr>
<td>2012</td>
</tr>
<tr>
<td>2032(^*)</td>
</tr>
<tr>
<td>07/2005(^*)</td>
</tr>
<tr>
<td>Total Megawatts</td>
</tr>
<tr>
<td>8,863</td>
</tr>
</tbody>
</table>

\(^1\) 21\(^{st}\) Edition of “Commercial Nuclear Power Plants,” January 2001
* ANO-1 has a renewed license as of 6/2001
** These dates are for planning purposes only

The contributing factors to this improving public image include:

- good nuclear plant performance (i.e., safety, cost of electricity, and capacity factor),
- recent energy and electricity supply concerns (i.e., California problems in 2001 and the Middle East conflicts),
- more outspoken support by leaders in government and industry, and
- the news media finds the nuclear industry renaissance intriguing (i.e., more positive news articles on nuclear power).

According to U.S. Secretary of Energy, Spencer Abraham, in a speech given in February 2002, “... lingering public concerns about the safety of nuclear power plants is an ongoing challenge for the nuclear industry. I think the industry has accomplished the most important work to assure the public – it has operated its plants safely, efficiently, and professionally and earned the trust and respect of an increasing proportion of the public. Recent polls indicate that 65% of the public believes in the use of nuclear power\(^1\).”
plants as well. Since 1989, the U.S. industry has monitored the performance of three important, redundant standby safety systems used to respond to unusual situations. The latest figures show that key safety systems are highly capable of performing their safety functions if called upon.

Safety is also measured in terms of the industrial safety accident rate. That rate has plummeted from 2.1 lost-time accidents per 200,000 worker-hours in 1980 to 0.24 in 2001. By comparison, the accident rate for the U.S. manufacturing sector was 4 per 200,000 worker-hours in 2000 – the last year for which figures are available from the Bureau of Labor Statistics. The industrial safety rate is a “useful measure of the culture of nuclear safety and the attitude of plant management and staff to safe operation across the board,” according to Ralph Beedle, chief nuclear officer and senior vice president of the Nuclear Energy Institute. “Not only is it safer to work in a nuclear power plant than in general manufacturing, but it’s safer working in a nuclear power plant than in finance, insurance, and real estate.” Figure 3 provides a graphical view of industrial safety accident rates from 1992 to 2000.

Safety factors, like socio-economic factors, are difficult to quantify in tangible economic impacts, but these factors do have intangible impacts that can be significant. A positive safety image for the nuclear industry is especially powerful because of its influence on public perception, government regulation, and political support. At present, the safety factor is strongly favorable for license renewal.

4. Capacity Factor

One of the major factors in strong performance of the nuclear industry is the capacity factor. In 1990, the average capacity factor for U.S. nuclear plants was about 70%, which resulted in 577 billion kilowatt-hours (kWh) of electricity production. By the end of 2000, that figure increased to almost 90%, or 754 billion kWh, and has continued to increase to an expected 91.5%, or 778 billion kWh, in 2002. Figure 4 provides a graphical view of the capacity factor changes from 1980 through 2002.

The two largest nuclear utilities in the U.S., Entergy and Exelon, have done even better in capacity factor improvement than the U.S. average. In 2002, Entergy’s nuclear fleet of 10 units had an average capacity factor of 96.4%, compared with 95.6% in 2001. Exelon’s nuclear fleet of 17 units had an average capacity factor of more than 92% in 2002, compared with 94.4% in 2001. These performance records are translating into improved economic status for nuclear plants, which provides the needed incentive to seek license renewal.

Due in part to the capacity factor improvements, the production cost of electricity at U.S. nuclear plants is now the lowest of any major expandable electricity source according to Resource Data International. In 2001, the latest year for which data are available, estimated production costs at nuclear plants averaged 1.68 cents per kilowatt-hour, which represents a 40% decrease in production cost during the past 10 years. In 1999, nuclear plant production costs fell below those of coal plants for the first time in more than a decade. Figure 5 shows the trend of nuclear electricity production costs from 1991 through 2001.
sources of electricity generation is a major factor in the economics of license renewal. Again, the primary question for deciding whether to seek license renewal is:

“Is this nuclear plant capable of making a reasonable return on investment 20 to 40 years from now?”

With a low cost for electricity production, combined with a relatively low cost for obtaining a renewed license, the answer to this question is likely affirmative. Therefore, the capacity factor has a significant role in determining whether to seek license renewal.

5. Environmental Factor

Electricity produced by nuclear power plants is a major contributor to clean air in the U.S. Nuclear power plants in the eastern U.S. make it possible for many states to meet the requirements of the Clean Air Act. Since the 1970’s, nuclear power plants have contributed to about half of the voluntary carbon reductions achieved so far by all U.S. industries. As shown in Figure 6, data from the U.S. Energy Information Administration indicates that nuclear power plants constitute 76% of the emission free sources of electricity in the U.S., with hydro power plants a distant second at 22%.

![U.S. Sources of Emission Free Electricity Generation](image)

**Figure 6 – Sources of Emission Free Electricity Generation**

Environmental factors, like safety and socio-economic factors, are difficult to quantify in tangible economic impacts, but these factors do have intangible impacts that can be significant. A positive environmental image for the nuclear industry is especially powerful because of its influence on public perception, government regulation, and political support. At present, the environmental factor is generally favorable and becoming more favorable due to public information campaigns. For example, during a 2002 public opinion survey, 61% of respondents who were registered voters and had a college degree were favorable toward nuclear energy. The respondents were then given the following message:

“There are more than 100 nuclear power plants in the United States that generate 1/5th of all the electricity we use in the United States without producing any greenhouse gases or other air pollution.”

The respondents were again asked about their position on nuclear energy, and the favorable rating went from 61% to 75%, a 23% increase in favorable responses.

As a result of such positive public opinion related to the environmental message about nuclear power, the U.S. nuclear industry is now focusing public information campaigns on the “clean air” and “emissions free generation” messages.

One tangible economic impact of the environmental factor could be the introduction of environmental credits or emissions trading. Currently, the U.S. has emissions-trading programs for “renewable” electricity generating capacity and energy efficiency programs, but nuclear plants are excluded from receiving this credit. Without license renewal, the retirement of nuclear power plants in the U.S. would dramatically increase the emission of carbon dioxide or “greenhouse gases,” since the only viable replacements for nuclear plants currently are fossil fueled power plants.

Using data from 1998, nuclear power plants contributed $7 billion in avoided clean air costs for that one year. This amounts to $68 million per year for each of the 103 operating nuclear power plants in avoided clean air costs. With continuing political pressure to deal with clean air concerns in the U.S., it may be possible some day for nuclear power plants to receive the environmental credits that they deserve. One recent example of this possibility is the proposed legislation in New Hampshire to include nuclear energy in its clean air emissions trading program. If approved, the New Hampshire program would mark the first time the environmental benefits of nuclear energy have been recognized in a formal clear air compliance program.

III. Conclusion

Is the decision to seek license renewal in the U.S. purely an economic decision based on the cost of license renewal? Based on recent analysis, additional factors need to be addressed before the decision to seek license renewal is made. One key question that influences this decision is:

“Is the nuclear plant capable of making a reasonable return on investment 20 to 40 years from now?”

Since the answer to this question is uncertain, another important consideration is the long-term strategy of the organization. If the economic strategy includes a focus on nuclear power plants, then license renewal can add value to the corporate strategy.

Therefore, the relatively low cost of license renewal is a positive factor in the decision to seek license renewal. When this positive factor is combined with positive regulatory, socio-economic, safety, capacity, and environmental factors, the decision to seek license renewal is currently affirmative for Entergy’s fleet of nuclear power plants.
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