THE NEW ENGLAND COUNCIL

NEW ENGLAND ENERGY ALLIANCE

# *Nuclear Energy in New England*

**A Valuable & Dependable Source of Electricity**

**April 2006**

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A Valuable & Dependable Source of Electricity

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# Sponsors

**The New England Council, Inc.** is the country's oldest regional business organization. The Council is an alliance of businesses, academic and health institutions, and public and private organizations formed to promote economic growth and a high quality of life in the New England region.

The Council is dedicated to identifying and supporting federal public policies and articulating the voice of its membership regionally and nationally on important issues facing New England. The New England Council is also committed to working with public and private sector leaders across the region and in Washington through educational programs and forums for information exchange.

**The New England Energy Alliance** is a coalition of energy providers, business and trade organizations and others concerned about future energy supplies. The Alliance advocates for action to ensure the availability, reliability and affordability of future energy supplies, which are vital to sustain the region's economic growth and prosperity. Formed in August 2005, the Alliance works to balance public debate about, and help identify solutions to, the growing risks to the region's energy supply infrastructure.

# Executive Summary

New England's five nuclear energy plants are the "backbone" of the region's electricity grid – providing reliable, base-load capacity using a dependable fuel source. Because of their low operating costs, nuclear energy plants generate electricity economically – which is important in a region that has some of the highest electricity rates in the nation. These plants also avoid air emissions that contribute to acid rain and smog – and will play an important role in attaining greenhouse gas reduction goals for those states with in-state programs as well as those participating in the Regional Greenhouse Gas Initiative.

This paper was sponsored by The New England Council and the New England Energy Alliance to advocate the role and benefits of the region's nuclear energy plants. As electricity demand in New England is expected to increase at a rate of one new power plant a year – but with none currently under construction – the region's nuclear generation is essential to maintain a balance between supply and demand.

The New England Council and the New England Energy Alliance support maintaining the region's nuclear generation capability– through power uprates and relicensing– provided the plants maintain compliance with federal safety standards and requirements.

New England's nuclear energy plants:

1. **Provide an essential and reliable source of electricity that maintains grid stability.** The second largest source of supply, New England's nuclear energy plants generate more than a quarter of the region's electricity at capacity factors (a measure of power plant reliability defined herein) that far exceed other generating technologies. Nuclear units typically operate "round-the-clock" for more than 500 days before refueling.

2. **Generate electricity at the lowest cost.** Nuclear energy plants have the lowest production costs of any major source of electricity – less than a third of the cost of natural gas-fired generation.

3. **Produce no air emissions.** In generating electricity, nuclear energy plants produce no nitrogen oxide or sulfur dioxide that cause smog and acid rain, and no carbon dioxide, a major greenhouse gas, or particulate matter which has been linked to public health effects.

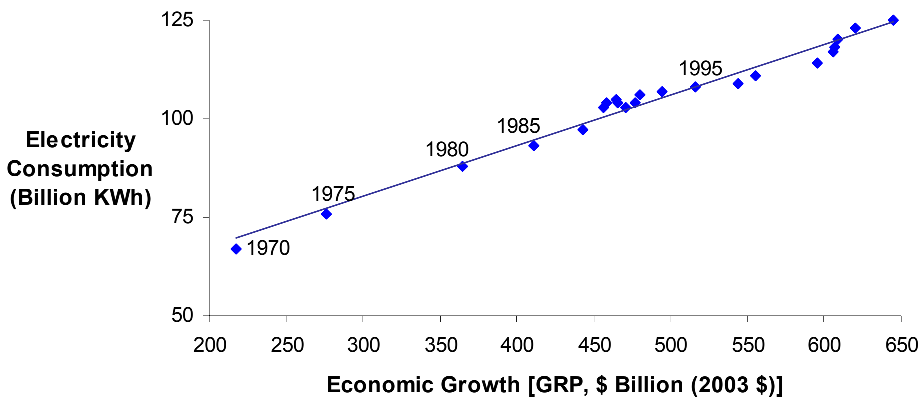
4. **Comply with strict regulatory requirements.** The U.S. Nuclear Regulatory Commission enforces strict safety and operating standards that every plant must comply with — with records and proceedings available for public scrutiny. Moreover, nuclear energy plants are among the most secure industrial facilities in the country.

# Introduction

**Economic Growth is Increasing Electricity Demand.** As shown in Figure 1, since 1975, the region's electricity consumption has doubled to support the region's growing high tech economy — which more than tripled during this same time period.

**Figure 1 – New England Economic Growth & Electricity Consumption**

*Electricity demand increases with economic growth – this relationship is undeniable and likely to remain strong due to the region's high tech economy.*




Source: Energy Information Administration, U.S. Department of Energy, U.S. Department of Commerce

Today, even as the region has become considerably more energy efficient, peak electricity demand is projected to increase by approximately 15% over the next decade.[1] Unfortunately, the construction of new electricity generating plants is not keeping pace with this constantly increasing demand. Recently, ISO New England, the independent operator of the region's electricity grid, issued a clear warning that as early as 2008 new sources of generation will be needed to close a growing and consequential gap between supply and demand.[2]

**Nuclear Energy Is An Essential Source of Electricity Supply.** For decades, nuclear energy plants have played a vital role in reliably and economically meeting New England's electricity demand in an environmentally compatible manner. Given that electricity demand is projected to increase at the rate of one new generating plant a year (about 400 to 600 megawatts), maintaining existing nuclear facilities should be an important building block of the region's energy future.

Aside from helping achieve a balance between electricity supply and demand, maintaining the safe operation of the region's five nuclear energy plants has two other valuable benefits. First, retaining fuel diversity provides both an economic and security hedge – as New England has few indigenous energy sources and therefore heavily relies on imports from other regions and abroad. Second, this generating technology produces unmatchable emissions-free electricity "round-the-clock".

Looking forward, it is essential that the region's nuclear energy plants continue their track record of safe and reliable operation. Several of these plants have, over the last several years, received permission from the U.S. Nuclear Regulatory Commission to increase their generating output (called a power uprate) to levels that their original designs allow them to accommodate. This new incremental capacity is an important step in deferring the construction of new facilities and conserving fossil fuels.

More important than uprates, however, is regulatory approval for the renewal of operating licenses for an additional 20 years. Two of the region's nuclear energy plants have received approval to extend their operations for 20 years beyond their initial license period, while two others have recently submitted applications to do so.

**The Benefits of the Region's Nuclear Energy Plants.** Sponsored by The New England Council and the New England Energy Alliance, this paper describes, in layman's terms, the role of and benefits from electricity generated by nuclear energy plants.

For simplicity, this paper is divided into four additional sections titled: A Dependable Source of Electricity; Low Cost, Emissions Free Generation; Increasing Electricity Generation Thru Uprates; and Future Electricity Generation Thru License Renewal. These sections define the role of nuclear energy in the region's electricity mix and address the need for its continued safe operation to maintain an otherwise tenuous balance between supply and demand. Information is also provided on used nuclear fuel storage and disposal because, while there are safe and effective short-term storage remedies at individual plant sites, there must be progress toward a long-term national disposal program.

Publicly available information and data – through 2004, unless otherwise noted – was relied upon and referenced in endnotes. Simple calculations were made to provide perspective as well as to provide comparisons with other sources of electricity supply.

The New England Council's and New England Energy Alliance's strong advocacy for the continued operation of the region's nuclear energy plants does not constitute an endorsement for any particular project or individual plant. Both organizations believe that federal safety and regulatory processes with local and state government input along with public participation must be allowed to assess each proposed project or action on its own merits. Indeed, this paper refers to individual nuclear energy plants for identification purposes only – with all subject matter approached generically and regionally.

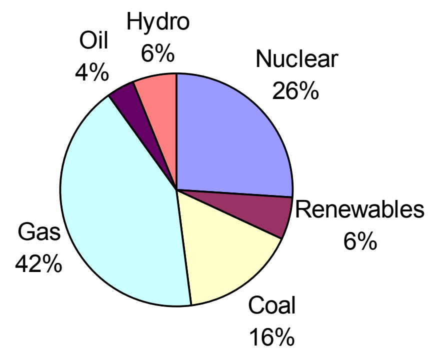
Similarly, focusing only on the region's existing nuclear energy plants should not be misconstrued as a statement that the construction of new ones should not be seriously considered in regional planning and policy efforts. Both the Council and Alliance believe that over the long-term, the region cannot afford to arbitrarily exclude any type of electricity generating option including new nuclear energy plants.[3] Recent federal legislation provides incentives and funding for nuclear energy programs as well as new plants. In fact, several partnerships and consortiums are moving ahead with plans to pursue new plant development in other regions of the country.[4]

# A Dependable Source of Electricity

**Region's Second Largest Source of Supply.** As shown in Figure 2, about 26% of New England's electricity is generated from nuclear energy facilities. Given the region's increasing dependence on natural gas for electricity generation (expected to increase beyond 50% over the course of the next several years), nuclear energy is the keystone in maintaining a diversity of fuel types and a critical factor in improving reliability and stabilizing costs.

**Figure 2 – New England Electricity Production by Fuel Type (2005)**

*Nuclear energy is the region's second largest source of electricity supply.*




Source: ISO New England

At the individual state level, nuclear plants comprise about 74% of electricity generation in Vermont, 54% of Connecticut's, 43% of New Hampshire's and about 10% of Massachusetts'.[5] From another perspective, they can meet the electricity demand equivalent of *all* the residential households in Connecticut, Maine, New Hampshire Vermont and Rhode Island combined.

Nationally, nuclear energy supplies about 20% of the country's electricity through the operation of 103 facilities in 31 states.[6] Globally, a total of 443 plants are operating in 30 countries – with high technology countries like Japan, South Korea and France relying on nuclear energy to deliver up to three quarters of their electricity. Worldwide, there are 25 new nuclear energy plants under construction in 10 countries.[7]

As Shown in Table 1, there are five nuclear energy units generating electricity in New England under the ownership of three experienced companies that operate nuclear and fossil fueled generation facilities throughout the U.S.[8]

**Table 1 —New England's Nuclear Energy Plants**

| Plant | Location | Size (Megawatts) | Owner-Operator |
|---|---|---|---|
| Millstone 2 | Waterford, Connecticut | 878 | Dominion Nuclear |
| Millstone 3 | Waterford, Connecticut | 1148 | Dominion Nuclear |
| Pilgrim | Plymouth, Massachusetts | 685 | Entergy Nuclear |
| Vermont Yankee | Vernon, Vermont | 510 | Entergy Nuclear |
| Seabrook | Seabrook, New Hampshire | 1155 | FPL Energy |

**Reliable, "Round-the-Clock" Generation.** New England's nuclear energy units (along with those fueled by coal) are classified as base-load generation – operating 24 hours a day, seven days a week, not changing production to match fluctuating electricity demand which changes from hour-to-hour.

Nuclear plants run about 540 days (some plants run in excess of 700 days) before they are shut down for refueling. Because of their "round-the-clock" operation, those operating in New England maintain the stability of the region's electrical grid.

The reliability of a generating plant is an important measure given that electricity is a vital commodity with fluctuating demand. Because electricity cannot be stored, it must be produced immediately upon demand. Reliability is therefore an important gauge of a facilities' value to the region's electricity grid stability. A common measure of reliability is "capacity factor" – the percentage of electricity actually produced, compared to the amount the plant is capable of generating.[9]

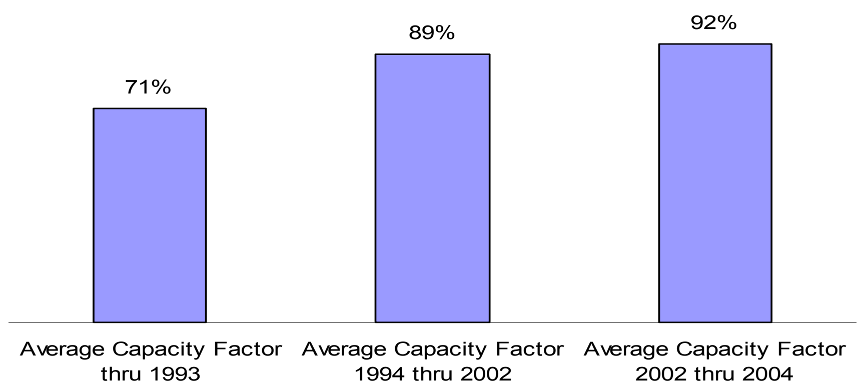
Nuclear plants typically have capacity factors of about 90%, significantly exceeding those of other generating technologies. Coal, oil and natural gas-fired generating plants typically can achieve capacity factors ranging from 70 to 85% if they are called upon to operate as base-load facilities.[10] Wind facilities typically have a capacity factor of only 30% – a circumstance dictated by Mother Nature.[11]

Over the course of a decade, U.S. nuclear plants have significantly increased their operating performance to 90% – mostly through reducing the period of time it takes to refuel, but also by better management and preventative maintenance practices. In 2005, the average refueling outage was 38 days, down significantly from 1990 when the average outage was 104 days.[12] Nationally, the resulting increased electricity production since 1990 – achieved without having to build one new facility – is equivalent to the electricity generated by 20 plants the size of the Seabrook Nuclear Power Station.

This performance trend is just as pronounced in New England. As shown in Figure 3, the region's nuclear energy plants have significantly improved their performance since 1993 and have continued this trend after states initiated electric industry restructuring beginning in 1998.[13]

**Figure 3 – Performance of New England's Nuclear Energy Plants**

*The operating performance has improved dramatically over the past decade due to better management practices.*




Source: Nuclear Energy Institute

The importance of these improvements in the region's nuclear energy plant operating performance can be gauged in terms of how many new natural gas-fired generating plants (the only type built in the region over the past decade) have been deferred because of them. Using this practical measure, the construction of at least two generating plants have been deferred – conserving enough natural gas to heat 750,000 of the region's homes a day.[14]

**Continued Safe and Secure Operations.** All nuclear energy plants are required to meet strict safety standards set by the U.S. Nuclear Regulatory Commission (NRC). A systematic and aggressive inspection program and rigorous preventive maintenance programs are closely monitored on a day-to-day basis by at least one full-time resident NRC inspector assigned to each nuclear energy plant. In addition, in-depth inspections of various safety and operating systems by special teams of NRC experts ensure the timely maintenance of all plant equipment. Under federal law, inspection records are publicly available.

Nuclear energy plants were the most secure commercial facilities before September 11 and they are even more so today. Since September 11th, NRC has further strengthened security at nuclear facilities using state-of-the-art analyses and counsel from military and civilian experts. The nation's nuclear energy plants are protected by a combination of robust physical design of steel and concrete, redundant physical barriers and sensitive detection equipment, sophisticated surveillance and access technology as well as paramilitary security force of well-trained, well-armed officers.[15]

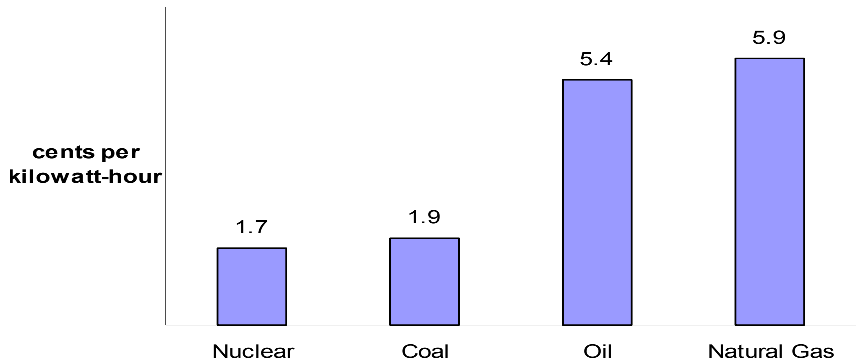
# Low Cost, Emissions Free Generation

**Dependable Fuel Supply.** Nuclear energy is not subject to weather or climate conditions as well as unpredictable cost fluctuations and supply disruptions – as some fossil fuels are. Moreover, the technology's uranium fuel is abundantly available in the U.S., Canada and Australia. The facilities for processing uranium into a fuel suitable for usage in a nuclear energy plant are available in the U.S. and other allied countries.

**Lowest Cost Electricity Generating Facilities.** Nuclear energy plants have the lowest production costs of any major source of electricity – production costs (which include fuel, labor, materials and services) are at an all-time low.[16] The improved operating performance of nuclear energy plants (as previously discussed) and the consistently low cost of uranium fuel are responsible for driving down the unit cost of electricity produced. It is important to note that fuel accounts for about 80% of the cost of electricity of fossil-fired generating plants. By comparison, uranium accounts for only about 25% of the cost of electricity produced in a nuclear energy plant.[17]

As shown in Figure 4, electricity from a natural gas-fired plant costs three times more than electricity generated by a nuclear energy plant. It must be noted, however, that the distinct marginal cost advantage of nuclear energy plants vis-à-vis other generating facilities can be somewhat offset by higher capital and decommissioning costs (that are unique to nuclear energy plants).

**Figure 4 – U.S. Average Electricity Production Costs (2004)**




Source: Nuclear Energy Institute

Not surprisingly, nuclear energy is a stabilizing factor in New England's competitive wholesale electricity markets. While the costs of most other fuel sources – such as oil and natural gas fluctuate significantly and perhaps more important unpredictably, nuclear energy costs have stable trends – and industry projections forecast very little change in cost over the horizon. In fact, a recent World Nuclear Association analysis shows nuclear energy plants to be the lowest-cost electricity generating technology in most major countries.[18]

**Emissions-Free Electricity Generation.** Nuclear energy is an emission-free source of electricity producing no nitrogen oxide ($NO_x$) or sulfur dioxide ($SO_2$) that cause smog and acid rain, carbon dioxide ($CO_2$), which is a major greenhouse gas (which leads to global warming), or particulate matter linked to public health effects.

In 2004 alone, the region's nuclear generating units avoided the generation of more than 77,000 tons of $SO_2$, over 19,000 tons of $NO_x$ and 23 million tons of $CO_2$ – the amount of emissions that would have been generated if the electricity were generated by fossil fuels (based on regional average fossil fuel emissions rates).[19] These savings are equivalent to taking one million cars off the roads of New England – or almost all of the registered vehicles in the State of Maine.[20]

Nuclear generation is expected to play a key role in regional efforts to reduce greenhouse gases ($CO_2$ being the most prevalent). Additionally, seven northeastern states signed a memorandum of understanding in December 2005 establishing the first carbon dioxide cap and trade program in the U.S. This Regional Greenhouse Gas Initiative (RGGI) includes all the New England states, except Massachusetts and Rhode Island, as well as Delaware, New Jersey and New York.

The RGGI cap on $CO_2$ emissions – affecting only electricity generation – is intended to maintain current emissions levels through 2014 and reduce them 10% by 2019. Continued operation of the region's nuclear energy plants – as well as renewal of their operating licenses – will be needed to achieve the RGGI $CO_2$ reduction targets. In fact, computer models produced for RGGI assume the nuclear plants in the region continue to operate.

If nuclear energy plants were allowed to retire at the end of their initial operating license or closed prematurely over the next 15 years, replacement generation would have to come from other generation sources that do not emit $CO_2$ in order to meet RGGI goals.

Given that electricity demand is projected to increase, replacing the region's nuclear generation would require the construction of at least 26 wind projects the size of "Cape Wind" (400 MW) – at a cost of over $10 billion.[21] Replacing all five nuclear generating units with land-based wind power would require more than 650,000 acres – an area two times larger than the Boston metropolitan area.[22] In addition, the intermittent generation of electricity from wind power — which have capacity factors of only 30% or less — would not be able to replace the steady, base-load generation from nuclear energy plants – and would therefore require some type of back-up generation capacity or imports from other regions.

# Increasing Electricity Generation Thru Uprates

**Optimizes a Plant's Operating Capability.** In the simplest terms, a power uprate allows a nuclear energy plant to increase its electricity generation capability without having to change the temperature or pressure that it operates under. In other words, many nuclear energy plants generate electricity below the level that their design will safely allow.

There are three broad categories of power uprates — the following are descriptions in layman's terms:[23]

- **Recapture of measurement uncertainty.** Since many plants were initially licensed, techniques for analyzing their operation have considerably advanced through new methodologies and computer technology. These uprates are typically on the order of just several percent – but still enough electricity to supply a large office tower or industrial complex. Generally, no operational procedures or equipment are changed.

- **Instrumentation setting adjustment.** Sometimes called "stretching power" these uprates can increase a plant's output by up to 7% and involve changes to instrumentation settings. Once again, advanced analysis techniques allow for instrumentation to more precisely monitor the plant's operation. Generally, no major plant modifications are required

- **Equipment modification and upgrading.** These uprates have been approved for electricity production increases as high as 20% — almost the equivalent to a large wind farm or small natural gas fired plant. In these instances, equipment not involved with the nuclear reactor – such as pumps, motors, main generators, turbines and transformers – is upgraded to handle the increased amount of steam produced (which, like in a fossil-fueled plant, turns a turbine and a generator).

**A Well-Defined, Proven & Open Process.** Since 1977, the NRC has approved scores of power uprates (ranging up to 20%) and is currently reviewing or is expecting to review about 20 additional applications over the next several years.[24] In fact, as more experience has been gained over the years, plants that were initially approved for small power uprates have successfully re-applied for larger ones.

Preparing power uprate applications can involve the work of dozens of engineers and technical consultants over the course of up to a year. The burden of proof requires the plant operator to demonstrate that the uprate will maintain the facility's compliance with all NRC safety regulations.

The NRC performs its review under established guidelines, and deliberations are open to the public. NRC's decision-making is subject to oversight by the U.S. Congress and can also fall under the jurisdiction of federal courts if guidelines have been violated or not objectively applied. Moreover, the NRC staff findings undergo an independent review by the Advisory Committee on Reactor Safeguards (ACRS). This committee is composed of 11 prominent scientists and engineers with expertise in a wide variety of nuclear-related disciplines supported by a technical staff.

To keep the public informed, the NRC publishes a notice in the Federal Register when: it receives a request from a licensee for a power uprate, giving the public the opportunity to request a hearing; after a finding of no significant environmental impact is made, if applicable; and if a power uprate is approved.[25]

**Increased Electricity Generation a Bargain for Region.** Since 1979, four of the region's five nuclear energy plants have received NRC approval for power uprates totaling about 220 megawatts — which will ultimately allow the production of electricity to supply the equivalent of about 20% of Boston's total electricity demand.[26]

Beyond the absolute need for additional supplies of electricity, the extra generation through power uprates has been accomplished for between 50-70% of the estimated capital cost of a new natural gas fired plant and around 35% of the investment cost of a medium sized wind renewable facility.[27]

# Future Electricity Generation Thru License Renewal

**An Important Form of Conservation.** The 40-year license term of nuclear energy plants reflects the amortization period that was traditionally used by electric utility companies for large capital investment – and is not based on safety, technical or environmental issues.

The decision to seek license renewal is based on the plant's economic situation and whether it can meet NRC license renewal requirements. The NRC formally reviews all license renewal applications in a stringent process that can last up to three years. To date, the NRC has approved license renewal for 39 nuclear energy plants, has another 12 under review and 27 others have expressed intention to file.

License renewal enables a significant amount of efficient, reliable electricity to be maintained or conserved on the system for a fraction of the cost of new power generation. On a per kilowatt basis, the capital cost of nuclear plant license renewal is only 8% of the cost of new natural gas-fired power plant and only 4% of the cost of a new wind plant.[28] Not only does license renewal eliminate the need to build new power plants, it also reduces the need for new transmission lines associated with new generating facilities.

**A Focus on Safety & Environmental Assurance.** As discussed earlier, nuclear energy plants are subject to a rigorous program of NRC oversight, inspection, maintenance, equipment replacement and testing. These programs along with maintenance practices ensure that plant systems, structures and components continue to meet safety standards regardless of their chronological age or usage intensity.

A license renewal application must identify all plant systems, structures and components that are safety-related or whose failure could affect safety-related functions – and demonstrate that the effects of chronological aging as well as expected wear and tear will be managed so that the intended functions will be fully maintained for the period of extended operation.

A plant-specific supplement to the generic environmental impact statement (GEIS) is submitted to the NRC. A public meeting is held to scope out or identify environmental issues specific to the plant. The result is an NRC recommendation on whether the environmental impacts preclude license renewal. This recommendation is presented in a draft plant-specific supplement to the generic environmental impact statement, which is published for comment and discussed at additional public meetings. After consideration of comments, NRC prepares and publishes a final plant-specific supplement to the GEIS.[29]

**Opportunity for Public Participation.** Public participation is an important part of the license renewal process. In recognition of this, the NRC makes information available in many ways. Shortly after the NRC receives a renewal application, a public meeting is normally held to provide information about the license renewal process and opportunities for involvement. Additional public meetings are held by the NRC during the review of the renewal application with findings and recommendations published when completed.

Concerns may be litigated in an adjudicatory hearing if any party that would be adversely affected requests a hearing. The public may also petition the Commission for consideration of issues other than the effects of aging.

**Extensive Review Periods.** There is no prescribed time frame for when a licensee must apply for license renewal – but such requests are typically made no later than five years before license expiration. The license renewal process is lengthy and comprehensive, taking between 22 and 30 months.[30]

**Table 2 — Status of License Renewal for New England Facilities**

| Plant | Operating License Expiration Date | License Renewal Status |
|---|---|---|
| Millstone 2<br>Millstone 3 | 2035<br>2045 | Applications submitted in January 2004, with renewal approved in November 2005 |
| Pilgrim | 2012 | Application submitted in January 2006 |
| Vermont Yankee | 2012 | Application submitted in January 2006 |
| Seabrook | 2026 | No application submitted to date |
| Source: U.S. Nuclear Regulatory Commission | | |

**Safe and Secure Spent Fuel Storage.** The *Atomic Energy Act of 1954* assigned responsibility for commercial used nuclear fuel (the solid fuel discharged after it has been used in the production of electricity) management to the federal government. Until accepted by the U.S. Department of Energy (DOE), used fuel is generally stored in secure pools of water inside nuclear energy plants.

Subsequent legislation charged the DOE with safely and permanently disposing of used nuclear fuel from plants to a designated site at Yucca Mountain in Nevada and established the Nuclear Waste Fund – the mechanism by which ratepayers would fund its safe transportation and disposal.[31] Completion of the Yucca Mountain repository has been repeatedly delayed – and used fuel has not been removed from storage at nuclear energy plants.

Because of DOE's failure to meet its obligations, a growing number of operating nuclear energy plants – including those in New England – have used fuel pools that are nearing capacity. In order to continue operating, especially during a license renewal period, these plants need to supplement their storage capability through on-site dry cask storage.

To date, approximately 30 U.S. nuclear energy plants have constructed or are planning to construct such storage facilities – referred to as independent spent fuel storage installations (ISFSI) – to safeguard used fuel until a federal facility becomes available.[32, 33] ISFSI facilities consist of airtight stainless steel fuel canisters, which are placed inside large steel-lined concrete casks stored on reinforced concrete pads and are designed to protect against floods, earthquakes, tornadoes, projectiles, temperature extremes and other unusual scenarios.

While safe and environmentally sound, ISFSI facilities are not a permanent solution and measures are needed to ensure the federal government can meet its obligation to accept and manage used nuclear fuel generated by nuclear energy plants.

# Recommendations

Given the importance of nuclear energy in supplying reliable, economic and environmentally compatible electricity to the region, The New England Council and The New England Energy Alliance recommend regional policymakers:

1) Recognize that nuclear energy plants are New England's second largest source of electricity supply, generating more than a quarter of the region's electricity at a third of the cost of natural gas-fired generation. And, that in generating electricity, nuclear energy plants produce no nitrogen oxide or sulfur dioxide that cause smog and acid rain, no carbon dioxide which is a greenhouse gas (and leads to global warming), or particulate matter which has been linked to public health effects.

2) Support in principle nuclear energy plant power uprate and license renewals. Participate, along with local communities, in good faith in the subsequent comprehensive, well-defined and transparent regulatory review process to determine if compliance with all NRC safety standards and regulations will continue to be met.

3) Include the region's existing nuclear plants, as well as the potential to construct a new nuclear facility, in all energy, environmental and economic planning – the arbitrary exclusion of this proven source of electricity supply could prove costly to the region's businesses and consumers. Moreover, every reasonable effort should be made to assure that the federal government meets its obligations to accept and manage used nuclear fuel given that a permanent solution is desirable and the region's electricity consumers have already significantly contributed to funding a solution.

## End Notes

[1] "Forecast of Capacity, Energy, Loads and Transmission, 2005-2014, ISO New England, April 2005.

[2] "Energy Chief Warns of Blackouts by '08" *The Boston Globe,* June 15, 2005.

[3] ISO New England recently stated that the region should consider the construction of new nuclear energy plants as part of its planning efforts. "Utility Officials Ponder Coal, Nuclear Plants", *The Boston Globe,* March 23, 2006.

[4]Additional information regarding new nuclear energy plant development can be found at www.nrc.gov/reactors/new-reactor-licensing.html and www.nei.org.

[5] "State Nuclear Facts", Nuclear Energy Institute (www.nei.org).

[6] "Reliable Electricity", Nuclear Energy Institute (www.nei.org).

[7] "Reliable Electricity", Nuclear Energy Institute (www.nei.org).

[8] During the 1990s, four other nuclear energy plants in New England were retired: Yankee Rowe, Connecticut Yankee, Maine Yankee and Millstone 1. With these plants in operation, nuclear energy provided as much as 35% of the region's electricity. The companies that currently own and operate the region's operating nuclear energy plants operate a total of 18 other nuclear generating units in other states in addition to those in New England.

[9] Often times, oil and natural gas-fired generating plants have low capacity factors because they are called upon to operate only during peak electricity demand periods. Conversely, they can and often do have a high "availability factor" – which is defined as the percentage of time that a plant is available to produce electricity if called upon over the course of a year.

[10] "U.S. Capacity Factors by Fuel Type", 2004, Nuclear Energy Institute (www.nei.org). When oil and natural gas-fired power plants are used to meet the fluctuations in electricity demand, they can sometimes have low capacity factors. It should be noted, however, that these capacity factors are determined by the need for electricity and not the availability of the generating plant to operate at full capacity.

[11] Capacity factor for wind facilities of 25 to 40% is common. American Wind Energy Association (www.awea.org).

[12] "Reliable Electricity," Nuclear Energy Institute (www.nei.org).

[13] The New England states were at the forefront of the national trend to introduce competition into the electricity industry. In 1998, Massachusetts and Rhode Island became the first two states in the country to fully open their electric markets to competition. New Hampshire, Maine, and Connecticut shortly followed. (Vermont did not). As part of those restructuring efforts, electric utilities were required to divest their generating assets. As a result, most of the region's power plants were sold including New England's nuclear energy plants.

[14] It was estimated that the region's plants' combined (weighted average) capacity factor increased from approximately 70% to 94% from the early 1990s to 2004. This increase in generation was calculated to be the equivalent of about two, 500 Megawatt new combined cycle natural gas-fired plants (operating at an 80% capacity factor). To estimate the amount of natural gas use deferred, it was assumed that for every 500MW of capacity, a natural gas plant consumes about 105 Mcf of gas per day which is the equivalent consumption of approximately 350,000 homes using natural gas for heating, hot water and cooking.

[15] "Nuclear Security Enhancements Since September 11, 2001", Backgrounder, U.S. Nuclear Regulatory Commission, Office of Public Affairs.

[16] "Economical Energy Source", Nuclear Energy Institute (www.nei.org).

[17] More information on the economic performance of nuclear energy plants can be found at www.nei.org

[18] "The Economics of Nuclear Power", World Nuclear Association, December 2005.

[19] "Emissions Avoided by the U.S. Nuclear Industry", State-by-State, 2005, Nuclear Energy Institute (www.nei.org).

[20] Maine Department of Transportation statistics.

[21] The amount of annual generation from the region's nuclear energy facilities was calculated to be approximately 36 billion kilowatt hours assuming a capacity factor of 94% (average capacity factor for 2004). The number of wind projects was calculated assuming those facilities would have a capacity factor of 40%. It was also assumed that those facilities would have a capital cost of $1,015 per kW capacity based on "Assumptions to the Annual Energy Outlook", from the U.S. Energy Information Administration, U.S. Department of Energy.

[22] It has been estimated by the American Wind Energy Association that in open, flat terrain, a utility-scale wind plant would require about 60 acres per megawatt of installed capacity. However, only 5% or less of this area is actually occupied by turbines, access roads and other equipment. A wind plant located on a ridgeline in hilly terrain would require much less space as little as two acres per megawatt (www.awea.org).

[23] Simplified from "Power Uprates for Nuclear Plants", Fact Sheet, U.S. Nuclear Regulatory Commission.

[24] "Power Uprates for Nuclear Plants", Fact Sheet, U.S. Nuclear Regulatory Commission.

[25] Simplified from "Power Uprates for Nuclear Plants", Fact Sheet, U.S. Nuclear Regulatory Commission.

[26] Assumes 219MW of power uprates generate 1.8 million Megawatt-hours of electricity based on a 2004-weighted average capacity factor of 94%.

[27] Assumes the capital cost of a new wind generating facilities to be $1,015 per kW and the average capacity cost associated with power uprate to be $300 - $400 per kW.

[28] Capital costs associated with nuclear plant license renewal was estimated at $42 per kW compared to $1,015 for construction of a new wind generating facility.

[29] "Reactor License Renewal", Backgrounder, U.S. Nuclear Regulatory Commission.

[30] "Reactor License Renewal", Backgrounder, U.S. Nuclear Regulatory Commission.

[31] The Nuclear Waste Policy Act of 1982 established the Nuclear Waste Fund, the mechanism by which ratepayers would fund the safe transportation and disposal of spent fuel (one tenth of one cent kilowatt-hour fee for electricity generated by nuclear power plants). DOE executed contracts with nuclear plant owners specifying its statutory obligations in return for payment of fees. To date, New England consumers have contributed nearly $2 billion to this fund but DOE has not yet begun to move the spent nuclear fuel to a federal site.

[32] Dry Cask Storage of Spent Nuclear Fuel", Backgrounder, U.S. Nuclear Regulatory Commission.

[33]33 The region's closed nuclear plants, including Yankee Rowe, Maine Yankee and Connecticut Yankee have each built ISFSIs in order to decommission their sites. These ISFSIs utilize dual-purpose canister systems licensed by the NRC for both storage and transportation. The owners of these plants have filed suits in the U.S. Court of Federal Claims for damages based on the financial burden imposed by DOE's failure to meet its contractual obligation.

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