The status and future of nuclear power in the United States

BY LARRY R. FOULKE

No new nuclear plants have been ordered over the last 25 years, but there are steps that can be taken to help jump-start the process.

DEPARTMENT OF ENERGY (DOE) Secretary Spencer Abraham summarized well the current status of nuclear power in the United States in remarks he made last year. He stated that "Nuclear power is a vital part of the nation's electricity supply. It has played a major role in supplying electricity in the United States for over three decades. Currently, 103 nuclear power reactors produce approximately 20 percent of the electricity consumed in this nation."

The current performance of nuclear plants in the United States is excellent. Over the past 20 years, the average capacity factor has increased from about 60 percent to over 90 percent. This increased capacity translates into an additional 23 000 megawatts of power on the grid—the equivalent of building 23 new plants. Nuclear safety has been excellent and there have been substantial reductions in operating and maintenance costs, worker exposures to radiation, and quantities of radioactive waste generated. Since the mid-1970s, nuclear energy has enabled the United States to avoid emitting over 80 million tons of sulfur dioxide and about 40 million tons of nitrogen oxides.[1]

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Nuclear-generated electricity is among the cheapest available today. The production costs (fuel, operations, and maintenance) of most nuclear plants are less than 2¢/kWh and the best plants generate electricity for only about 1¢/kWh. This has not gone unnoticed by the industry. A growing number of reactor facilities have received 20-year license extensions and many more plants are expected to follow in the next few years. Performance is excellent and there is a good market for pre-owned plants. Recent university data[2] suggest that there is an upswing in nuclear engineering enrollments. Yucca Mountain is moving along toward becoming a geological repository for utility spent fuel and defense high-level waste, and the Nuclear Regulatory Commission (NRC) has promulgated a modern licensing process including early site approval and precertification of reactor designs.

All this good news is attributable in no small way to the President's National Energy Policy,[3] which endorses nuclear power, and an alphabet soup of exciting DOE programs such as DOE 2010, NEPO (Nuclear Energy Plant Optimization), NEER (Nuclear Engineering Education Research), NERI (Nuclear Energy Research Initiative), and INIE (Innovations in Nuclear Infrastructure and Education).

However, despite all this excellent performance and good news, no new nuclear plants have been ordered in the United States in the last 25 years. Given an energy source with so many benefits, why have there been no new plant orders?

This article addresses that issue and identifies some steps to jump-start new plant orders. These remarks represent a synthesis of views from many of my colleagues in the American Nuclear Society.

But before addressing the issue of building the next nuclear power plant, let us acknowledge that there is a lot going on in nuclear technology in the United States other than the use of nuclear power to produce electricity.

Today, in addition to providing clean energy, a dazzling array of nuclear technologies helps to:

- Improve medical diagnosis.
- Protect livestock health.
- Develop water resources.
- Preserve food.
- Promote agricultural productivity.
- Cure human illness.
- Enhance human nutrition.
- Advance environmental science.
- Eradicate virulent pests.
- Strengthen industrial quality control.

Currently, more than 12 million nuclear medicine procedures are performed each year in the United States, and it is estimated that one in every three hospitalized patients has a nuclear medicine procedure performed in the management of his or her illness.[4]

Abundant energy provides life quality

Our national well-being depends on reliable and abundant energy. Energy is the daily bread of civilization. We use energy to

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till the soil, grind grain, move flour to the bakeries, and bake the bread. Energy drives the U.S. economy. Energy heats our homes and pumps our clean water. We use energy to build not only our homes, but also everything in our homes. In short, energy drives society—in every economy and every civilization (which would simply vanish without energy). Energy frees humankind to be creative. On the other hand, without abundant energy, there would be no unemployment; we'd all be working 24 hours a day and seven days a week simply to stay alive—chopping wood, hoeing the crops, subsisting and surviving. In addition, social security would not be a problem; the average life span would probably drop by 20 years to return to what it used to be. However, those are improvements we can do without.

In addition, the U.S. economy is, according to Peter Huber,[5] increasingly using energy in the form of electricity. Back in the 1880s, no electricity was used. Ever since, the share of all energy used in the United States in the form of electricity has grown to 40 percent and that trend will continue. According to Huber, more than 90 percent of the growth in energy demand since 1980 has been met by electricity. Automobiles will continue to become more electrified, become hybrids over the next 10 years, and then be followed by a transition to electric propulsion or the use of hydrogen as a fuel (perhaps produced by electricity), or a combination of both.

The renaissance of nuclear power in the United States is inevitable. This statement, however, is not meant to be anti-solar and anti-wind. Where feasible and sustainable, solar and wind energy will be delivered as electricity just as will nuclear energy. Solar and wind power have always played a role and they always will. But they alone simply cannot do the job. It boils down to numbers. Just as it takes more potatoes to feed an army than to feed a family, it takes more energy to run a nation (gigawatt chunks) than to run a household (kilowatt chunks).[6]

Neither is the statement, that "the renaissance of nuclear power in the United States is inevitable," meant to be anti-conservation. Where feasible and rational, the efficient use of energy should be promoted. Over the past two decades, Americans have indeed learned to use energy more efficiently. "The United States uses about 10% more energy today than it did in 1973, yet there are more than 20 million additional homes, 50 million more vehicles, and the gross national product is 50% higher."[7]

The transportation sector offers the greatest opportunity for conservation and reduced dependence on foreign and domestic fossil fuels because it is the largest consumer of petroleum. To reduce U.S. reliance on foreign oil and make a cleaner environment, all feasible domestic energy options should be exploited to free the nation from using carbon-based fuels. Unfortunately, the United States has responded to decreased domestic production of oil and gas by increasing imports. However, that strategy simply will not be viable in the future. Today, many believe that we are facing worldwide pollution that is environmentally unacceptable. Furthermore, within 10 to 15 years we will be facing oil and gas prices that will be politically unacceptable. Electrical energy, generated by any means, will pave the way for an eventual shift from the use of petroleum in transportation, either directly through electricity or as a generator of hydrogen through electricity.

But conservation alone cannot do the job. There are 1.6 billion people in the world today who have no access to electricity.[8] In the year 2000, 1.1 billion people lacked access to safe drinking water.[9] They also need energy.

This all sounds logical and compelling. However, no new, large commercial electrical generating capacity of any kind will be built today without a suitable and reliable financial return on investment from the private sector. Hence, industry and government need to work together to address specific financial risks involved with building nuclear plants.

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To have a new nuclear plant by 2010, industry should encourage the government to take additional steps to mitigate financial risks. While energy planning should not constrain price competition or innovation, it should promote dependable and clean energy supplies for the long term. The nation's energy plan should permit government intervention in situations where market forces alone cannot bring about long-range goals to meet a national imperative. Driving forces such as environmental quality and energy independence require more aggressive short-term government investment to obtain the long-term benefits that nuclear energy provides.

Major deterrent to near-term nuclear power

As indicated above, a major roadblock to building a new nuclear power plant in the United States now is financial risk.

Other barriers to building new nuclear plants have not vanished but have been reduced:

- The management of spent fuel took a giant step forward with the support of a geological repository at Yucca Mountain by the President and Congress. "Spent fuel management" is a problem of perception and, therefore, a political issue. In reality, the used fuel from nuclear power plants has some great advantages that we do not exploit—the waste is of small volume per MW of energy produced; it is sequestered and segregated from the start; and it is easy to track. In fact, only about 3 percent of used fuel is truly waste. The bulk of the used fuel remains as valuable fertile and fissile material that we may recycle someday—and, thereby, reduce waste volumes and activity still further.
- Renewal of the Price-Anderson Act appears to have support from both houses of Congress.
- The NRC's new combined construction and operating licensing process (10 CFR 52) looks promising, but until it is demonstrated and court-tested, there will still be concern whether or not the new ITAAC (Inspections, Tests, Analyses, and Acceptance Criteria) process works.
- The majority of the population is pronuclear, especially in light of growing environmental concerns regarding global warming, although they tend not to be activists in their belief.

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■ Operating costs are low, and the facts show that the risk to humans from nuclear power per MW of energy produced is very low.

The nuclear industry responded to the President's National Energy Policy with "Vision 2020,"[10] which sets a goal of 50 000 MW of new nuclear generating capacity to be added to the U.S. grid by 2020. The Nuclear Energy Institute took a lead role in formulating this vision and has established an Executive Task Force on New Nuclear Power Plants to help guide near-term industry actions toward that goal.

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The industry applauds the DOE's Nuclear Power 2010 triple initiative in which the government and the private sector will work together to (a) explore sites for new nuclear power plants, (b) demonstrate the efficiency and timeliness of key processes designed to make licensing of new plants more predictable, and (c) encourage and fund research needed to make the safest and most advanced technologies available. This is all excellent but it may not be enough.

Government has a role to ensure supply

Governing bodies have, and have had, a clear role and responsibility to assure reliable sources of energy, and, hence, to help remove barriers to an expanded role for nuclear power in the United States. Such issues are too important to be left to the vagaries of a free market. Such issues must be considered and planned in light of the inextricable linkage among energy independence, national security, global economic competitiveness, and environmental quality.

Governing bodies can mitigate these risks for the benefit of the nation. While deregulated markets can stimulate low prices through competition, they do not capture well the long-range benefits of energy independence, energy diversity, and a reduction of environmental pollution.

Once upon a time in a regulated market, the utility's job was to provide reliable power while recovering costs in the rate base. In other words, reliability of supply and financial solvency were paramount. But now many utilities face new economic forces. There is little premium for vision and investment in the national welfare. There is currently no financial benefit for production of electricity from non-polluting energy sources or for enhancing the nation's energy independence and security.

Moreover, the CEO of a generating company has little incentive for doing more than that which satisfies his board of directors. National imperatives seldom come into a board decision—financial return does. Hence, national imperatives force us to find alternative ways to motivate the mitigation of financial risks and to promote financial credits for the nonfinancial benefits of the nuclear option.

Financial issues and mitigating actions

Let us consider the four major issues and the potential mitigating actions for near-term nuclear power in the United States. The actions proposed are not out of line with a recent report to the Nuclear Energy Research Advisory Committee (NERAC) by an integrated project team composed of key DOE staff members and Scully Capital Services.[11] Let us also keep foremost in mind that new nuclear power plants are projected to be competitive after the first several plants are built and the financial risks associated with the first plants no longer exist.

Issue 1: Markets are not prepared to finance new nuclear projects because of their high cost, particularly early plants, and power companies are concerned about earnings dilution during construction.

The higher cost of early plants is associated primarily with two learning-curve issues: First-of-a-kind-engineering and construction. Once these two issues are put behind the industry, new nuclear plants may still be relatively expensive but they will generate power that is competitive in many markets. Early costs for these learning-curve issues could be addressed by government dollars as a "preferred equity" investment.[12] Dividends to the government on the equity investment would occur after plant capacity factors reach a preset level. Commercial lenders would then loan only as much as they consider economically justified.

As an alternative, the government could provide loan guarantees for a portion of the plant cost during the construction period. Once the high-risk period is passed and the plant is operating, the plant owners could restructure the debt, thus avoiding the need for guarantees by the government.

Investment tax credits payable during construction to mitigate the issue of significant earnings dilution during the construction period have usefulness, although the credits are limited. Investment tax credits would amount to a modest percentage of the investment in a given year, but the credit would normally be granted only once for a particular investment. Since a new plant will take three to four years to build, two or three years of investment will still have to be carried without earnings. Hence, investment tax credits are not enough to eliminate the hit in earnings over a multi-year period—but they would help mitigate them.

Also, accelerated depreciation could be made available for new nuclear plants to be more in line with other major industrial facility additions.

Such steps may be necessary in a deregulated environment in which the power company cannot pass on construction costs as an "allowance for funds used during construction."

Issue 2: There are concerns about delays and/or termination of plant projects as a result of acts of government (regulator) or the acts of the public (intervenors).

The government could assume extraordinary costs associated with delays due to the acts of government or the acts of the public (as a consequence of government actions) through standby credit facilities. Through these facilities, the government would agree to carry interest payments resulting from construction delays caused by changing government requirements and not contractor faults. Such standby credit facilities could also offer a "make whole" provision under which the government would take ownership of the plant and repay both the lender and equity-holder in the event that "acts of the government" and "acts of intervenors" (that could result from government actions) prevent plant commissioning. This step would provide excellent protection from the specific risks that are at issue but without the disadvantages of loan guarantees.

Issue 3: A great financial risk is recovering costs from a deregulated market.

The solution here is a long-term power purchase agreement from a creditworthy entity. Reduced uncertainty in siting and licensing is helpful, but it may not be enough. Given the higher capital cost of a nuclear plant, the risk of long-term recovery of that investment is a great financial penalty faced by the plant owner.

The government could guarantee the purchase of a certain amount of the future power production from a new plant at a negotiated price. This would mitigate the risk of forecasting electricity demand and price for many years out in the future. This temporary floor price would allow investor returns similar to that achievable from alternate power-generated sources.

Issue 4: The government should provide credits for the nonfinancial benefits of nuclear power.

Free enterprise can hurt the nation if credits for nonfinancial, national benefits such as environmental quality, energy security, and the burnup of weapons-grade fissile material are not entered into the financial equation. Initiatives must be pursued to create a level playing field for nuclear power. Carbon trading would create an enormous incentive to build nuclear plants. Every citizen is a stakeholder when it comes to burning up weapons-grade fissile material, and having clean air, clean water, reliable electricity supplies, and energy security.

More prominence must be given to the emission-free nature of nuclear power, and its role in helping to meet the challenge of international agreements to limit carbon emissions. Emissions credits for nuclear generation would go a long way toward encouraging new construction.

These financial proposals are meant to ease the introduction of the next generation of nuclear plants. Once the technology and processes are demonstrated, overcoming many of the first-of-a-kind hurdles, normal financial markets can be expected to provide traditional financing as more generating companies and financial markets become confident in the technology and reliability of construction schedules. Regardless of the financing scheme, clean air credits are a legitimate incentive that will help stimulate nuclear construction and provide a mechanism for addressing the challenge of Kyoto.

The bottom line

The bottom line is that to get a new nuclear plant by 2010, industry and the government should deliberate together, and the government should act to help the industry deal with today's financial showstoppers. The government may not be able to implement all the actions described above, but industry should be prepared to employ any risk-mitigating opportunities that present themselves in the future. It appears that the deliberations have begun (see *Inside NRC*, October 7, 2002).

These actions proposed above in response to the four major issues would almost certainly jump-start the nuclear industry. But how likely is it the Congress would look favorably on funding these proposals? The antinuclear segment of the population might look at these steps with great delight and use them to conclude that nuclear power cannot realistically make a comeback, at least not in the near term (to 2020). However, energy independence and environmental quality are too important to leave to short-range market forces and to the opponents of nuclear power.

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The challenge is to find ways by which the government can stimulate energy independence in a politically acceptable way. To promote political acceptability, the industry should share the financial risk. Vendors make partnerships with nuclear utilities today for service and operation. Vendors can also make similar partnerships for future construction. Under the historical business model, vendors engaged with the utility on a transactional basis without providing any equity investment. In a new business model for the renaissance,[13] long-term relationships between vendors and utilities may be needed to give the utilities confidence that the vendors are also willing to make investments and share the risk.

Some might suggest that we should simply wait for the price of energy to go up and then nuclear energy will find its proper place.

The rationale for EISA would be to make the nation energy independent, to provide for energy security, and to expand the nation's sources of environmentally clean energy.

Unfortunately, with a capital-intensive technology, the price of energy is correlated to the cost of money, which does not help the economics of new nuclear plants. Following the Arab oil embargo of 1973, the price of energy was very high, and interest rates on any construction rose to 20 percent. Moreover, building new nuclear plants is a time-consuming process and the need for them is inevitable. So, why wait? We need the nuclear option soon—the time to build is now.

A proposal: EISA

A government loan guarantee example/model could be derived from the shipbuilding or highway industries. For example, the government could fashion a broad program of federal energy financing that contains mechanisms like those in the Transportation Infrastructure Finance and Innovation Act (TIFIA).[14] The Department of Transportation loans money, limited to a portion of the total cost, for the construction of highways and bridges. The money from such an act, which could be called the Energy Infrastructure and Security Act (EISA), would be used for loans, loan guarantees, and specific insurance against unique business risks. Additional financial tools, such as power purchase agreements, could also be included.

The rationale for EISA would be to make the nation energy independent, to provide for energy security, and to expand the nation's sources of environmentally clean energy. Such an act—combined with the relatively good financial condition of many of the nuclear utility conglomerates,[11] the anticipated energy needs of the nation, and the need to maintain the nuclear infrastructure—could put new energy projects on the books. Rebuilding the nation's energy infrastructure requires vision and advance planning. An EISA program would not be limited to nuclear projects but could be applied to building a diverse energy infrastructure. With an EISA program, the nation could also take steps to strengthen the distribution grid to get power from large new plants to areas of the country where power is needed.

What this will take is creative leadership and risk sharing with the government by members of industry (utilities and vendors) that believe nuclear power is essential to their long-term competitive position as well as the nation's.

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Long term and near term

There needs to be a near-term track (2010) and a long-term track. Getting on the long-term track requires that all parts of the nuclear enterprise be engaged. The purchase of a new nuclear plant in the near term is only one key ingredient to long-term development. Other key ingredients include the vendor, architect/engineer and educational infrastructures, continued research and development, and healthy national laboratories.

To introduce the technologies that have been identified as Generation IV, a new risk-informed licensing process that is technology neutral will be required, since many Generation IV reactors are not water-based.

For a near-term plant to be built by 2010, it is prudent to focus on the technology that can restart the nuclear industry in the United States quickly—that is, existing, but improved Generation III+ designs that are or can be certified quickly by the NRC. Generation IV reactors may some day provide even more economic and attractive alternatives, but that day is most likely beyond 2010. Hence, we must continue to invest in Generation IV technologies, but we must not rely on their leading a nuclear renaissance.

Any proposal for Generation IV needs to have a significant risk-sharing component to be politically acceptable. It also needs to be part of a demonstration package (let us call it the prototype of a fleet). Thus, we envision a cost-sharing demonstration project for Generation IV. Price guarantees are not part of that package nor is cost overrun or rate protection. DOE has proposed a split of some expenses for advanced reactors. This cost-sharing should be broadened to the total project (that might then make the plant economical) and costs can be repaid once the plant begins producing electricity.

For Generation IV reactors, a research/demonstration plant should be built on a DOE site to prove design principles that could lead to a certification. To introduce the technologies that have been identified as Generation IV, a new risk-informed licensing process that is technology neutral will be required, since many Generation IV reactors are not water-based. The regulators should be urged to use this time to develop a process to establish new licensing criteria and a collaborative role with developers to test the new technologies through a process using a research/demonstration plant to ultimately lead to certification of new designs. This is a way to get the demonstration and certification at the same time, and it may cut the deployment time and costs considerably.[15] This too would require a risk-sharing approach with DOE. The cost-sharing should be based on the research, development, and testing elements of the research/demonstration facility, which the government could logically support while the cost of construction could be borne by the industry supporting the demonstration effort.

It was made quite clear by the actions of Exelon—when it decided that it is not in the business of developing new nuclear technologies and dropped its participation in the South African pebble bed modular reactor (PBMR) project—that the DOE's expectation that industry will lead in the introduction of new nuclear technologies is not valid. This means that the DOE is the logical leader in the development and demonstration of advanced reactors with the necessary financial support.

International leverage for Generation IV reactors is certainly possible and has been set up by the creation of the Generation IV International Forum (GIF). The activity of the GIF and the Generation IV initiative support the recommendation in the Bush administration's National Energy Policy to pursue research in collaboration with international partners to develop the next generation of nuclear technologies. The future of nuclear energy is an international future—involving the collective skills, expertise, and resources of many nations.

The GIF, initiated in January 2000 and formally chartered in July 2001, is an international collective represented by the governments of the leading nuclear nations. They agree that nuclear power is important to future world energy security and economic prosperity, and are dedicated to joint development of the next generation of nuclear energy systems.

Closing thought

We conclude by pointing to remarks made last year by Angie Howard[16] at the Conference on Nuclear Training and Education. She observed that "Today's challenges are the results of success . . . the success of a mature and productive nuclear industry that is on the verge not only of realizing the full potential of its first generation of existence, but of laying the foundation for another generation—a generation that will carry the industry from the 50th anniversary we will soon be celebrating right through to the nuclear centennial."

References

1. Abraham, S., remarks at the Global Nuclear Energy Summit, Washington, D.C., February 14, 2002. (See also *Nuclear News,* April 2002, p. 26.)
2. Walter, A., "Feeding the Nuclear Pipeline: Enabling a Global Nuclear Future," IAEA Scientific Forum, Vienna, Austria, September 17, 2002.
3. National Energy Policy, Report of the National Energy Policy Development Group, May 2001.
4. NERAC Final Report, Subcommittee for Isotope Research and Production Planning, April 2000. Posted at <nuclear.gov/nerac/finalisotopereport.pdf>.
5. Huber, P., address to the National Chamber of Commerce, Washington, D.C., September 24, 2002.
6. Hayden, H. C., *Solar Fraud,* Vales Lake Publishing, LLC (Pueblo West, Colo.), 2001.
7. Position Statement on Energy by the National Society of Professional Engineers, January 21, 2002. Posted at <www.nspe.org>.
8. Priddle, R., press conference by the International Energy Agency, World Summit on Sustainable Development, Johannesburg, South Africa, August 28, 2002.
9. United Nations, Human Development Report 2002, United Nations Development Program, chap. 1, p. 29. Posted at <hdr.undp.org/reports/global/2002/en/>.
10. Nuclear Energy Institute, Vision 2020, Rev. 1, May 2002. Posted at <www.nei.org>.
11. Scully Capital Services, "Business Case for New Nuclear Power Plants," Briefing for NERAC, October 1, 2002.
12. Berg, D., personal communication, October 7, 2002.
13. Kennedy, E., Infocast Conference, Washington, D.C., September 10, 2002, and *Nucleonics Week,* vol. 43, no. 37, September 12, 2002.
14. Transportation Infrastructure Finance and Innovation Act (TIFIA). Posted at <tifia.fhwa.dot.gov/>.
15. Kadak, A. C., "Licensing and Deployment of Advanced Reactors," International Meeting on Probabilistic Safety Assessment, October 6–9, 2002.
16. Howard, A. S., "Developing the Nuclear Workforce," keynote address to the Conference on Nuclear Training and Education, Orlando, Fla., August 20, 2002. NN