# Nuclear Power Plant License Renewal

## Policy and Economic Considerations

**Christopher C. Hansen**
**Kansas State University**

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## ABOUT THE AUTHOR

Chris Hansen is a candidate for a Bachelors of Science degree in Nuclear Engineering at Kansas State University. He was selected as a participant in the 1997 Washington Internships for Students of Engineering (WISE) program. His internship was supported by the American Nuclear Society (ANS). This paper is a result of Mr. Hansen's research during the internship.

## WISE

The Washington Internships for Students of Engineering is a ten-week, competitive selection program for engineering students who have completed their junior year and displayed evidence of leadership skills and interest in public policy. The students spend the summer in Washington, D.C. learning how engineers contribute to public policy decisions on technical issues. Frequent meetings with government officials and organizational lobbyists provide an opportunity for the students to examine a wide range of issues and approaches to policy decisions. During the course of the ten weeks, each student selects an individual policy issue to research and completes a paper. For more information about the WISE program, contact Anne Hickox, 400 Commonwealth Dr., Warrendale, PA 15096, 412-776-4841, ext. 476.

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# INTRODUCTION

The light switch. A simple object with a simple expectation each time we use it. The lights will come on. However, the technology and planning that make this possible are far from simple. Capital investments valued into the hundreds of billions of dollars have been made in some of the most advanced technologies on earth to make our light bulbs shine, industries run, and our communications systems connect. Literally, our lives depend on cheap, reliable electricity.

The domestic power industry has entered a period of tremendous uncertainty. Deregulation, and the resulting direct competition, as well as emerging new technologies have made long term planning very difficult in the energy industry. Immediate payoffs and short term stockholder profits will become the chief driving forces in production strategy. Coal, nuclear, hydroelectric and natural gas currently form the basis of U.S. electricity generation technology. However, careful planing will be required to maintain and expand electricity generating capacity. One option is to extend the license period of nuclear power plants.

The use of nuclear fission technology to generate electricity has been in use for over 25 years. The industry was launched by President Eisenhower and his Atoms for Peace initiative in 1953. With much anticipation as the ideal source of power, the nuclear industry thrived. Today, one-fifth of electricity is generated by nuclear fission in the United States.

The Atomic Energy Commission (AEC), the original agency created to oversee nuclear technology, established many rules for the new plants, including limiting the initial license for a facility to 40 years. The conventional wisdom of the time fixed forty years as the amount of time needed to amortize the capital investments of an electric plant. Although there is some controversy about the 40 year restriction, most analysts agree that it is not safety related. [1]

In 1991 the Nuclear Regulatory Commission (NRC), which evolved from the AEC, established a rule allowing utilities to apply for a twenty year extension to their original operating license. This new rule now makes a 60 year life span for nuclear power plants a possibility.

This paper examines the economic and policy issues that must be confronted by a utility to extend the life of its nuclear facilities. Material and technical challenges, ranging from the reactor vessels to the electric cables must be addressed. Governmental regulation, environmental concerns, and opposition from anti-nuclear groups must also be factored into the decision. However, it is the economic bottom line of electricity demand and profit returns that remains the crux of the decision. Fundamentally, each nuclear plant must maintain profitability. Alternatives and recommendations will be explored to meet our

pressing need for electricity. It is clear that each one of us expects the light switch to continue to work.

## I. Nuclear Power Background

The nuclear power industry experienced incredible growth during the late 1960's through the 1970's. The electric industry as a whole was predicting 7 percent growth rate in the U.S. and power companies expanded to meet this expected demand. Nuclear power plants were ordered in record numbers, and capacity grew accordingly. Unfortunately, the demand projected was higher than the actual rate of around 2 percent. Economic pressures of the Arab oil embargo and slowing domestic growth, put the breaks on the rapid pace of expansion. The industry also had its first major safety setback in 1979, when the Three Mile Island reactor had a loss of coolant accident and partial meltdown. Plant orders began to fall off, and several of the facilities in mid-construction canceled. This trend was further exacerbated by the accident at Chernobyl in 1986. Thus, during the last decade, nuclear power has been forced to deal with two problems, poor public support and lower than expected electricity demand.

These problems are steadily being corrected. After a lull in overall plant construction, the supply of electricity is finally lagging behind demand. Power companies are now beginning to consider more capacity. Growth rates in demand have remained steady at approximately 2 percent. Nuclear power represents just over 20% of the current market, thus capacity lost or gained nuclear is significant to the market. Another important trend in nuclear power is the significant improvements in capacity factors. Nuclear power plants in the United Sates have improved capacity factors from an average of 58 percent in 1980 to an all time high of 79 percent in 1995.[2] This jump in capacity factors demonstrates the overall advances in reliability and net generation by the industry. Without question it is the best of times for Nuclear power performance. However, the industry still faces many technical challenges, especially age related degradation. Total plant management of aging is a major concern for plants operating until the end of a forty year license. This becomes even more acute for longer license periods.

## II. Technical Challenges

The first problem a utility must analyze in moving forward with a license renewal application is determining the amount of investment needed to repair or replace aging components. License renewal analysis must answer several key technical questions. Pressure vessels, steam generators, containment building degradation, and upgrading instrumentation and control mechanisms are components that must receive critical attention to ensure the safety of the plant in extended operation. Each entails significant capital expenditures, and the

development of age related inspection programs. Programs for monitoring, and correcting these problems have been and continue to be a high priority for the industry and government research programs.

## A. Reactor Pressure Vessels

The reactor pressure vessel is the most vital component of a nuclear power plant. The vessel serves as the primary containment for the burning nuclear fuel. Critical fission reactions produce high fluence levels of neutrons that can strike the walls of the vessel and cause the metal to become brittle over time. This constant bombardment of neutrons on the metal creates dislocations, or gaps, in the metal's microstructure. When the concentration of dislocations becomes too high, the metal becomes brittle. The brittle metal is then susceptible to failure under the high temperature and pressure conditions of an operating reactor. Steps must be taken to alleviate this problem. However, total replacement of the vessel would quickly end any plans to extend the life of a facility because of the prohibitive costs. [3]

Pressure vessels were originally designed for 40 years, and may require significant rejuvenation to bring them back into safety compliance and restore the ductility to the vessel. The use of an annealing process that can literally bake the embrittlement out of the metal, thus increasing its ductility and making it safe for continued use, is one option. "Defects can migrate to form larger defects, leading to structural failure in the material. Annealing of the irradiated material at elevated temperatures is very important in decreasing the concentration of defects formed by irradiation. Post-radiation annealing can greatly decrease the concentration of radiation defects and they can sometimes be completely eliminated." [4] Annealing technology is not a new process, but it has not been thoroughly tested for use in the nuclear industry. The NRC and the DOE are both working with the industry to determine the viability of this option. During the past several years, the DOE has been responsible for examining reactor pressure vessel annealing. This important research tested the viability of using annealing to extend the life of pressure vessels. In the pilot program, the DOE used a gas fired heating system to raise the temperature of the vessel to over 450 degrees Celsius for several hours. Unfortunately, this research had its funding killed in the last Congress. The industry then stepped forward to complete the project at about its 90 percent completion point. The data analysis should be complete by the end of this year. [5] The initial results both here and abroad are very promising, but further work must be done.

## B. Steam Generators

Another key component subject to long term degradation are the steam generators. Steam generators are used in pressurized water reactors to convert the heat from primary coolant, which comes directly from the core to steam.

This steam is then forced into the turbine assembly, producing electricity. The constant high temperatures and corrosive water chemistry have caused cracking in this vital component. Steam generators installed in the first generation of U.S. reactors have had a life expectancy of around 20-30 years, depending on internal chemistry controls and reactor operating temperatures. Despite intense efforts to control water chemistry and reduce corrosion, these must eventually be fully replaced. Steam generators are a serious economic investment, ranging between $100-200 million. In addition, new generators take about four years to complete, so advanced planning by a utility is a must. The new generators use an advanced stainless steel alloy in the heat exchanging tubes, and are designed to last years longer than the older models. [6] Also, the new design has greater heat exchanging efficiencies, and this can enhance the long term profitability of the plant.

License renewal may give utilities more incentive to replace old generators because of the additional years of component use. For instance, if a utility was forced to replace an aging steam generator in the 30 $^{th}$ year of operation it would have only 10 years to amortize those cost under its original license. The ability to renew would allow a utility to stretch out that payback time to 30 years. License renewal depends on managing aging effects and managing the costs associated with improvements.

## C. Reactor Internals

The reactor internals are stationary, support structures inside of the core vessel. They are subject to extremely high radiation exposures, and can suffer from the same long term degradation as the vessel itself. Embrittlement and mechanical failure are both key concerns. Some study has been done to investigate the use of annealing technology to repair the components, but the most likely solution is to replace them as per test indications. Again, these parts are a safety and reliability concern, but with the proper inspection and design solutions can be found.

## D. Cables/Instrumentation

A nuclear power plant has literally thousands of miles of electrical cable. The cables have two different categories of use, environmentally qualified (EQ) and non-environmentally qualified. The EQ cable is located in areas that would experience rapid changes in pressure and temperature as a result of an accident. Thus, for the safety of the plant, they must be able to operate through the worst accident conditions. The non environmentally qualified cable present a less stringent set of requirements, but again are subject to aging effects and are included in the relicensing of the plant. Both types are typically encased in silicone rubber compounds that become hardened over time, and can lose their dielectric properties. In relicensing, the plant must demonstrate that it has programs in place to inspect the cable throughout the plant. This has been standardized for EQ cable but not with the remaining wire. [7]

## E. Containment Buildings

The last major technical challenge to overcome is the repair and upgrading of the reactor containment buildings. Forty years of weathering and changed standards will force utilities considering renewal to use new concrete and steel construction methods to make the necessary improvements. Early inspection and repair will pay for itself in the long run. The cost benefit ratio for the building shell has been estimated at 289:1.[8] License renewal can be beneficial to safety in both the short and long term, while at the same time being cost effective operationally.

The industry and regulators are well aware that the technical challenges of aging reactors is only the first step in making the decision to renew a reactor's license. The most important factor in the way of plant license renewal is economics. No material or technical impediments exist that cannot be designed for or costed out.[9] However, more research must still be completed, but each is manageable with investments in engineering and materials.

# III. Government Involvement

## A. Nuclear Regulatory Commission

The Nuclear Regulatory Commission has exclusive control of the actual license renewal process, and regulates its implementation. In December of 1991 the first license renewal rule was established, Title10 of the Code of Federal Regulations Part 54. This rule allowed utilities to consider license renewal as a possibility; however, plant engineers found it problematic because it did not give utilities credit for past inspections. A revised rule was adopted in May of 1995 that concentrated on long lived, stationary equipment instead of spreading its focus to components covered in other regular maintenance rules. This change helped the engineers and regulators to focus on the critical components instead of reinspection of already scrutinized parts. This balance continues to be discussed by the utilities and the NRC.

The Electric Power Research Institute (EPRI) and the Nuclear Energy Institute (NEI) have both been involved in streamlining licensing renewal. From their efforts, generic guidelines have been established. Ten license renewal industry reports (IRs) were completed in 1994. These 10 IRs describe the generic technical evaluations of the effects of age-related degradation for PWR reactor pressure vessels, internals, reactor coolant pressure boundary components, containments, and low-voltage EQ cables. This document was then submitted to the NRC for comment. The comments have been 88 percent resolved, with the remaining issues center around EQ cables.[10] Both industry and the NRC are researching better ways to manage this problem.[11] This effort represents a significant milestone in improving the license renewal and it will help reduce

utility cost uncertainty for license renewal. It is hoped that research and cooperation will reduce total application cost and time for utilities and owners groups. The entire application will take 3 to 5 years to complete and approximately 5 years for the NRC to finish its technical review. Following the technical review, public hearings and comments would be accepted and a final decision would be rendered by the commission. This timetable can begin after a plant has been in operation for 20 years, thus leaving ample time, (over 10 years) for utilities to make adjustments to total electricity generation, if needed. Basically, the Commission wants complete documentation to present a robust case to the public that old plants are still safe. [12]

The regulatory structure of the NRC is an ever evolving scope of requirements and enforcement. Decisions of the NRC are not simply a function of staff work and commission votes. The high turnover of the commissioners, the political nature of their appointments, and the power of litigation makes the entire process an exercise in political pressure and oversight. The NRC has a history of playing the tough regulator, providing the public every opportunity to influence the process. The industry feels the NRC is reactionary in nature, and the publishing of safety reports (SALP) that often show minor problems in plant systems has hurt the public relations of nuclear utilities. The current administration has taken a much more strict stance on enforcement. This has been balanced by several pragmatists on the commission. The staff works to find a good mix of compliance and flexibility. [13] However, the industry often believes that it is being scrutinized too harshly.

The NRC also publishes a watch list each month of individual plants with safety concerns. Several plants have been on this list for years at a time. The anti-nuclear forces, such as the Nuclear Information Resource Service and Greenpeace, believe that this indicates the NRC has been ineffective in correcting deficiencies and has not used any teeth in its enforcement. A license has never been revoked for a power plant. [14] However, “watch list” status and its repercussions can have a direct economic effect on the stock market. Investors will normally not invest in plants that have had safety problems, especially those currently under stricter scrutiny by the NRC. Anti-nuclear groups have also been vigilant to challenge nuclear regulation decisions and utility action in the court system. Litigation can delay construction and plant upgrades for years, thus increasing the costs. License renewal will face this same deluge of attacks, and cost estimates will have to be adjusted to pay for legal fees.

## B. Department of Energy

The Department of Energy is the principle agency involved in nuclear technology research. The department has examined reactor pressure vessels, vessel internals stress corrosion cracking, steam generator integrity, and fatigue modeling techniques. This research examined total life management but it was not well funded due to emphasis on the Advanced Light Water Reactor

Development Program.[15] The DOE feels that basic nuclear power research is essential and would not be carried out solely by the industry because it has little short term gain for an individual utility. Congress obviously feels otherwise, and this debate has shaped up to be a classic argument about the role of the government in science.

# IV. Economic Considerations

Economic considerations remain the crux of any relicensing program and they must be constantly reevaluated. They can be clarified into three types: modeling and predicting the electricity demand in the future, understanding the costs of continuing to operate the existing facility and quantifying the costs associated with other options, such as fossil fuels and renewables.

## A. Future Electricity Supply and Demand

The United States currently generates over 3,000 gigawatt hours of electricity or 500 GWe per year. The 109 domestic nuclear plants supply 99.8 GWe of that installed capacity. During the period 2000 to 2015 a total of 47 U.S. nuclear power plants are scheduled to reach the end of their 40 year operating licenses. Those 47 plants represent a net electric generating capacity of 34.5 GWe, approximately 35% of installed nuclear generation.[16]

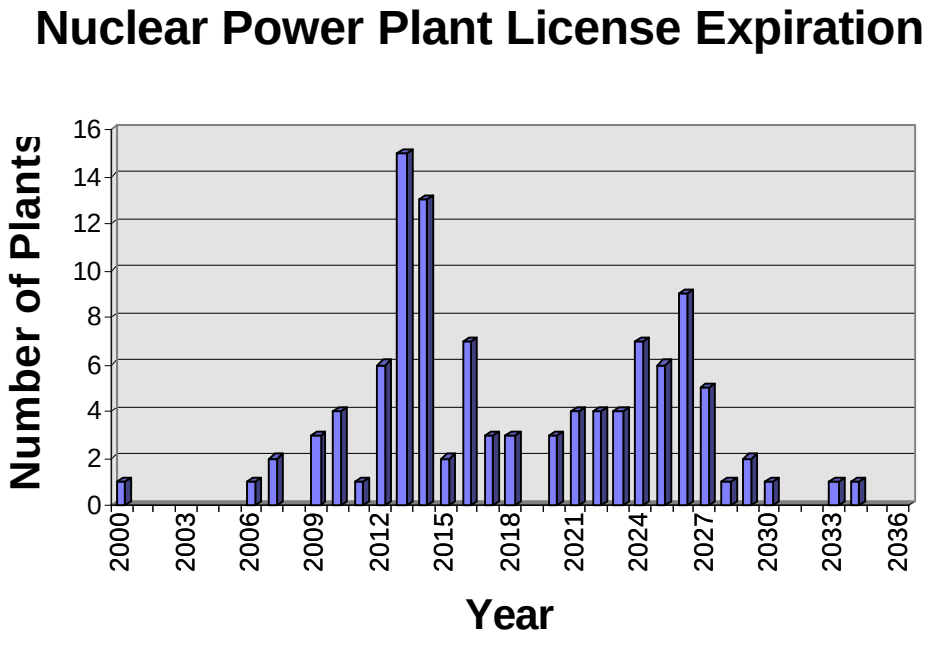


Fig. 1. United States Nuclear Power Plant License Expirations[17]

The United States will face electricity shortages if suitable replacement power capacity or life extension for nuclear plants is not achieved. The striking thing about these statistics is the immediacy of the problem. Within 15 years, 7 percent of our nations current electricity generation will need to be either replaced or renewed. In addition, the expected continued two percent increase in demand must also be adjusted for. This poses both long term and a short term problems.

The electricity supply in the United States is a very regionalized commodity. Electric power cannot be stored cheaply or effectively, which makes it a product very unlike other consumer goods that can be stored and sold at a later date. Electricity must be used immediately as it is generated. Transmission technology is also a limiting factor, while one region may be able to sell excess power to the adjacent regions, it becomes very difficult, for example, for California to sell excess power to Florida. Thus, supply and demand economics are relatively regional in nature. In the Northeast and the areas around Chicago, nuclear power supplies over 40 percent of the electricity. [18] Regionalization electric economy will be a major factor for utility consideration in pursuing license renewal.

Another important economic consideration for a utility is the differences between baseload and peak demands. Baseload demand is the foundation, or the amount of generation needed at all times to keep the grid supplied. Peak power, by contrast, is required only during high demand period, such as a summer heat wave. This demand distinction is very important for utilities because different types of fuels can be used to most economically meet the changing demand. Nuclear power is most cost effective as a baseload source. The marginal cost of nuclear generated electricity is directly related to the overall capacity factor that a plant can maintain. The capacity factor is determined by the total amount of electricity sent to the grid divided by the amount possible if the plant had been on line a 100 percent of the time at full generating capacity. Thus, the higher the capacity factor the more profitable the plant. The industry has made significant improvements in average capacity factor in the past 10 years. If this trend continues, nuclear power can be the lowest cost option for baseload power.

Peak generating plants with heavier costs in fuel than high capital and operating expenses can be taken on and off line more easily. Natural gas turbines are a prime example. They can be quickly put in operation meet peak loads and then relatively cheaply be taken of the grid to save costs. Nuclear power does not have this capability. Profit maximizing utilities must have a hybrid generating base, and the merging of non-nuclear utilities with nuclear facilities provides this “win-win” situation. Such an arrangements can provide complementary peak and baseload generating capabilities, and reduce stranded cost exposure. The market can support both types of generation. The most competitive utilities will

take advantage of the low marginal costs of nuclear power coupled with the lower capital costs of fossil to form a hybrid of grid supply to meet local peak and baseload demands. This is exemplified by the proposed merger of Baltimore Gas & Electric and Potomac Electric, which have contiguous market areas and cite fuel diversity as a main advantage to the merger. [19] Other utilities both large and small are also exploring new configurations to be competitive in the changing market. Duke Power has broaden its scope through acquisitions to become a complete supply through delivery energy network. This diversification is essential to remaining competitive. Industry experts have fixed the benefit of industry wide license renewal at over $49 billion in extra plant value.[20] The rewards are certainly significant.

## B. Application Costs

The process of fulfilling the NRC requirements for license renewal is difficult and costly. Total application costs are estimated to be between $20 and $50 million. This can vary greatly depending on the amount of testing that has occurred in the past and how the plant has monitored passive systems susceptible to aging. Application work can be broken down equally into two parts. Technical work, the actual testing and certification of components and setting up the streamlined process that must be followed to meet NRC requirements. Both involve changing the focus of operations and maintenance to examine the long term. Managing the effects of aging from day one of plant operation must become the priority. Total life management can pay for itself by reducing larger maintenance costs brought on by delayed detection. A paradigm shift in corporate culture from an 'outage to outage' horizon to a multi-decade approach will be very difficult.[21]

The overall goal is to make the approach the new paradigm and help the industry as a whole benefit from the past experiences. This should cut the cost of renewal by several million dollars per plant in the next decade. The NEI is working with the NRC as the industry umbrella organization to facilitate these cost savings through standardization. It is hoped that in the next ten years, costs can be reduced to less than $10 million through generic inspection techniques and environmental submissions.

There are two power companies that are currently considering license renewal, Baltimore Gas and Electric (BGE) and Duke Power. BGE has already begun technical submissions for their Calvert Cliffs Plant, and is committed to sharing the experience it has gained as the first plant to seek renewal. [22] Duke Power is expected complete technical submittals by fall of 1997 and application materials in late 1998.[23] BGE The Babcock and Wilcox and Westinghouse owners groups are also working on generating generic application systems for use at the plants in the group.

## C. Cost Amortization

One of the strongest reasons a utility would want to renew its current license is to help spread the depreciation of capital costs over more years. This could decrease investor liability, and improve the chances of higher profits. This would also help reduce the cost of electricity for the consumer and make capital upgrades more feasible for the electric companies. One example, is a utility that is required to anneal its reactor pressure vessel. Hypothetically, this multi-million dollar project may be necessary during the 35 $^{th}$ year of operation. The costs of which could only be spread out over five years if the plant did not pursue license renewal. With the extension, the utility could payback the annealing investment over 25 years instead of having to absorb the cost during the five years remaining on the original license.

In addition, the utility could use these additional years of operation to collect decommissioning costs. Electricity deregulation has brought both of these stranded cost issues to the forefront. License renewal could help stave off what would be a debilitating trend for the industry.

### D. Insurance

Nuclear power plants must carry huge liability insurance policies throughout the operation of the plant. In a license renewal scenario, an insurance company would have to assess the increased risk of older plants and adjust the rates accordingly. This becomes a significant issue in plant life extension, and could have a large financial cost. This is directly related to investor confidence, and the two will inevitably be linked together.

## V. Policy Issues

### A. Public Safety

The protection of public safety and welfare is a delicate process of balancing risks with economic gain. Inherently, it is a political process. Utilities, regulators, scientists, environmental groups and consumers are all stakeholders in finding a balance between safety and economic growth.

The anti-nuclear groups focus their efforts on playing watchdog over the entire process. Public interest group, such as the Nuclear Information and Resource Service, have been deeply involved in the debate over the safe use of nuclear technology for the past 30 years. They view the current arrangement of regulator and licensee as a conflict of interest. The utilities are the overwhelming majority of the operating budget for the NRC, accounting for $403 million or 85% in FY1996.[24] Thus, they feel that the NRC has an interest in maintaining the industry's profit margins. The public safety, the anti-nuclear groups charge, is placed at risk through this relationship.[25] However, license renewal does give the plant safety engineers to examine components that would otherwise be inspected less frequently. Industry analysts have proposed that

early inspection of passive components could pay for itself. The upgrades necessary for life extension can yield enough short term benefits in improved operations to justify their expense. Plants will be safer and run at higher capacities in the short run because of this long range maintenance approach.

Rising litigation and regulation costs have helped stop new nuclear plant construction over the past 20 years. Proposals to build on new sites must overcoming the "not in my backyard syndrome" and intense environmental standards. License renewal of current plants already certified can help avoid using new sites and new environmental problems.

Ben Franklin once wrote, "A society unwilling to take risk, or a society seeking zero risk will be neither free nor deserve to be free." Risk is involved in all aspects of our life, as a society we must find the balance between risk and safety. Public safety is a tempest of a policy issue.

## B. Environmental Standards

The 'Achilles Heel' of any renewal program can be the imposed tough environmental standards. The rule in 10 CFR 51 forces utilities to recertify the plant's environmental impacts, which can be costly. The NEI has been working to reduce the amount of retesting that must be performed to meet this rule. The industry would like to be given credit for recently performed tests that duplicate the current requirements. The inspection of buried pipes and storage tanks used for diesel fuel is one example. Nuclear power plants must maintain backup electricity generation for emergency situations. This requires an elaborate system of fuel conduits and tanks to ensure fuel will be available for extended periods. This equipment is used during an accident situation, therefore it falls within the scope of aging management inspection. [26] The pipes and tanks require excavation to properly inspect them and utilities would like to avoid this cost by submitting recent past inspection in the place of new renewal inspections. The NRC has been working with the industry and has reduced the number of requirements to approximately 23 report categories from 37. [27] The issue has evolved into a more generic, instead of plant specific, issue. This should result in greater efficiency for the utilities who decide to pursue a renewed license.

## C. Long term waste deposition

One of the key drawbacks of nuclear power is the storage of nuclear waste. This remains one of the key policy questions that must be solved for the long term viability of the nuclear power industry. The 1982 Nuclear Waste Policy Act mandated that the DOE be responsible for storing spent fuel starting in January of 1998. However, this obligation will not be met due to a number of political and

scientific setbacks. This delay will exacerbate an already growing problem of on-site storage at the plants. Many plant's capacity will be full by the end of this calendar year, as was planned for in the original legislation. The utilities will continue to press for government acceptance, which has been upheld in the courts. If this proceeds the utilities will to have to build additional on site storage at the cost of hundreds of millions of dollars. The cost of more storage may derail any license renewal programs.

This has also been one of the largest safety issues. The anti-nuclear groups are very concerned about this exposure, both from the on-site storage and the eventual transportation of the material. The regulation of this transportation dilemma is also viewed as a weak link in the overall protection of the public welfare. There has never been a leakage of radiation in the transportation of nuclear materials in the United States.

The other key concern for applying utilities are environmental justice codes that must be examined for new low level and high level waste facilities. Federal Law requires that any 'major federal action', including nuclear waste facility licenses, must consider minority groups and concurrent land use factors. This can develop into a heated public debate, and should be carefully approached to avoid more costs. Litigation costs can often eclipse initial application costs, and this could easily hold true for waste facilities.

The consideration of plant life extension forces the issues of additional storage space. Clearly, the utilities cannot continue to store the spent fuel on-site for decades. A 20 year license extension will make this problem 50 percent more serious industry wide. The way in which the government and utilities meet this challenge will help determine the outcome of a plant life extension decision.

## D. Clean Air Act

Nuclear Power emits virtually no pollutants into the air. This has been one of the main advantages of Nuclear power since its inception, but now this has become even more important. The recent proposed changes to the Clean Air act may significantly help the nuclear industry. The policy decision to strictly limit the amount of greenhouse gases that industry and utilities are permitted to emit will boost the economic advantages of nuclear plants. Congress is currently trying to weigh the environmental responsibilities with maintaining a growing economy. This entire debate may have profound impacts on the individual decisions of utilities to extend the life of their nuclear plants. For instance a utility that has both coal and nuclear may be forced to close several coal plants to meet the new guidelines, and this will make keeping nuclear generation as high as possible to meet the unmet demand. License renewal may have found its biggest proponent in the place one would least expect it, the environmental groups.

## E. Deregulation and Stranded Cost Recovery

A deregulated electricity market will completely end the practice of standardizing prices, guaranteeing investment return and controlling consumer choice. The current Congressional push to move the electricity industry to a deregulated market should be completed in the next several years. The most significant for the nuclear industry will be the amount stranded costs that the new regulations will allow utilities to recover. Both the Federal Government and the state public utility commissions (PUC's) will be involved in this key policy decision. [28]

The policy makers must determine how much, if any, of the initial capital investments made under the current system will be allowed to be recouped. Many consumer advocates argue that none of the stranded costs should be guaranteed and that utilities should have to be accountable for past investment decisions. This would lower electricity costs in the short run, but force utilities to fend for themselves in the newly opened market. The utilities counter that they must be allowed to recover those costs because the investment decisions were made before deregulation, and that failure to provide compensation would devastate any future profitability. This could also lead to widespread bankruptcy in the industry.

One model that has been experimented with in California, is the limited recovery time approach. This allows utilities to recover stranded cost during the first five years of deregulation. After which, no cost recovery is allowed, and every utility must make sound investments based on open market forces only. This approach does ease the immediate burden, but can still leave a significant cost load for an utility to bear at the end of the five years.

Each scenario and solution has winners and losers. The Congress and the state PUC's will have to carefully weigh evidence in each case to ensure a strong utility industry. History will be a prevailing guide, and prudence should follow.

# VI. Power Generation Alternatives

Licenses for 47 of the 110 nuclear plants in the United States will expire by the end of 2015. If these plants are closed, the Nation's baseload supply will be reduced by 35 GWe. This loss represents the loss of nearly 7 percent of the total electricity generated in the United States today. [29] The alternatives are simple, replace this source with other fuels, or reduce the amount of energy used through conservation. Alternative fuels are in two main categories, fossil fuels and renewables. Fossil fuels currently supply 66 percent of domestic electricity. For this share to increase, significant capital investment and pollution remediation would have to occur.

Coal fired electricity generation on average, is currently the lowest cost supplier of electricity, with an average cost per kilowatt hour at 1.89 cents. Generation technology is highly developed, but the pollution mitigation equipment is still being heavily researched. Actual coal supplies have been estimated to be viable for the next 300 years domestically. If 50 MW of nuclear power is replaced by new fossil fuel plants, the resulting carbon emissions would be 67 million tons of carbon.[30] Coal has been the workhorse of U.S. electricity, but pollution concerns may tip the balance away from coal, the most heavily polluting of the fossil fuels.

Natural gas is the cleanest of the fossil fuels, it emits carbon at only half the rate of coal. The United States enjoys large reserves of natural gas, and new discoveries are being made monthly. Small, combined cycle turbines have been developed that can use natural gas very efficiently. However, large scale applications, above 500 MWe, would require significant investments in infrastructure, pipelines and furnaces to make natural gas viable. Large scale use would also increase the price of natural gas by significantly increasing the demand. This is a promising option, but significant carbon emissions may reduce its competitiveness.

Renewable energy sources produce less than one percent of electricity in the United States. The technology and reliability of wind, solar, biomass, and tidal power are not sufficiently developed. They remain very expensive, and will not replace more concentrated sources of power in the near future. Renewables do have many small scale applications, but significant research must be conducted before they become a commercial option.

Hydroelectric power is a major source of electricity, producing 10 percent of domestic power. While it is viewed as the cleanest and most environmentally friendly of all power sources, it leave a huge footprint on the areas surrounding the plants. More importantly, hydroelectric sites have been exhausted. The dam booming years in the 1930 and 1960 utilized all the prime sites for hydroelectric facilities. Little growth can be achieved form this source.

Conservation must also be considered as part of the solution in meeting the electric demands in the United States. The less electricity required by industry and consumers, the less pollution will be discharged onto the planet. Industry and manufacturing have reduced consumption per unit of output by 40 percent during the past two decades.[31] The U.S. must strive to continue this trend.

## VII. Recommendations

The United States should support license renewal for commercial nuclear power plants. The extended lifetimes of the plants will help maintain a stable baseload energy supply well into the next century. In addition, the extended lifetimes will allow greater flexibility for the utilities to make good business decisions, with longer amortization periods. This entire process will be dependent on the government supporting nuclear research and by fulfilling its obligation to store high level waste in a timely fashion. The NRC must also work in cooperation with the industry to develop streamlined and efficient procedures to meet regulation requirements. The decision to renew should not be decided over burdensome regulation, but instead by prudent economic analysis.

Nuclear power can meet the economic requirement of a deregulated market. This is especially true if performance continues to improve. License renewal can pay for itself by increasing plant performance over the short term, and reducing maintenance costs in the long term. While the decision to use a nuclear plant for an additional 20 years is not a simple one, with prudent management and long term vision, nuclear power can give utilities the bulk economies of scale they will need to be competitive in the next century.

The United States should embark on a long term energy strategy. Nuclear power should be a integral part of any such plan. The technical questions of license renewal are being answered. The economic forecast remains unstable, and the regulation hurdles are becoming more pragmatic. The country is at a crucial window of opportunity to increase our electricity supply to met the growing demand without having to significantly increase our emissions of fossil fuel pollutants or rely on costly renewables. License renewal is the first step in those efforts.

# REFERENCES


[1] INGAA Foundation, “Nuclear Power plants and the Implications of Early Shutdown for the Futrue of Natural Gas Demand, 1997, pg. 54

[2] Nuclear Regulatory Commission, ‘NRC Information Digest’, 1996, pg. 28

[3] Doroshuk, Barth, Personal Interview, July 10, 1997

[4] Radiation Damage of Structural Materials, Koutsky, Kocik, Eliseveier Press, Amsterdam,1994, pg. 121

[5] Warn, John, Department of Energy, Personal Interview, July 11,1997

[6] Callaway, Clive, Nuclear Energy Institute, Personal Interview, June 18, 1997

[7] Yoder, Carl, Baltimore Gas & Electric, Personal Interview, July 10, 1997

[8] “Longer Life for Nuclear Plants”, Technology Review, May /June 1990, pg. 30

[9] Newberry, Scott, Nuclear Regulatory Commission, Personal Interview, July 2, 1997

[10] Electric Power Research Institute, ‘License Renewal Industry Report Summary’, 1994, pg. 2

[11] Yoder, Carl, Baltimore Gas & Electric, Personal Interview, July 10, 1997

[12] Newberry, Scott, Nuclear Regulatory Commission, Personal Interview, July 2, 1997

[13] Ibid.

[14] Lochbaum, David, Union of Concerned Scientists, Personal Interview, July 3, 1997

[15] Harrison, Dennis, Department of Energy, ANS Transaction Papers, June 1997

[16] NRC Information Digest, Nuclear Regulatory Commission, 1996, pg. 21

[17] Nuclear Energy Security, Department of Energy, 1997, pg. 5

[18] INGAA Foundation, “Nuclear Power Plants and the Implications of Early Shutdown for the Future of Natural Gas Demand”, 1997, pg. 17

[19] INGAA Foundation, “Nuclear Power Plants and the Implications of Early Shutdown for the Future of Natural Gas Demand”, 1997, pg. 11

[20] License Renewal Will Add Value to Today’s Nuclear Plants, Insight, Nuclear Energy Institute, May 1997

[21] Doroshuk, Barth, Baltimore Gas & Electric, Personal Interview, July 10, 1997

[22] Ibid.

[23] Nuclear Regulatory Commission, Commissioners Briefing, June 18, 1997

[24] NRC Information Digest, Nuclear Regulatory Commission, 1996, pg. 17

[25] Gunter, Paul, Nuclear Information & Resource Service, Personal Interview, July 2, 1997

[26] Rycyna, John, Baltimore Gas & Electric, Personal Interview, July 10, 1997

[27] Walters, Doug, Nuclear Energy Institute, Personal Interview, June 18, 1997

[28] Derderian, J.D., House of Representatives Commerce Committee, Group Interview, June 27, 1997

[29] Nuclear Energy Security, Department of Energy, 1997, pg.

[30] Swink, Denise, Group Interview, June 28, 1997