THIRD WAY

REPORT *Published December 6, 2012 • 48 minute read*

A Strategy for the Future of Nuclear Energy: The Consolidated Working Group Report

New Millennium Nuclear Energy Partnership

Introduction and Summary

Today's nuclear energy technologies offer our nation a resource that can safely provide around-the-clock energy at affordable prices while minimizing emissions. The United States is the birthplace of nuclear energy and has been the leader in commercial reactor technology since its inception. Our nation maintains the capacity and expertise to retain the title of nuclear pacesetter, but international investments in research and deployment of nuclear technology has put that position at risk.

However, the future of domestic nuclear energy is dependent upon an interwoven set of decisions made by the public and private sectors. On one hand, private industry must make business decisions about constructing and operating nuclear energy facilities which are expensive up-front investments, despite uncertain government policies and regulations. On the other, the policy goals of the government—the production of safe, affordable, and clean base-load energy—cannot be achieved without private sector cooperation and investment. The New Millennium Nuclear Energy Partnership ("the Partnership") has come together to offer new ideas on how government and industry can work together to ensure America's long-term leadership in—and benefits from—nuclear energy.

There are three key challenges facing the industry and government regarding the future of nuclear energy in the United States. First, near-term low natural gas prices—coupled with limited electricity demand growth forecasts—have meant that many energy companies have increased significantly electric power generation using existing power plants that are natural gas-fired, but are deferring major investments in base-load capacity (e.g., nuclear) and instead

are looking toward marginal capacity investments in new power plants using natural gas as an interim solution. Of course, the future trends in natural gas prices are uncertain, with both history and global demand suggesting that the price could fluctuate significantly in the coming years.

Second, last year's accident and associated events in Japan at the Fukushima Dai-ichi plant have caused some to question the future of nuclear energy in the U.S. We are convinced this is a mistaken conclusion, and the risks of nuclear energy remain extremely low. Still, it is essential that the industry strengthen stakeholder confidence that the United States' nuclear energy plants adequately ensure the health and safety of the public and protect the environment. Further, we believe that the current impasse related to used nuclear fuel management can be credibly addressed via the recommendations of the Blue Ribbon Commission on America's Nuclear Future (BRC).

Third, nuclear energy is expanding rapidly around the world. On our present course, the U.S. will be challenged in its position as a leader in nuclear energy technology and its influence over global nuclear safety and security. An international presence by a strong and collaborative American nuclear energy enterprise is vital to efforts to reduce the threat of nuclear weapons proliferation and ensure nuclear energy safety. We can assure that presence and influence best if we have a robust domestic infrastructure that serves as a platform for export of nuclear technology, components, and human capital.

Within the context of these challenges, the Partnership's multi-disciplinary group of industry, environmental, government, academic, innovation, and financial leaders have worked to develop a consensus view on the future of nuclear energy. The broad outline of the Partnership's strategy was defined during a summit held in December 2010, which was hosted and moderated by Third Way and the Idaho National Laboratory, chaired by a bipartisan duo of U.S. Senators, and attended by the Secretary of Energy, the

Chairman of the Nuclear Regulatory Commission, the President's Energy Advisor, other Members of Congress, and senior industry and public policy leaders.

After the summit, Partnership members divided into four working groups, and this paper is the result of their deliberations. The sections of this paper track the four topical areas of the working groups in addressing the key challenges to the future of nuclear energy in the United States, with the addition of an initial section offering the over-arching recommendations of the entire Partnership:

- **General Recommendations:** Offers insights on the vital role of nuclear energy in national energy policy and the need to develop a politically sustainable national energy policy through a Quadrennial Energy Review. These recommendations assure a durable energy policy framework for decades in the future.

- **Public-Private Partnerships:** Recognizes the value of public-private partnerships in meeting current and future challenges and identifies crucial elements for developing successful partnerships between the federal government and private industry to best mitigate the risks involved in nuclear energy projects and leverage the expertise of both sectors.

- **Financing New Nuclear Energy Projects:** Provides options that will enable initial and long-term financing for this capital-intensive industry. Recommendations address issues relating to revenue insufficiency in the construction of new plants, financial risk mitigation, and project finance challenges.

- **Infrastructure Development:** Considers the importance of rebuilding the U.S. nuclear industrial infrastructure and positioning U.S. industry to continue to be a leader in the global nuclear energy marketplace. Addresses issues relating to the domestic supply chain, nuclear liability, workforce development challenges, and regulatory hurdles.

- **New Nuclear Energy Technology:** Investigates technological advancement issues that could provide new advanced reactor designs for electricity generation and for industrial use, the regulation and licensing by the Nuclear Regulatory Commission of new nuclear energy technologies, and options for a sustainable nuclear fuel cycle.

The recommendations in this report form the foundation for a consensus strategy between government and industry that can help the U.S. realize the benefits of nuclear energy.*

* The Partnership's strategy is intended to complement the recommendations of the Blue Ribbon Commission on America's Nuclear Future for managing the back-end of the nuclear fuel cycle. Consequently, the Partnership's recommendations in the area of managing used fuel are limited to development of enabling technologies.

General Recommendations

A National Energy Policy

All of the recommendations in this report are intended to represent a multi-decade strategy for growth of the domestic nuclear energy sector and for the U.S. to regain its position as a leading market and policy force in the global expansion of nuclear energy. But the future of nuclear energy policy cannot be charted in a vacuum. The global marketplace is shaped by various national energy policies that guide decision-making and provide market predictability to advance national energy goals. These policies have served as the foundation for the growth of indigenous nuclear energy industries around the world by providing opportunities to build, refine, and deploy technology at a significant scale. To that end, the U.S. government should establish a robust national energy policy that provides a framework within which the private sector can make long-term investment decisions. Furthermore, the national energy policy should guide the direction of industry and government work on all energy technologies, including nuclear energy.

To succeed, a national energy policy must have broad-based support and a lifespan that exceeds typical appropriations

and election cycles, and it must provide for Administration and Congressional oversight with the advice of independent experts from industry and academia in energy, economics, environment, and public policy.

Recommendations

- ***The President should establish a full interagency Quadrennial Energy Review (QER).*** The QER will provide the structure for evaluating the substantive national energy interests and priorities for the government, which is essential to establishing a national energy policy (e.g., national security, environmental quality, husbanding of indigenous energy resources, and impact on the national economy). The Executive Office of the President (EOP) should lead this process. It should include the participation of relevant government agencies, as well as those members of industry that have the practical experience in the development, demonstration, and deployment of large-scale energy technology, as well as academia and public policy organizations with relevant experience in energy policy development.

- ***The QER should specifically address the role of nuclear energy.*** The purpose of characterizing the role of nuclear energy is not to select specific technologies for the marketplace. However, given the large role that nuclear energy plays in our energy mix and the intertwined public and private roles in this technology, it is vital that the QER identify the energy technology options that should be developed and demonstrated via government-industry partnerships based on the mutual agreement of government and industry.

- ***Congress should establish an entity that provides an operational focal point for energy policy implementation and regulatory improvement.*** The mission of this statutory entity should flow from the QER, and it should provide a forum for coordination of effort by government, industry, academia, and public policy organizations. There are precedents for putting it within various entities, including:

  - Congress (like the previous Joint Committee on Atomic Energy);
  - The EOP (like the National Security Council);
  - A new government agency (like DARPA);
  - A government-industry partnership (like SEMATECH, the public-private consortium that promoted the U.S. semiconductor industry in the period 1987-1996); or
  - A government chartered private corporation (like COMSAT).

Ensuring Sustained, Safe, and Reliable Operation of Existing Nuclear Power Plants.

There are 104 nuclear power reactors operating in the United States. The existing U.S. nuclear power fleet has a remarkable safety and performance record. Today, these reactors account for about 20% of the nation's electricity and 70% of the low greenhouse gas-emitting electricity production. Ensuring the safe and reliable operation of existing nuclear power plants is an ongoing and urgent issue, since energy companies will have to make decisions within the coming decade on upgrading or replacing equipment and plants. The first of the current nuclear fleet will complete their 60th year of service by the late 2020s. At stake is the potential loss of over 2,000 GWe-years of existing safe, clean, low-cost electricity production capability over the next 30+ years. The impact of this loss in existing base-load generating capacity will result

in significant new costs to consumers, reduced grid reliability, and an increase in emissions and price volatility as capacity is replaced with non-nuclear sources.

The majority of the current U.S. nuclear energy fleet has received license extensions to provide 60 years of service, and the NRC is reviewing more license extension applications. For nuclear plant owners, investment in plant upgrades to enable life/license extension has historically been the lower-cost option for providing power. However, the U.S. nuclear fleet is aging, and it faces some important technical, regulatory, and business uncertainties regarding reactor life extensions beyond 60 years.

A regulatory framework that assures the option to safely extend the operating lifetimes for current plants beyond 60 years (and where possible making further improvements in their rated output) will bring certainty to industry and benefits to consumers and government that will extend into the second half of this century. Thus, license renewals are vital to our economy and our environment.

We believe it appropriate that efforts to increase the lifetime of nuclear plants are conducted within a public-private partnership. Government should be focused on funding and conducting the kind of long-term R&D that requires the unique capabilities of its national science and engineering infrastructure (e.g., evaluation of material degradation). Industry should sustain its focus on nearer-term issues associated with reactor operation.

Such a partnership effort has characterized the analysis and activities of industry and the NRC in response to the events at Fukushima Dai-ichi. Industry proactively has implemented additional in-depth safety capabilities in coordination with ongoing regulatory work of the NRC. It is clear that government and industry can and should work together to ensure that U.S. reactors continue operating safely.

Recommendation

- ***The nuclear industry and the Congress should ensure that sufficient funding is made available to develop the necessary technical underpinnings for long-term operation of currently licensed reactors.*** Federal funds should be focused on higher-risk (e.g., technical or licensing risk), longer-term research that is commercially viable. The unique capabilities of the national laboratory complex can provide valuable assistance in these type of activities. Partnering and collaborative efforts between government and industry are essential to balance the costs and risks for such activities. For example, in the short term, the scope of such activities should build on the present Light Water Reactor Sustainability program (jointly sponsored by DOE and industry). Over the longer term, these activities should be prioritized via the QER.

Implementing the Partnership's Strategy

The development of detailed implementing actions for each of the following recommendations is essential to the success of the Partnership's strategy. This paper's recommendations often explicitly assign an agency or government organization to serve as an "action party" that will lead their implementation. Note, however, that several of the recommendations require the formulation of a detailed implementation strategy in which industry must play a crucial role. As such, the EOP should create a body to develop detailed, industry-inclusive implementation approaches and identify the appropriate action party.

Recommendation

- ***The EOP should establish a standing "Nuclear Energy Strategy Group"*** comprised of authoritative representatives from government, industry, academia, and public policy organizations. This group will develop detailed approaches and criteria for the recommendations on issues related to nuclear energy. It should report to the statutory entity proposed in Section I(A) above.

Public-Private Partnerships

Nuclear energy involves a complex and intimate relationship between government and industry. In many countries that have a commercial nuclear industry, the government plays a central or strong role in the nuclear energy enterprise, ranging from policy direction to the actual ownership of essential parts of the nuclear energy industry (e.g., fuel cycle facilities and power plants). While the U.S. nuclear industry is primarily private and makes market-based decisions, it is necessarily intertwined with the government at every stage of its development and operation, and the market is influenced by government policy and regulation. Given the costs involved and risks introduced by the intertwined relationship of the public and private sectors, the development of advanced nuclear energy technology is generally beyond the reach of industry alone and requires government assistance to share risk.

As such, we must commit to forming the public-private partnerships* that provide mechanisms for sharing risks and costs where national interests—like clean energy development, improving national security, achieving energy security and independence, and rebuilding industrial infrastructure—are at stake. Successful and well-functioning public-private partnerships, both large and small in scale, can deliver increased cost-competitiveness, expanded safety benefits, and the development of technologies for export. It is therefore important that we develop an operating model for public-private partnerships that incorporates a history of best practices, adapts to changing conditions, and delivers the best chances for eventual commercial success.

* A public-private partnership may be defined as follows: "... a contractual agreement between a public agency (federal, state, or local) and a private sector entity. Through this agreement, the skills and assets of each sector (public and private) are shared in delivering a service or facility for the use of the general public. In addition to the sharing of resources, each party shares in the risks and rewards potential in the delivery of the service and/or facility. (The National Council for Public-Private Partnerships, www.ncppp.org)"

Model for Public-Private Partnerships

Recent experience with energy-related partnerships has revealed a number of issues that need to be addressed by the nuclear industry and the Nuclear Energy Strategy Group. These include questions of how the priorities for partnerships are established within government, the roles and authorities of the public and private sectors in a partnership, checks and balances that weigh national interests against business benefits and risk, and accountability when one partner fails to fulfill the provisions of the partnership agreement.

The recently completed Nuclear Power 2010 program and the ongoing LWR Sustainability program serve as reasonably successful partnership models. However, both of these involve relatively low risk to either partner, compared to the much larger public and business risks encountered in developing, demonstrating, and deploying major new technologies. The difficulties encountered by the original FutureGen coal energy project* and deferment of the Next Generation Nuclear Plant project** (despite substantial federal and private investments), demonstrate the hurdles that can arise for projects with larger overall costs and risks. Further, the government's failure to fulfill the requirements of the *Nuclear Waste Policy Act* highlights the need for appropriate risk management provisions for such partnerships between government and industry.

* The original FutureGen Project and the FutureGen 2.0 Project are both directed toward developing and demonstrating alternative combustion and carbon capture and storage technologies to achieve near zero-emissions for coal-fueled power plants.

** The Next Generation Nuclear Plant Project is directed toward developing and demonstrating modular high temperature, gas-cooled reactor technology for production of industrial process heat, electricity, and hydrogen.

Recommendations

The Nuclear Energy Strategy Group should:

- ***Design management models that are appropriate for the varying risk profiles of partnerships.*** In developing methods for governing public-private partnerships, the value, risk, and nature of a partnership's deliverables (e.g., studies, technology R&D, physical hardware, a manufacturing facility, or a licensed nuclear energy production facility) must be evaluated. This should also include a determination of the appropriate roles and responsibilities for both government and private sector involvement in the oversight, management, and fiscal control.

- ***Establish benchmarks to assess the continuing viability of partnerships.*** A pre-established evaluation method with specific criteria is essential to determine whether public and private sector interests and priorities are being fulfilled by a partnership.

- ***Provide for a mechanism for amending partnership agreements.*** During the life of a partnership, particularly for a large project, we can expect changes in scope, approach, cost, and government priorities. Currently, there is no mechanism or criteria for equitable management of partnership changes. Providing such a mechanism will improve private sector confidence that partnering with government will achieve its goals and result in the expected return on investment with acceptable business risk.

- ***Accept the use of commercial accounting standards.*** The business community relies on the Generally Accepted Accounting Principles (GAAP) established by the Financial Accounting Standard Board (FASB), as opposed to those prescribed by the Government Accounting Standard Board. Recognizing that the national interest will be served by collaborations and partnerships between the government and industry, the government should accept the use of commercial accounting standards for public-private partnerships. Failure to do so drives up the cost of doing business with the government and does not provide substantial public benefit.

- ***Develop a protocol for terminating partnerships.*** If a partnership dissolves, there should be a path by which each party shares the financial burden of the termination, based on pre-established criteria.

Cost Sharing

In recently proposed public-private partnerships for nuclear energy projects, the requirements and expectations for cost sharing between government and industry have been incompletely and somewhat arbitrarily defined, particularly for major projects that involve development, demonstration, and deployment of new technologies. Industry and government need cost-share formulations that are based on an assessment of acceptable business risks. Each party must also recognize that the financial risks in nuclear energy projects are greater in the development and licensing stages, and vastly overshadow later demonstration and deployment risks.* An important consideration in a successful public-private partnership is the continuity of cost-share funding. This is particularly difficult since the government is funded annually and without any guarantees of continuity. A change in priorities for either Congress or the Executive Branch can result in inadequate funding for the projects.

* For example, the development of the technical requirements framework for review of license applications in parallel with design development incurs high financial risk due to uncertainties in the licensing technical safety basis requirements.

Recommendations

- ***The Nuclear Energy Strategy Group should establish consistent criteria for cost sharing based on risk and processes to routinely evaluate cost-share arrangements against these criteria.*** The partnership agreements must acknowledge the greater technology, design, and licensing risk early in a major nuclear energy project's life, particularly for new technologies. Also, the agreements should include cost sharing provisions that take into account the investment in energy technology that precedes the formation of the partnership, and such allowance should be considered in establishing the overall federal and non-federal cost-share in the agreement.

- ***The Nuclear Energy Strategy Group should define a federal funding mechanism to ensure the continuity of federal funding over the agreed term of an energy technology project.*** Historically, federal programs have a poor track record of funding the entire life of an energy collaboration, and the business community has therefore become wary of partnering with the U.S. government on such projects. One solution could include a funding model that would be part of a congressionally authorized, multi-year contractual mechanism with penalties borne by each party in the event that annual funding commitments are not met.

Financing New Nuclear Projects

New nuclear energy facilities are expensive and capital intensive. Estimates for constructing a large Generation III+ light water reactor plant range from $6–10 billion per unit. As a consequence, more than 70% of the cost of energy from a nuclear reactor arises from the cost of the initial investment to construct the plant. With operating costs quite low, most of the costs must be borne before the reactor begins to produce energy or revenue.

Today, policy uncertainties (e.g., questions about future costs for CO2 emissions or continued reliance on imported energy and energy sources), low natural gas prices, and the high

capital cost of new nuclear plants has meant that most new generation capacity may be moving to natural gas-fired plants and/or renewable energy projects (where required by state standards). Energy companies face business uncertainty about whether nuclear or other capital-intensive options are a wise investment in the near term.

The financial sector also faces significant risks in reactor plant construction. These include cost overruns, frequent change orders due to design and licensing alterations, and plant abandonments in the U.S. during the last wave of nuclear deployment in the 1970s and 1980s. These issues were exacerbated by the high cost of capital driven by the "energy crisis" in the 1970s.

Also complicating financing of new nuclear energy projects is the difference between equity and debt investment. For most projects, the financing should be a combination of debt and equity. Sufficient debt financing helps attract equity financing, both by proving that debt markets expect the project to succeed and by offering equity investors a higher return due to the leverage provided by the debt financing. In order to create the conditions for successful financing of a nuclear project, the project must offer a return to both equity and debt investors.

At present, the perceived risks of developing, demonstrating, and deploying new nuclear energy technology mean that private market capital is available only with appropriate government policies intended to spur such investment. Together, the federal government and industry must address the problems of insufficient revenue, financial risk, and support for project finance. Affirmative policies in these three important areas can help to ensure adequate private financing for a new nuclear energy build-out.

Revenue Insufficiency

To encourage the private sector to invest in new and advanced technologies like nuclear energy, we need an array of government policies at both the state and federal levels,

such as loan guarantees that help achieve cost-effective debt financing, and production tax credits that help reduce the effective cost of energy from new production facilities. Moreover, regulated utilities and power generators are more likely to invest if some kind of cost recovery exists that will help secure state approvals and minimize their cost of capital.

Recommendation

- ***Revenue incentives should be enacted to encourage construction and operation of energy production facilities using new and advanced technologies.*** This could include things like a production tax credit and loan guarantees, as well as broader energy policy incentives like a clean energy standard.

Financial Risk Mitigation

Power plant investments can be risky, even with established technologies. These risks can lead to significant economic losses that must be allocated among the project's partners, investors, suppliers, vendors, and customers. If the project is directly owned by the corporate parent, or a partnership of such parents, the liabilities of such risks may be unacceptably large. This is particularly true for capital projects as large as nuclear power plants, which outweigh the market value of most modern energy companies. For example, the largest U.S. utility/power generation company has a market capitalization of $40 billion, and most are less than $10 billion. The small size of U.S. companies relative to the large infrastructure projects such as for new nuclear reactors makes such projects extremely challenging.

There are many differences between regulated and merchant markets, but the basic problems of the high up-front capital costs and financial risks of nuclear energy facilities (compared to the cost and financial risks of other sources) make nuclear energy development challenging in both business models. In merchant markets, these characteristics make it difficult for investors to expect a nuclear project to earn enough revenue to cover its relatively high up-front

capital costs and the financial risk premiums that will be required to build it. In regulated markets, these same characteristics make it difficult for investors to expect the energy company's economic regulator to approve the full cost of a new nuclear project. Accordingly, federal policies to reduce the effective cost and financial risks of new nuclear projects and ease cash flow burdens during construction should be effective in both business models. Such policies should create opportunities to reduce the risk of nuclear projects through effective project management and avoid shifting risk to taxpayers.

An important role for government assistance to the private sector in obtaining financing and managing the costs for the initial wave of new reactors is through loan guarantees like those authorized in the *Energy Policy Act of 2005*. The future owner of the nuclear facility pays the premium for these government "insurance policies," which helps mitigate the perceived risk by the financial community of project failures and can reduce the overall capital investment required by the private sector by reducing the cost of financing (e.g., interest rates). This government action leverages major investments by private industry to provide clean, safe, and reliable energy as demon strated by today's operating fleet of power-generating reactors.

Recommendations

- ***The Administration and Congress should assert their continued commitment to nuclear energy loan guarantees.*** Put simply, this is a key enabling path for financing of nuclear projects on reasonable terms, particularly for larger projects. Government support through this financing regimen is important since it is clearly in the national interest to create additional safe, clean, and reliable energy.

- ***The Administration should develop transparent criteria for establishing credit costs for loan guarantees.*** The credit subsidy costs associated with the loan guarantee program vary widely. Recent applicants have found that the criteria for determining the credit subsidy cost are neither well established nor transparent. Such criteria should be developed jointly by government and industry—or at the very least should be made clear to the applicant companies—and should reflect the actual risk to the government.

- ***The loan guarantee program should shift to industry after a pool of new plants is built.*** After a sufficient number of new nuclear reactors have come online, the U.S. should no longer bear the risk of default. Rather, the loan guarantee program should transition from the government to the pool of new nuclear energy plant owners. As an example, assuming 20 new plants comprise a large enough guarantee pool, the owners of the first 20 plants enabled by government loan guarantees could be required to collectively provide a loan guarantee to the 21st plant. These 21 plants could be required to provide a loan guarantee to the 22nd plant, and so on. This would, in effect, transfer the risk of subsequent projects' defaults from the taxpayer to the nuclear industry.

- ***Industry should establish best practices for projects receiving loan guarantees.*** As a complement to the above recommendations, the industry should set up "best practices" standards for awarding such loan guarantees that would ensure that all projects meet strict project management, risk metric, and other requirements in order to minimize the possibility of any project defaulting. Both the loan guarantees and the standards for achieving them would need to be structured in a manner that facilitated participation by merchant, regulated, and consumer-owned nuclear projects, as well as project partnerships.

- ***Government policies, guarantees, and incentives should support joint ventures between investor-owned, cooperative, and municipal utilities.*** Joint ventures between utilities that honor the differing finance options available to these sectors are commonplace arrangements that help defray and mitigate risk. Government should support such joint ventures by ensuring that loan guarantee programs: (1) permit a project partner's undivided ownership interest to serve as collateral for only that partner's loan (and not require cross-collateralization), and (2) support pari passu financing structures.

Project Finance Needs

To mitigate the risk discussed above, many energy companies, both large and small, use project finance to develop new power projects. Under this approach, the project is owned by a separate limited-liability affiliate that is legally structured to limit the exposure of the parent company and its partners. With such limited recourse to the parent, such a project must carefully limit and manage its risks in order to achieve both debt and equity financing.

Typically, project finance achieves these low levels of risk through contracts with the equipment manufacturer and the engineering firm that will construct the facility to ensure performance and a predictable cost. Power purchase agreements with a wholesale buyer can ensure sufficient revenue. Regulated electric utilities may use a form of project finance that relies on regulated rates to provide revenue sufficiency, in which case the primary focus is on ensuring the project's costs will be low enough—and performance will be adequate—to allow for inclusion of those costs in the rate base.

Project finance also can include debt financing by companies with balance sheets not large enough to underwrite the entire cost of new investments in nuclear energy plants. Such companies can thereby issue that debt at the project level—provided each project has sound finances and fundamentals and can demonstrate sufficient management ability and

contractual certainty to attract debt investment. Yet even very large companies may face the risk of reduced credit ratings from putting a large amount of additional debt on their balance sheets, which can have serious financial consequences across the company. Accordingly, non-recourse project finance can be critically important to both mid-size and large companies that are planning large scale plant investments.

The higher level of risk and very large capital investment associated with new nuclear plants means that the project finance approach can only proceed if the risks of new nuclear technology can be mitigated enough (e.g., through government loan guaranties) to attract project-level debt investment. Otherwise, only those few companies or partnerships that are large enough to underwrite the debt portion of a new nuclear plant with the strength of their own balance sheets will be able to develop new nuclear plants.

Small modular reactors (SMRs) have the potential to ease this project financial challenge through incremental deployment and financing. The extent to which this financial challenge is eased will depend on the SMR construction/deployment schedule and the total number of modules that a plant needs to achieve a viable business case and satisfy load growth needs.

Recommendations

- ***Congress should offer production tax credits and other incentives to help mitigate the above market costs of these projects and make them available to both for-profit companies and not-for-profit utilities.*** Small and mid-size companies, as well as cooperative and municipal utilities, need tax grants and subsidized bonds to mitigate construction, cost, and technology risk. The current tax code provides a production tax credit (PTC) for the first new nuclear projects. These tax credits will help the first entities that develop new nuclear plants to mitigate costs, and they should be extended to ensure that a predetermined amount of new capacity can qualify. These credits cannot be used, however, by not-for-profit municipal and cooperative utilities that can comprise joint ventures. Making the tax credits transferable to project partners, permitting the conversion of the credits into grants or refundable credits, or permitting the use of tax-favored bonds (such as tax credit bonds and Build America bonds) by not-for-profit municipal and cooperative utilities would foster joint venture projects.

Nuclear Infrastructure

Enabling Success for the U.S. Government and Industry

For more than sixty years, the United States has led the world in the development, deployment, and operation of the global commercial nuclear fleet. This leadership had two important implications for the United States: it enhanced our security, and it offered an engine for economic growth.

This nuclear energy leadership provided an important component of U.S. national security, by giving this nation effective influence over nonproliferation issues and global nuclear safety standards. The commercial relationships that U.S. suppliers developed during the formative decades (1950-1970) of nuclear energy deployment strongly reinforced U.S. norms for nuclear nonproliferation and safety. In effect the

U.S. was able to export its nuclear nonproliferation and safety policies to much of the world.

The original U.S. dominance in nuclear energy was also an important driver of growth in the American nuclear energy manufacturing and service sectors. In addition to the design and manufacture of reactor parts, fuel, and other components, the U.S. led the world in engineering, procurement, and construction (EPC) and architectural engineering (AE) services. All of these produced high-skill, high-wage jobs in industries throughout the United States.

Unfortunately, the three-decade drought in the construction of new plants in the United States, corresponding with enormous growth in the nuclear energy infrastructure internationally, has led to this country becoming primarily a global service provider in nuclear energy. This has limited our ability to influence nuclear energy security issues and take advantage of trade-based growth opportunities. The Government Accountability Office recently estimated that the U.S. share of the global market declined sharply during that period, to approximately nine percent in 2008.

While there are plans to build new reactors in the U.S. and the first combined construction and operating licenses have been issued for two projects, the bulk of the growth is happening overseas. According to the World Nuclear Association (WNA), more than 60 power reactors currently are being constructed in Taiwan, China, South Korea, Russia, and fifteen other countries. WNA also reports that 155 power reactors, with a total net capacity of some 175,000 MWe, are being planned and over 320 more are proposed.

Given this dramatic global growth, the United States has an opportunity to restore its leadership role. This would give the U.S. greater opportunity to influence global nonproliferation safeguards for decades to come and assist in establishing the nuclear safety norms for the next generations of nuclear plants. It could also raise U.S. exports by billions of dollars per year and create thousands of U.S. jobs in the nuclear energy supply chain. But to get there, industry and government must

work together to establish our position in the worldwide market for nuclear energy infrastructure.

Government Involvement in Infrastructure Development

Fair, open, and transparent competition is the hallmark of the American way of doing business and can drive innovation, create jobs, and ensure the best value for customers. American government and industry need to work together to create opportunities to strengthen the position of our exports in the global marketplace. These opportunities can be central to re-vitalization, re-building, and expansion of the industrial infrastructure that supports the nuclear energy enterprise both domestically and globally.

Recommendations

- ***The Department of Commerce should establish a "TEAM USA" for nuclear energy.*** Such a team will provide a coordinated effort among government, industry, and the research community to enhance and expand U.S. exports of civil nuclear technology and services. The objectives will be threefold: (1) ensure coordination between the government and industry through greater access to international markets; (2) establish a coordinated access point to global customers interested in developing nuclear energy programs by providing information on and access to government programs and resources (e.g., the NRC and the national laboratory complex), industry human resources development programs, and university and government educational efforts; and (3) organize and sponsor trade promotion activities in foreign and domestic settings.

- ***The government should seek to improve the Commercial Nuclear Cooperation Agreements System.*** It is essential that the U.S. establish new agreements under the *Atomic Energy Act* (and renew those already existing) in a timely manner if our domestic nuclear energy suppliers are to conduct business in the international market. It is critical that a balance is struck that recognizes the economic, national security, and non-proliferation benefits of having U.S. companies compete globally. Section 123 of the U.S. Atomic Energy Act requires the conclusion of a specific agreement for significant transfers of nuclear material, equipment, or components from the United States to another nation. The Agreements allow for cooperation in other areas, such as technical exchanges, scientific research, and safeguards discussions. In order for a country to enter into such an Agreement with the United States, that country must commit itself to adhering to U.S.- mandated nuclear non-proliferation norms.

- ***Changes need to be made to the DOE regulations (10CFR810.8) to facilitate international interactions on commercial nuclear safety issues.*** Some of these provisions inhibit effective and timely interaction between U.S. companies and representatives from other nations on discussion of commercial nuclear safety issues.

- ***The Office of the United States Trade Representative should designate civil nuclear energy commerce as within the responsibility of one of their senior officials.*** Having a senior trade official responsible for this sector is important to ensuring that global trade practices in nuclear energy are monitored and enforced. The official should be required to issue a periodic report assessing the openness of global nuclear energy markets.

The Partnership applauds the White House for appointing a Director for Nuclear Energy Policy within the National Security Council. This appointment is the direct result of a recommendation made by the Nuclear Energy Institute and

the Civil Nuclear Trade Advisory Committee. This position should serve as an "ombudsman" to provide leadership and coordination for nuclear energy policy within the Administration.

Nuclear Liability

The current international nuclear energy market has ineffective liability arrangements to address compensation in the event of a nuclear accident. The IAEA developed Convention on Supplementary Compensation for Nuclear Damage, which was adopted in the late 1980s, but it has not yet entered into force. The U.S. should work with its international partners to ensure that this convention is adopted.

In order for the CSC to enter into force, at least five nations—with a minimum combined total of 400,000 Megawatts (thermal) of installed nuclear capacity—must sign, ratify, and deposit the instrument of ratification at the IAEA. To date, four nations with a total combined installed nuclear capacity of 308,000 MW (t) have done so. Potential near-term participants include Canada, Japan, China, South Korea, and India.

Recommendation

- ***The government should work to achieve a common global nuclear energy liability regime.*** The U.S. should continue to conduct discussions with its international partners to ensure this convention is adopted and enforced.

The Nuclear Energy Business and Workforce

In the current global revival of nuclear energy, the United States has an historic opportunity for economic growth. The Commerce Department estimates the international market for nuclear energy equipment and services at $500–740 billion over the next 10 years. As a rule of thumb, every $1 billion of exports by U.S. companies supports 5,000 to 10,000 domestic jobs. U.S. success in international tender offers

serves long-term U.S. influence on global nuclear policy as well. We can deploy fresh U.S.-obligated technology, establishing decades of global reliance on U.S. manufactured fuel and U.S. equipment and parts and fostering extensive human networks between our new customers and U.S. personnel.

The nuclear energy industry employs thousands of workers in the U.S. supporting a domestic and global marketplace. The construction of a typical U.S. LWR nuclear power plant requires an average workforce of 1,400–1,800 during construction (with peak employment as high as 2,800 jobs per unit) and about 700 permanent jobs while the plant is operating. Outages and refueling of plants also raise the number of employees on a regular basis.

Recommendations

- ***The government should develop a Civil Nuclear Energy Sector Understanding.*** Such an agreement should provide for minimum terms and conditions for export-credit agency loans, loan guarantees, and other support for the civil nuclear energy industry by national governments. This proposal is analogous to the OECD's 2007 Sector Understanding on Export Credits for Civil Aircraft. The primary objective should be to establish common standards for interest rates, amortization period, and other conditions of government financing of nuclear exports. A secondary objective should be to consider the rules for "sweeteners" to achieve deals such as government-funded training of foreign customers and unrelated sales of non-nuclear goods and services.

- ***The government should establish an "open markets" test as a criterion for access to U.S. government financial incentives for construction of domestic nuclear energy facilities.*** This test should measure the presence of both de facto and de jure obstacles to international competition in the nuclear energy sector in the applicant's home market. The U.S. government financial incentives are outcome-based and agnostic regarding the applicant's domicile; in turn, the federal government should ensure the applicant's country of domicile demonstrates open competition for nuclear energy projects.

- ***The government should take steps to increase the usefulness of the Export-Import Bank of the United States.*** Trade finance is estimated to play a role in nearly 90% of U.S. exports. The export credit agencies, including the Ex-Im Bank, are vital as lenders of last resort, taking risk shunned by the private market and assuring customers for nuclear energy that financing will be available when needed. In the global nuclear energy market, the Ex-Im Bank is a valuable tool in establishing a more level playing field for U.S. suppliers. Following up on the reauthorization of the Ex-Im Bank, the U.S. should make all haste to re-evaluate the domestic content requirement, expand the definition of content to include R&D and other elements to recognize the value of innovation, consider "national interest" as a criterion for support, and allow the support of service technology.

Regulatory Considerations

The current export controls regime hobbles the ability of U.S.-based industry to compete in the global nuclear energy enterprise. Further, important differences in global standards for nuclear energy systems lead to different expectations on nuclear safety risk and result in the design of a nuclear energy system often having to be tailored to the country where the sale is being made.

Recommendations

- ***The Administration and Congress should simplify the U.S. export regulations process for commercial nuclear technology.*** The complexity of the U.S. export regulations regime stems in large part from the four agencies that share jurisdiction and responsibility for administering the controls over nuclear technology exports. Each of these agencies has promulgated its own rules, and there is no statutory requirement for timely license processing. The Administration and Congress should consider consolidating and clarifying authority in one agency, consistent with the principles guiding the President's Export Control Reform Initiative. They should seek to make the export license process more streamlined and timely.

- ***The government should establish a rational, common approach to reactor licensing across global markets.*** The U.S. government should endorse and promote the recommendations of the World Nuclear Association's Working Group on Cooperation in Reactor Design Evaluation and Licensing. Governments and regulators should create mechanisms designed to foster cooperation on standardization among industry, regulators, and law and policymakers. The WNA's proposal envisages three phases: (1) share design assessment; (2) validate and accept design approval; and (3) issue international design certification.

New Nuclear Energy Technologies

It is an appropriate and necessary function of government to provide R&D support for high-risk and potentially high-payoff energy technologies that private industry is generally unwilling to pursue on its own and where there is a compelling national interest. The next generation of nuclear technologies presents an opportunity to address issues that continue to confound the nuclear energy industry. This includes providing scalable, grid-appropriate generating capacity that is energy price competitive, reducing up-front

capital costs for new generation, and providing disposition options for used nuclear fuel. Yet funding the R&D on these new, necessary, and exciting ideas is difficult for publicly-held companies that must continue to earn regular quarterly profits and answer to shareholders. Failure to get the government involved in spurring such technological development will result in a stagnant domestic nuclear energy industry that falls further behind foreign nations who are willing to commit to the future of advanced energy technology.

The government should be responsible for maintaining a basic nuclear technology infrastructure and conducting long-term fundamental research for nuclear science and nuclear technology applications. Federally funded research should be guided and informed by input on viability from the industry and public policy sectors. For technologies that are ready for application, the government should establish cost-shared partnerships with industry to complete technical and licensing development, construct and operate nuclear energy demonstration facilities, and enable commercialization by industry.

New Reactor Technology Development

The federal government must take on a leading role in fundamental research and initial development for new, advanced reactor technologies to ensure national interests will be addressed, including energy and economic security and independence, energy price stabilization, and environmental responsibility. Furthermore, the use of nuclear energy technology should be extended beyond the generation of electricity including advanced technologies such as the high temperature gas-cooled reactor and recycling reactors.

Most of these advanced technologies are still conceptual, or at the very early stages of commercialization. DOE often tasks the national laboratories and universities with the responsibility for carrying out the long-term, high-risk

research, and these programs should be funded without strict cost-share requirements. As this fundamental research transitions to the demonstration and deployment stages, industry should shoulder an increasing share of the funding responsibility.

Recommendations

- ***DOE should continue research & development, demonstration, and enable deployment for high-risk, potentially large payoff technologies.*** Examples include advanced small modular reactors (SMRs), which offer the prospect of lower capital intensity and grid appropriate capacity, high temperature reactors (including process heat for petrochemical and other industrial applications), and fast neutron spectrum reactors (including for actinide management), thus serving applications beyond electricity. Industry input in the early development process will help to ensure viability of technologies that can meet market needs.

- ***The QER should establish priorities for government-sponsored research into new nuclear technology.*** The development time for new nuclear technologies typically exceeds the time frame of the federal appropriation process. Too often, projects authorized in one Congress and implemented by an Administration are cut off before they bear fruit. The consequent shift in priorities results in development that has not adequately matured to support technology transfer to the private sector for commercialization. The QER provides the opportunity to insert rigor in the change control processes and restrain the "technology of the moment" shift in governmental priorities.

Regulation and Licensing of New Technologies

Nuclear energy is by far America's most regulated energy production technology. Overall, the more than fifty year history of nuclear energy regulation has been successful. Together, the NRC and the commercial nuclear industry have made the nuclear energy enterprise one of the safest

industries in the country. The NRC has functioned as a strong and independent regulatory body that provides the necessary level of assurance to the public that nuclear energy can be managed in a safe and secure manner.

The role of the NRC is to issue licenses and to oversee commercial use of nuclear energy, and is not a promoter of nuclear energy projects. As such, NRC activities to develop safety performance criteria and requirements for new or evolving nuclear energy technologies are limited to those activities mandated and funded by Congress (e.g., licensing work on the high-temperature, gas-cooled reactor technology for the Next Generation Nuclear Plant project), supported by the Department of Energy, or requested by viable advocates* for pre-application activities, or for licenses or design reviews, but which also are subject to the NRC budget process and Congressional appropriations.

* The term "advocate" is used here in contrast to an "applicant" for a design certification or license for a reactor technology. With new technologies, firms must begin to engage with the NRC well before they formally submit an application. However, under current NRC rules and practices, these parties are not technically "applicants."

In the past and on a continuing basis, the NRC has been involved in the development of industry codes and standards for conforming to the National Technology Transfer Act of 1995 and its implementing guidance in OMB Circular A-119. The NRC: (1) identifies and prioritizes technical standards that are needed; (2) coordinates the NRC's needs and priorities with standards-developing organizations; and (3) assigns authorized agency representatives on standards-developing committees. In this manner, the NRC works in a constructive and collaborative manner with industry stakeholders (i.e., industry-led development of engineering design, analysis, and acceptance criteria that may be approved by NRC).

Licensing of nuclear energy facilities by the NRC is adjudicatory by law, with the objective of ensuring NRC independence in reviewing and issuing licenses and to ensure opportunity for stakeholder involvement. This works well for

established technologies like large light water reactors. However, when it comes to establishing safety performance criteria and requirements for new or evolved nuclear energy technologies, the NRC should adopt a partnership approach.

To review license or design certification applications for new or evolving technologies, it is expected that the NRC would use its available body of regulations and guidance. That is, the NRC regulatory framework for light water reactors would form the starting point for its review of new technologies, while the Commission and the industry develop safety performance criteria. However, for advanced technologies, some current regulations and guidance will need to be changed to recognize the differences in the safety capabilities of the advanced technology and to realize the associated benefits.

Under current practice, an industry advocate for a new technology submits proposed changes to regulatory requirements or processes, followed by NRC review (with subsequent requests for additional information and replies from the industry advocate), and eventually leading to an NRC "output document" or "disposition." This process is similar to the one that governs review of formal license or certification applications. However, such an "arms-length" approach hinders cooperative development of safety and performance criteria for new technology. To do so effectively, the advocate must have detailed technical interaction with the NRC staff and other experts, particularly when a proposed change challenges NRC precedent. An overly formal or rigid process makes this impractical.

Further, industry advocates face considerable uncertainty with regard to the status of proposed safety and performance criteria for new technologies when under review by the NRC staff. Is what they are hearing from NRC staff authoritative or not? Does the staff speak for the Commission, or not? The industry needs to have confidence that the new or revised safety and performance criteria discussed with NRC staff will be substantially similar to the final requirements. Otherwise,

the design and supporting R&D cannot proceed with acceptable business risk.

This is not to suggest a wholesale change in the way the NRC does business. Rather, the NRC should adopt the successful approach that it has used for national consensus standards development (i.e., industry-led development of engineering design, analysis, and associated acceptance criteria that is subsequently approved by the NRC). After the initial cooperative process is complete and new performance criteria and requirements have been established, the NRC would then revert to the adjudicatory framework for review of applications for certification of designs and licensing of specific facilities. Of course, in the adjudicatory phase, the NRC would act with full independence and ensure full stakeholder participation.

In addition, the NRC could conduct its own enabling R&D for promising new technologies. This could help it to identify changes to existing requirements and processes, and ensure that the technical staff is prepared to manage areas beyond solely licensed facility oversight and license application review and processing.

Recommendations

- ***Congress should direct funding to support NRC participation in developing safety and performance standards for promising new technologies.*** The NRC should work with the industry to develop safety standards and requirements through national consensus standards developed with industry stakeholders. While such activities would be entirely separate from formal review of design certifications and license applications under the Administrative Procedure Act and the Atomic Energy Act of 1954, the development could, if necessary, occur prior to or in parallel with NRC review of applications. Risk and performance-based insights should be included in the development efforts. NRC resources for such activities could be augmented through subcontracting and/or establishing a federally funded research & development center for such support.

- ***Congress should direct funding for the NRC to prepare a plan for developing regulatory requirements for promising new nuclear energy technologies, as determined in cooperation with industry and DOE.*** The NRC, in cooperation with industry and DOE, should undertake planning and implementation of a long-term program to develop technical requirements and review criteria for new technologies, including required resources. These technologies should include new and evolutionary reactor technologies, fuel cycle facilities, and other activities involving nuclear materials used in energy production. The NRC can build on the work currently underway with industry groups in developing regulatory positions on key issues.

- ***The NRC should establish processes for developing safety and performance requirements for new technologies.*** The NRC should establish interactive partnering processes that help industry advocates plan and prepare for eventual license applications. The NRC should further establish that staff-accepted requirements developed for design and R&D of new technology to support design development activities are authoritative. This process should be similar to the one that the NRC has historically employed in cooperating on and accepting national consensus standards developed with industry. (Such activities would be entirely separate from formal review of design certifications and license applications under the Administrative Procedure Act and the Atomic Energy Act of 1954.) Congress should direct funding for such activities to the extent these activities cannot be paid for by advocate and applicant fees. Further, if and when the NRC lacks authority to develop the partnering processes recommended above, Congress should provide it with the authorizations necessary to do so. This legislation should not reduce the independence of the NRC.

- ***Congress should provide resources to the NRC for it to strengthen its capability for reviewing new technologies.*** Congress should establish a dedicated, appropriated account to bolster the NRC's ability to conduct anticipatory research and develop technical capabilities within its staff. Planning the direction of such research and technical staff development should be based on the best collective judgment of regulators, power/energy producers, suppliers, and other experts as to which technologies show the most promise for commercial deployment.

Developing Options for a Sustainable Fuel Cycle

In January 2012, the Secretary of Energy's Blue Ribbon Commission on America's Nuclear Future (BRC) provided recommendations for managing the back end of the nuclear fuel cycle. The recommendations of the BRC report address a broad range of issues centered on used nuclear fuel storage and transportation and high-level waste disposal. The Partnership anticipates that the BRC's recommendations will be carefully weighed and ultimately acted upon by government and industry. The following recommendations focus on establishing an appropriate governance structure and developing enabling technologies that support the near- and long-term decisions required for a sustainable fuel cycle.

Public confidence in the long-term viability of nuclear energy has been reduced by the political impasse that has left a highly uncertain pathway for the disposition of used nuclear fuel. While storage of used nuclear materials has been found to be safe on site at nuclear power plants, current policy has resulted in significant taxpayer liabilities and long-term uncertainty. To break the impasse, the government must support enhanced efficiency of the once-through fuel cycle that we now use for light water reactors. And it must help industry seek alternatives that would bring benefits in the areas of resource utilization, assurance of fuel supply, waste

management, maintaining technological leadership, and nonproliferation policy.

Government should sponsor research on separation and recycling of waste in its national laboratories. The objective of this research should be to identify improvements in sustainability, economics, and proliferation-resistance. This should include use of advancements in modeling and simulation and other predictive capabilities to evaluate a broad set of options. Along with the NRC, this work by the national laboratories should include development of the regulatory framework for back-end fuel cycle technologies.

Recommendations

- ***The government and industry should work together to enhance the safety, security, and efficiency of the once-through fuel cycle.*** This should include re-establishing the capability for and performance of in-pile and out-of-pile testing to support innovative fuel development and validating modeling and simulation efforts and to extend the useful operational lifetime of existing fuel designs. This could mean more efficient use of available energy in current fuel designs or alternative fuel designs that enhance the resilience under accident conditions. The QER should address this issue and provide a path towards implementation.

- ***The national labs should conduct R&D on technologies that provide alternatives to the once-through fuel cycle.*** Such research will lead to technologies with long-term sustainability, broaden the range of industrial applications for nuclear reactors, and ensure the safe management and disposition of used fuels. Such R&D would likely include fuel resource exploration, used fuel disposition, reducing transuranic production in reactors, separations and partitioning technologies, reduction of effluents, waste form behavior, fuel fabrication processes, fuel performance under irradiation, fissionable material reuse, and transmutation systems. Promising technologies should be taken to the demonstration phase to position the United States to take advantage of potential benefits and maintain a leadership role for the U.S. in nuclear technology.

- ***Congress should provide enabling legislation for establishment of an organization dedicated solely to the purpose of civilian used nuclear fuel management.*** This organization should be empowered with the authority and resources to succeed in its mission.

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