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Where Do We Go From Here? Reflections on the Future of Nuclear Energy in the United States

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Excellence is an art won by training and habituation. We are what we repeatedly do. Excellence is not an act, but a habit. (Aristotle)

Less than three years ago, many inside and outside the nuclear industry were sounding the death knell of nuclear energy in the United States. The forecasting branch of the US Department of Energy, in particular, predicted in December 1997 that no nuclear plant would operate beyond its 40-year licence term and 24 plants would close prematurely.

Predictions and conventional wisdom, however, are fickle partners. Nuclear energy is in a stronger position today than at any time in its history. A June 2000 report from BP Amoco noted that the global use of nuclear energy last year increased by 3.8% compared with 1998, well above the ten-year trend and significantly more than oil and natural gas. The rise was powered by an 8% increase in nuclear production in the United States.

US plants are performing at historically high levels, production costs are at historic lows, and owners are vigorously pursuing licence renewal and acquiring additional nuclear units. Moreover, the US public and Congress increasingly realise that economic progress and the environmental integrity of the United States depend upon a diversified and secure national energy portfolio that includes a robust nuclear energy industry.

Where We Are

A statistical snapshot of the US nuclear energy industry underscores the notion that nuclear energy is strong and getting stronger.

- In 1999, US nuclear plants set a new performance record by generating 728 billion kWh of electricity, the approximate equivalent of the combined nuclear generation of France, Japan and Belgium. The figure also represents a 50 billion kWh (8%) increase over 1998. Preliminary indications are that 2000 will be another record year. Data for the first quarter of 2000 — the most recent data available — indicate that nuclear plants are operating at about 5% above the same period of 1999. To put that in perspective, that is also enough additional electricity to serve the needs of the entire population of San Francisco.
- Capacity factors for the 103 nuclear generating units averaged 86.8% in 1999. By contrast, in 1980 US nuclear units had a net capacity factor of 57.6% and in 1990, 67.5%. US plant performance also led the world in unit capability factor. Last year, the unit capability factor for plants worldwide was 84.5%. For US plants, it was 88.7%.

- According to the Utility Data Institute, the 1999 US median operating and maintenance (O&M) cost for nuclear plants was 1.64 US cents per kWh, and the average O&M cost was 1.82 cents per kWh. Total costs are averaging 2.0–2.5 cents per kWh. Cost reductions reflect more efficient operations and power upratings. By contrast, the average production costs for a new gas-fired combined cycle plant were 3.0–3.5 cents per kWh, before gas prices recently reached their all-time high.
- Five units have received Nuclear Regulatory Commission (NRC) approval for another 20 years of operation — for a total of 60 years. Three units have formal applications under NRC review, and 26 other units have informed the NRC of their intent to pursue licence renewal. This means that, to date, the owners of more than 30% of the US reactor fleet have decided that licence renewal makes good business sense. The industry expects that almost all units will file for licence renewal eventually.
- In 1999, nuclear energy avoided emissions of 168 million tonnes of carbon, 4 million tonnes of sulphur dioxide, and 2 million tonnes of nitrogen oxide. From 1973 to 1999, nuclear energy avoided 2.6 billion tonnes of carbon, 63 million tonnes of sulphur dioxide and 25 million tonnes of nitrogen oxide. In 1998 — the last year for which statistics are available — nuclear power plants were responsible for nearly half of the total voluntary reductions in greenhouse gas emissions reported by US companies.
- For the eighth straight year, the United States exceeded the World Association of Nuclear Operator's 2000 goal for US plants for availability of three key plant safety systems — two main cooling systems and backup power supplies. Worker safety and collective radiation exposure also exceeded US plants' 2000 goals.

How did this renaissance in nuclear energy come about? Primarily, it was the product of innovative industry leadership and the hard work of a dedicated workforce. It was also a function of the industry's commitment to excellence and the constant effort to absorb the lessons learned from more than 2000 reactor-years of operation. As Aristotle said, excellence is not an act but a habit.

Most important, the renaissance of the US nuclear industry was the result of a unified industry articulating a vision of a prosperous future and working together toward that goal. One expression of that unity was the formation in 1994 of the Nuclear Energy Institute (NEI), a compilation of the best elements of four predecessor organisations. NEI represents the broad and varied interests of the diverse nuclear energy industry. Its role is to focus the collective strength of our nearly 300 members — about 18% of which are international — in order to help shape policies in the USA and globally that foster the use of a wide range of nuclear technologies.

The primary vehicle that animates those efforts, that lends action to the industry's strategic vision, is *Nuclear Energy: A Strategic Direction for the 21st Century*. In May 2000, NEI published the third iteration of the *Strategic Direction*, entitled *The Renaissance Revealed*. Based on a core of eight strategic "compass points", the *Strategic Direction* outlines how the industry can implement a number of powerful ideas — some old, some new — in our effort to navigate through a complex and dynamic business environment.

Those compass points are:

- Ensuring a US national energy policy that provides a diverse and reliable energy supply.
- Maintaining excellence in safe and reliable nuclear power plant operation worldwide.
- Achieving a safety-focused, performance-based regulatory framework.
- Attaining an integrated used fuel disposal programme and flexible low-level waste management approach.
- Capitalising on nuclear energy's intrinsic economic value.
- Maximising the value of nuclear generating assets in a competitive electricity market.
- Increasing the strong public and policymaker support for nuclear energy.
- Building the next generation of nuclear energy plants and related technologies.

Taken separately, these compass points are important and give focus to the industry's work. Taken together, however, they start a synergistic chain reaction. Advances in one lead to progress in others, that in turn results in improvements in still others.

That is why NEI and a number of organisations that support our industry weave the compass points of the *Strategic Direction* into the fabric of their annual and long-range plans. Even some of our international members look to US programmes and actions as articulated in the *Strategic Direction* for guidance. Already translated into Japanese, a summary of the latest version also was translated recently into Chinese.

How We Arrived

As noted, the excellent performance of the US industry revealed what the industry always knew: nuclear energy is a safe, economic and reliable generator of baseload electricity. When considered in light of the trend toward licence renewal, the onset of market competition and the industry's reinvention through consolidation, the future bodes well.

Adding momentum to the industry's march forward is the innovative and objective new approach to regulation under way at the NRC. Prompted by the industry's remarkable safety and operating record — and in no small measure, pragmatic oversight by the US Congress — the NRC is making the transition to a safety-focused, performance-based oversight and assessment process that was introduced industry-wide in April.

Working with Congress, the NRC and other stakeholders, the industry and NEI have helped shape a new approach to regulatory oversight that takes into account the industry's remarkable safety and performance records. This new process — which replaces the old Systematic Assessment of Licensee Performance and the Watch List approach — holds the promise of making the entire regulatory process more safety-focused, more efficient, less burdensome and less adversarial.

By heightening congressional awareness of the need for — and the environmental benefits of — nuclear energy, the industry underscored the negative impact of a prescriptive regulatory system on the industry's viability. Consequently, the NRC was given the impetus and the confidence to make

significant changes to how it regulates. Nearly 8000 industry man-hours were devoted to interactions between NEI and the NRC on developing the new programme, which remains a “work in progress”. In addition, NEI and the NRC are carefully monitoring implementation of the new process to identify potential improvements.

The new approach maintains the commission’s position as a strong, effective regulator and is centred on objective performance criteria. It enhances safety by focusing management and regulatory attention on areas of greatest significance. Moreover, it establishes clear, quantitative thresholds for performance, representing a vast improvement over the old process. Notably, the programme has garnered widespread praise from industry stakeholders because it has the promise of improving safety while significantly reducing unnecessary costs.

As the NRC implements and refines the new programme, initial reports from the stations reflect less burdensome and subjective NRC regulation. The process will also enhance public confidence in the industry because it is much more transparent and the inspection results are readily accessible via the Internet.

The NRC has also modelled its new enforcement and inspection programme on the new system, and the industry expects that this will continue to result in fewer non-safety-related citations and unwarranted or arbitrary fines. For example, in 1998, the industry received 1037 non-safety-related Level IV violations. That number dropped to 79 last year. And, again, the process is transparent, with the public and all stakeholders having Internet access to the data.

The importance of this change cannot be overstated. When licensees do not have to expend capital and intellectual resources on matters not related to safety, those resources can be better spent on items with safety and operational significance. Moreover, the drawn out fine–appeal–mitigation–re-inspection cycle can be very hard on public perceptions. It is not unusual for a single non-safety related violation to appear in the media four or five times. The public is generally unaware that this represents only one minor issue that in no way challenged plant safety.

The movement toward regulatory reform is a prime example of the synergies between the *Strategic Direction* “compass points” and NEI’s innovative efforts to raise the profile of the nuclear industry. As is well-known, the industry has laboured long and hard to get the US government to live up to its statutory and contractual obligations and to pass used fuel legislation in the US Congress. While the President vetoed the latest bill passed by both Houses of Congress, NEI remains committed to that end.

But it is also important to remember that the industry’s own waste management efforts over the past 40 years have worked so well that they have set a standard that other industries seek to match as they struggle to manage the disposal and clean-up of hazardous materials. Nevertheless, NEI’s efforts to secure legislation had a number of very beneficial ripple effects.

NEI’s work with Congress helped achieve increased funding for nuclear energy in general, and for nuclear research and development in particular. The

Nuclear Energy Research Initiative budget increased from US\$19 million to US\$22.5 million, and nuclear-related education and university research reactors rose from US\$700 000 to US\$12 million. In addition, Congress provided US\$5 million for initial funding for the Nuclear Energy Plant Optimization programme, which is design to fund innovative approaches to getting the most out of each plant. Congress also continued these programmes in the fiscal 2001 appropriations cycle.

Equally important, NEI used its work with Congress to assist in the development of a Nuclear Issues Working Group in the House and the Senate Nuclear Caucus as resources for members of Congress interested in nuclear issues. Most recently, NEI formed the Foundation for Nuclear Studies — a non-profit educational organisation — which will help lawmakers make prudent, informed legislative decisions by offering them the background they need to better understand our industry’s underlying scientific and technical basis.

These are all immensely important efforts because they have a policy “multiplier effect”. Our daily interactions with key members of Congress and their staffs have helped policymakers gain a greater appreciation and understanding of the vital work we do and its importance to the nation. They help establish a confidence level in our industry because they bring to light our safety, performance and economic qualities.

In short, the industry’s and NEI’s efforts to secure used fuel legislation resulted in progress across a broad front. They helped Congress appreciate the safety of our industry that, in turn, furthered policymaker interest in regulatory reform. Regulatory reform eliminated many of the financial uncertainties of nuclear energy, which prompted the financial community to adopt a much more bullish approach to the industry. And by emphasising nuclear energy’s environmental benefits — a topic addressed in the next section — the industry gains additional traction with the public, with policymakers and with business leaders.

Where We Are Going

Two dominant public policy issues will play a large role in nuclear energy’s future. Taken together, they almost inescapably lead to the conclusion that the industry will build new nuclear plants in the United States.

Continued economic progress depends upon a diversified and secure energy portfolio. As the digital economy continues to grow, the United States and the rest of the world will need significant amounts of new baseload generating capacity. Today, computer and Internet related uses of electricity constitute about 14% of US power consumption. A decade ago, that figure stood at 4%. Estimates of new generating capacity required over the next 20 years range from 300 000 MWe to 500 000 MWe — a dramatic increase over today’s installed capacity of 790 000 MWe. Already, in the first half of this year, electricity demand in the USA has increased between 3.5–4%.

Some of this new generation will be nuclear. In fact, the industry’s excellent operation has, in a way, already added new nuclear generation. Between 1990 and 1999, increased output from the US nuclear power plant fleet was the equivalent of adding about nineteen 1000 MWe nuclear plants. Nevertheless,

the time is rapidly approaching when these performance improvements will be supplanted by new nuclear plants. Why is this the case? Because increasingly stringent domestic clean air regulation and the potentially deleterious effects of global climate change make it an environmental imperative.

In March 2000, I testified before the Senate Energy and Natural Resources Committee and explained how annually, nuclear energy avoids the emission of 168 million tonnes of carbon in the United States. That roughly corresponds to the difference between current carbon emission levels and the 1990 levels we are trying to reach under the climate change treaty. Simply put, without nuclear energy, US carbon reduction requirements would double.

A similar situation exists here in the United Kingdom. A report by the Royal Commission on Environmental Pollution recently called for a 60% reduction in carbon dioxide emissions over the next half-century. After noting that nuclear energy is the UK's primary source of carbon-free energy, the report offered four possible scenarios for reaching that goal. All scenarios called for a large expansion of renewable energy sources. One scenario required the construction of 52 new nuclear plants; a second would require 19 new plants.

The World Energy Council also agrees that nuclear energy is important. That it why in its April 2000 report *Energy for Tomorrow's World*, the Council noted that the nuclear option must remain open. The report predicts that in 10 years market conditions and cost considerations will pave the way toward new plants. That is why, says the report, research and development should continue and emphasise both evolutionary plants and smaller designs for markets with less electricity demand.

That is why I tend to dismiss the German Green Party's effort to ban nuclear energy as nothing short of Orwellian "doublethink" — the ability to hold two contradictory beliefs in one's mind simultaneously, and believe both of them. There is simply no way for the Greens to act on their professed desire to stem global climate change while simultaneously doing away with nuclear energy.

Nuclear energy in the United States also avoids about 4 million tonnes of sulphur dioxide and 2 million tonnes of nitrogen oxides each year. Without this emission avoidance, the United States cannot expect to meet existing commitments under the Clean Air Act. The USA needs all forms of emission-free generation, but only nuclear energy has the ability to meet large and growing electricity demand. Given these contributions, nuclear energy is really a vital partner in clean air compliance. Yet its role, for now, is often unrecognised in meeting compliance goals.

One of NEI's more innovative efforts in this regard is the development of an updated computer model that can calculate more precisely the amount of emissions avoided by nuclear power plants. The purpose of the model is to calculate the role of nuclear energy in avoiding emissions controlled under the Clean Air Act. Users will be able to determine the amounts of sulphur dioxide and nitrogen oxide avoided annually by nuclear generation. Separate figures are also available for nitrogen oxide emissions avoided during the May–September "ozone season". Nitrogen oxide emissions during the warmer months contribute significantly to ozone levels and smog. The model also calculates carbon dioxide emissions avoided by nuclear generation.

As the electricity market restructures and competition evolves, it is possible that the economic value of nuclear energy as a compliance tool will be recognised. One of nuclear energy's most stalwart supporters, Senator Pete Domenici (Republican, New Mexico), introduced legislation that provided economic credit for emission avoidance. While the bill fell prey to political differences over the larger issue of electricity restructuring, it was a very encouraging effort.

NEI's new computer model will be an important tool once the economic dimension of emission avoidance is recognised. It has an economic function that calculates the value of avoided emissions based on quarterly updates of the trading price for sulphur dioxide and nitrogen oxide contracts. If nuclear energy is allowed to participate in carbon dioxide trading under an eventual global climate change effort, the model can also calculate the potential value of carbon emissions avoided by nuclear generation. This is yet another example of the synergies between the *Strategic Direction* "compass points". Nuclear energy's intrinsic environmental benefits help maximise the value of nuclear energy assets in a competitive market.

Nuclear energy's environmental qualities also help enhance the industry's already strong public support. To monitor trends in that support, NEI conducts opinion polling to stay abreast of public attitudes about our industry. The latest data collected in February 2000 are remarkably consistent with that collected since 1998: two out of three Americans support nuclear energy. In addition, 77% agreed that nuclear energy should receive tangible benefits for avoiding emissions. When asked if nuclear energy's role in reducing emissions should be a factor in electricity deregulation policy decisions that could influence the energy mix, 89% said nuclear energy's environmental benefits are important in policy decisions affecting continued nuclear plant operations.

NEI has consistently found that among the most influential public sector — college educated voters — support for nuclear energy remains high. Almost 90% support licence renewal and three-quarters of this group consistently support nuclear energy and the need to keep the option open to build more plants in the future. More than half of the respondents said the USA should build more nuclear power plants in the future.

These findings make it clear that the nuclear energy industry needs to make its case before the world and the American public. And that is exactly what NEI is doing, taking its message directly to the public, to policymakers and politicians, and to whoever else will listen. In support of that effort, NEI is pursuing a number of innovative communications strategies. As the World Wide Web becomes an increasingly important communications tool, NEI is moving energy policy dialogue to cyberspace. In addition to our member web site and revamped public web site, NEI maintains a number of specialised technical sites for the rapid exchange of industry information and data.

In June 2000, NEI introduced a new energy forum web site — SwitchonAmerica.com — and sponsored the first in a series of online discussions between the public and select energy industry specialists. NEI publicised the site through a series of advertisements in the *Wall Street Journal*. The ad campaign posed a series of important energy policy questions and prompted readers to visit the new site and join the forum discussion. NEI also regularly participates in web discussions sponsored by outside

organisations such as the *Washington Post* newspaper and the Environmental News Network.

The Road Ahead

The existing fleet of 103 nuclear power plants is a strong foundation for the future of the US industry. That is why the industry's immediate focus is on refining the licence renewal process. Every unit that meets the regulatory and economic standard for another 20 years of operation should be able to do so in the most efficient and effective manner possible. By working with our members, the public, the NRC and other stakeholders, NEI will pursue that goal vigorously.

Another primary goal is to continue improving the industry's performance trend. As previously noted, the past year was a record one for the industry, and indications are that 2000 will be even better. How far can the industry improve performance? Preliminary analysis suggests that the US nuclear fleet should be able to produce 790–800 billion kWh a year. The increase in output would come from two primary sources, higher capacity factors and power upratings.

If all 103 units achieved a 90% capacity factor, nuclear output would be about 758 billion kWh a year. At 92%, capacity factor output would reach 775 billion kWh a year. Both milestones should be achievable. The top two quartiles of plants already operate at 90% and the top plant quartile has a three-year rolling average capacity factor of 93.1%.

On top of the extra output from improved capacity factors, increases in power ratings could also boost production. The industry has already planned an additional 842 MWe of capacity upratings beyond the 2200 MWe captured between 1988 and 1999. Moreover, a recent change to NRC regulations could allow a 1% increase at each unit. For the entire US fleet, that represents about 970 MWe of additional capacity. Each 1000 MWe of added capacity represents approximately 7.5 billion kWh of output a year.

But what about new plants? Nuclear power plants — like clean coal technologies and many renewable energy sources — are high initial capital-cost technologies. Competitive electricity markets are driven primarily by short-term economic considerations. As a result, today in the USA most plants being built are lower capital-cost technologies like gas-fired plants — even though these units are very sensitive to fluctuations in natural gas prices and have been severely impacted by dramatic price increases.

The nuclear industry has a number of programmes under way to reduce capital costs — either through more efficient design and construction techniques, or through design changes and simplifications. To help identify policy initiatives that might be needed for new plants to be constructed competitively, NEI has developed a project financing computer model. In the coming months, the model will be used for sensitivity studies on the key cost and schedule targets a new plant must meet. In concert with this effort, NEI is proceeding with a number of benchmarking efforts designed to lower operating costs while sharing best practices between plants.

It is also important to remember, however, that there are three new standardised US plant designs approved by the NRC. While none are currently

being built in the USA, Japan recently completed construction of two advanced boiling water reactors (ABWRs) using a General Electric design. The Japanese experience in building these plants in about four years will help refine the process. With eight units already based on the ABB Combustion Engineering (CE) System 80 design in operation or under construction, in 1997 the Republic of Korea selected the ABB CE System 80+ (now a part of Westinghouse) as the technology base for the advanced Korean Next Generation Reactor. In addition to the General Electric ABWR and the System 80+, the NRC has also certified Westinghouse's modular design AP600. Westinghouse is currently exploring with the NRC the necessary steps for certifying an AP1000 design.

Nevertheless, NEI continues to support the US Department of Energy in an effort to define the "Fourth Generation" of nuclear reactor design. The goal of this international cooperative effort is to offer an even more viable and flexible nuclear energy option for the future.

Finally, construction of new nuclear units in the United States depends on continued refinement of the regulatory process and the continued progress toward construction and operation of adequate storage and disposal facilities for used nuclear fuel. Both are ongoing NEI priorities.

In terms of regulatory reform, NEI will continue its hands-on work with the NRC to help improve the concepts behind and the application of safety-focused, performance-based regulation. In terms of used fuel storage, NEI will work with the Department of Energy to emphasise continually the scientific bases for a repository decision. According to Secretary of Energy Richardson, the administration remains committed to a safe, permanent geologic repository. To that end, NEI will continue to work with DOE so the Secretary can make a decision next year to recommend Yucca Mountain to the President as the repository site. The industry will also continue its impeccable environmental stewardship of used fuel until the government fulfils its longstanding obligation.

Conclusion

The nuclear energy industry in the United States is in a stronger position today than at any time in its history. Production levels and safety are at historic highs, and costs are at historic lows. Owners are also vigorously pursuing plant re-licensing, and the industry is redefining itself through consolidation. The habit of excellence is contagious, and the industry is well-positioned for the onset of competition and market restructuring.

The future also bodes well for the industry. Increased demand for reliable baseload electricity, coupled with the growing importance of nuclear energy's emission-free nature, set the groundwork for industry expansion. While the immediate emphasis must remain the timely and efficient re-licensing of all units seeking another 20 years of operation, innovative approaches to new plants are also merited. The current 103 nuclear units provide a sound foundation for the future. Innovation and excellent operation will provide the mortar for new plant construction — new construction that is likely to begin well before the doubters think.