Energy & Infrastructure Program
Energy Project

Maintaining U.S. Leadership in Global Nuclear Energy Markets

A Report of the Bipartisan Policy Center's Nuclear Initiative

Co-chaired by Senator Pete Domenici and Dr. Warren F. "Pete" Miller | July 2012

BIPARTISAN POLICY CENTER

ABOUT BPC

Founded in 2007 by former Senate Majority Leaders Howard Baker, Tom Daschle, Bob Dole and George Mitchell, Bipartisan Policy Center (BPC) is a non-profit organization that drives principled solutions through rigorous analysis, reasoned negotiation and respectful dialogue. With projects in multiple issue areas, BPC combines politically balanced policymaking with strong, proactive advocacy and outreach.

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Introduction

Only a few years ago, there was considerable optimism in the United States and globally that the nuclear energy industry was poised for a renaissance. Electricity demand around the world, particularly in developing countries, was expected to grow dramatically even as the need for cleaner energy sources became more urgent. Nuclear power, with a proven track record of safe and efficient operations, was expected to play a large role in meeting these two energy challenges.

The U.S. Congress last passed comprehensive, bipartisan energy legislation in 2005. That legislation—known as the Energy Policy Act of 2005, or EPACT05—was designed to support a range of domestic energy resources, including nuclear energy. Since its passage, major shifts have occurred in energy markets and in the broader economy—not only in the United States but in much of the world. The U.S. electricity market in particular has been profoundly affected by slowing demand growth (in part caused by the sustained economic downturn) and by a significant decline in natural gas prices resulting from the cost-effective development of newly accessible shale gas resources.

These developments have substantially dimmed prospects for a near-term nuclear renaissance—at least in the United States. Nonetheless, promising opportunities remain for the industry, both domestically and in international markets. We believe nuclear power must continue to be viewed as a critical option for electricity generation—one that remains uniquely important for long-term U.S. national security and energy security. This means the federal government has a compelling interest in orienting policy to allow the industry to take advantage of key opportunities and overcome current challenges.

How that might be done is a question the Bipartisan Policy Center (BPC) asked in early 2011. The accident at Japan's Fukushima Daiichi Nuclear Power Station strengthened our conviction that it was critical to improve fact-based discussions about nuclear power in Washington, D.C., and around the country. Together, former U.S. Senator Pete Domenici and former Department of Energy (DOE) Assistant Secretary for Nuclear Energy Dr. Warren F. "Pete" Miller organized BPC's Nuclear Initiative to convene a series of public events aimed at raising the level of dialogue about nuclear energy's future in the United States.[1]

Most recent nuclear policy discussions have focused on specific financing and deployment challenges for Generation III+ nuclear reactors. In the current fiscal and political climate, efforts to further increase financial incentives for nuclear energy likely must overcome significant hurdles. BPC's Nuclear Initiative therefore focused on finding insights into comprehensive approaches to improve federal energy policy so that it can more effectively (1) address the spectrum of challenges facing nuclear power in the United States with the aim of preserving the safe use of nuclear energy as a reliable source of domestic low-carbon

electricity and (2) support U.S. technological and diplomatic leadership on international nuclear issues.

The key question BPC's Nuclear Initiative asked was: "Beyond urging the federal government to provide appropriate financial support for new nuclear plant construction in the United States, what other conditions are necessary to maintain the continued strength of our domestic industry?" Importantly, we define the industry's "strength" not only or primarily in terms of domestic growth (i.e., numbers of new plants proposed or under construction), but in terms of technological and operational superiority, a competitive international presence, credible leadership on safety and security, and solutions for defense waste and used nuclear fuel.

We did not set out to develop comprehensive policy recommendations; our aim was to tap the insights of a wide range of experts and stakeholders in probing issues that are of critical, near-term importance to the nuclear industry. This report lays out several strategic goals for maintaining U.S. leadership in nuclear energy domestically and globally. We also discuss key findings from our public event series and identify potential policy levers for achieving these strategic goals.

BPC Nuclear Initiative Event Series

Over the course of one year, BPC hosted a series of public events on critical issues for the U.S. nuclear industry. (Appendix A provides additional information about each event.) The event series began in August 2011 with "Evolving Nuclear Technology and Regulation: Lessons Learned from Fukushima." Commissioner George Apostolakis of the U.S. Nuclear Regulatory Commission (NRC) presented an overview of NRC risk assessment approaches and initial findings from the recently released NRC task force's 90-day report on the Fukushima accident. A lively panel composed of experts from industry and environmental groups debated necessary next steps for assuring reactor safety in the United States and around the world. The next BPC-sponsored public event took place in October 2011: "Effective Approaches for U.S. Participation in a More Secure Global Nuclear Market." Participants in this daylong workshop examined the interaction of U.S. commercial nuclear exports and nonproliferation objectives; they also explored how an effective domestic and foreign policy framework can help balance proliferation challenges with the economic and leadership opportunity the United States faces. Keynote speakers included former National Security Advisor General (ret.) Jim Jones, DOE Deputy Secretary Daniel B. Poneman, and Department of State Special Envoy for Strategic Stability and Missile Defense Ellen Tauscher.

A third public event in March 2012, "Preparing for Deployment of Small Modular Reactors," featured DOE Assistant Secretary for Nuclear Energy Dr. Peter Lyons and focused on new nuclear technologies. Lyons discussed DOE's Small Modular Reactor (SMR) Licensing Technical Support Program, a public-private cost-sharing program that is pursuing design certification for two SMR designs and taking other steps to support the early stages of SMR deployment. A fourth event, held in June 2012, tackled "Near-Term Progress on Nuclear Waste Management and Implementing the Recommendations of the Blue Ribbon Commission." At this event, co-chairs Domenici and Miller hosted Senators Jeff Bingaman and Lisa Murkowski, who are leading bipartisan efforts in Congress to implement the recommendations of the Blue Ribbon Commission on America's Nuclear Future.

Challenges and Opportunities Facing Nuclear Energy in the United States

Nuclear power already plays an important role in the U.S. energy supply mix: The nation's existing fleet of 104 reactors currently accounts for close to 20 percent of overall electricity production. In many parts of the country, nuclear plants help to assure grid stability and have been a major source of cost-effective, low-carbon base-load power for decades. The NRC, the industry's chief regulatory overseer, is expected to approve extension of the operating licenses for most of these plants to 60 years while striving for improved safety and increasingly efficient operations. At present, the domestic nuclear industry is looking at limited opportunities for expansion in terms of increasing the number of U.S. plants. Currently, four new Generation III+ nuclear reactors have been licensed by the NRC and are under construction in the Southeast. In addition, the Tennessee Valley Authority has restarted construction activities at Watts Bar II.

Given this near-term expansion, the United States will continue to be a world leader in the development of advanced reactor technologies, including Generation III+ advanced passive reactors and SMRs. International interest in developing new nuclear-generating capacity, on the other hand, presents potentially substantial business opportunities for the domestic nuclear industry. Commercial nuclear exports generate obvious economic benefits for U.S. firms and for the nation's overall balance of trade. Importantly, they also help the United States retain a major role in the evolution and maintenance of international nuclear safety and nonproliferation regimes. Other nations not only look to the U.S. industry for operational expertise, they see the NRC as setting the international gold standard for safety and physical security regulation. DOE's National Nuclear Security Administration, meanwhile, has a great deal of influence over the nonproliferation aspects of international fuel-cycle issues.

Set against this considerable legacy of institutional and technological dominance, however, are the many real challenges the U.S. industry confronts today, on multiple fronts—poor economics, increased safety and security requirements, and uncertainty about the resolution of the waste management issue. The crisis at the Fukushima Daiichi plant focused the attention of regulators and the public on the need for continued attention to safety and security at existing reactors, particularly as some of the older plants approach the end of

their extended 60-year license periods. In 2029, the earliest licensed plant will reach the 60-year operation limit, and, after that, approximately one-third of the fleet will quickly follow. While some plants may engage in another round of relicensing for up to 80 years, a significant fraction likely will be retired and replaced by newer-generation resources (potentially including some nuclear replacements).

Prospects for new reactor construction in the United States have constricted significantly in recent years. In the years following passage of EPACT05, 18 utilities applied for combined construction and operating licenses (COLs) to build a total of 28 reactors.[2] In addition, DOE received 19 applications for loan guarantees to support financing for 21 proposed reactors. A combination of factors—including downward revisions to electricity demand projections, difficulty executing the EPACT05 loan guarantee program as intended, and drastically reduced natural gas prices—has put all but two projects on hold. While these projects, comprising four reactors, have received NRC licenses and are currently under construction in Georgia and South Carolina, these plants still face financial, regulatory, and construction challenges.[3] And, though natural gas prices have historically been quite volatile, the ability to tap large shale gas reserves will likely keep natural gas prices sufficiently low to make financing additional new reactor construction very difficult for at least the next decade, if not longer.

Another critical factor for the nuclear energy industry—one that affects both existing reactors and the prospects for building new reactors—is the need to execute an effective strategy for storing and disposing spent nuclear fuel. While the current practice of storing this material on-site at operating and at shut-down reactors is safe, it is not an acceptable long-term strategy. The federal government is legally obligated to take title to the spent fuel and its failure to do so has made American taxpayers liable for billions of dollars in damages.

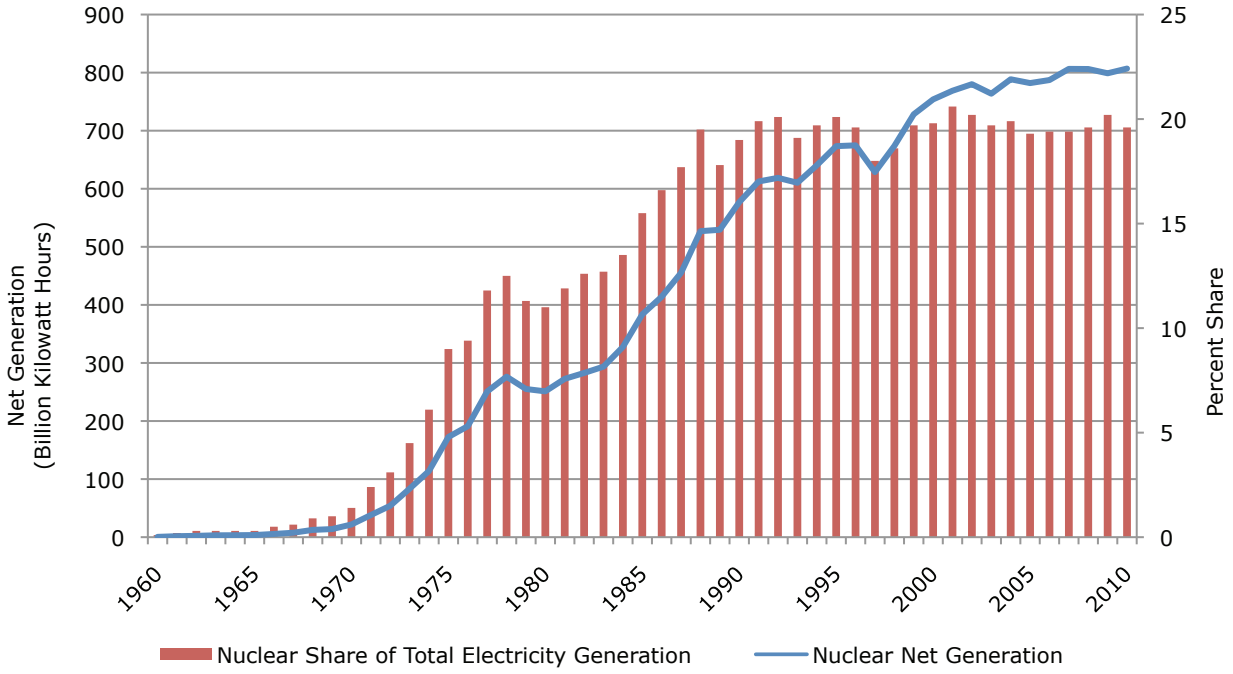
With the world's largest commercial nuclear fleet, the United States was once the world's leader in nuclear technology development and operations. In recent years, other countries, notably France and South Korea, have risen in international prominence; these countries will continue to develop technologies for domestic markets as well as to export. It will be increasingly difficult for the United States to maintain its technological leadership without some near-term domestic demand for new construction. Diminished U.S. leadership will make U.S. firms less competitive in nuclear export markets while also reducing U.S. influence over nuclear developments abroad. As more countries seek to develop nuclear capacity, the United States must work with the international community to minimize the risk of nuclear weapons proliferation.

Our event series explored several of these challenges and sought to identify areas where federal policy can most effectively address barriers to maintaining a viable domestic nuclear industry. We also believe that federal policy can help support U.S. leadership in international nuclear issues. The next section reviews near-term prospects for nuclear power domestically and internationally by highlighting the importance of continued U.S. leadership.

Current Status of Nuclear Power in the United States and Internationally

The 104 commercial nuclear reactors operating in the United States today account for approximately 20 percent of U.S. electricity production and represent more than 70 percent of the country's zero-carbon electricity supply.[4] During the past three decades, operational improvements at these plants have led to higher capacity factors and increased electricity output. Reliability has steadily increased such that the average nuclear plant today runs 90 percent of the time.[5] Electricity output has similarly increased, with the approval of 6,440 megawatts of electricity of cumulative capacity additions (referred to as "uprates") at existing U.S. nuclear facilities, the majority of which has been implemented since 2000.[6]

Figure 1. U.S. Nuclear Net Generation and Share of Total Electric Generation



Source: U.S. Energy Information Administration. Annual Energy Review. Table 9.2 Nuclear Power Plant Operations, 1957-2010. Released October 19, 2011.

The passage of EPACT05, which contained several provisions to support the construction of new reactors, revived interest in nuclear power and hopes for a nuclear renaissance in the United States. EPACT05 included a loan guarantee program, licensing assistance for first movers, and production tax incentives for new nuclear generators. Subsequently, manufacturers submitted four new reactor designs for certification under a revamped NRC licensing process and 18 utilities submitted COL applications for a total of 28 new reactors.[7]

In December 2011, the NRC approved the Westinghouse AP1000 reactor design, an innovative design that employs advanced technology and passive systems to further improve reactor safety and security.[8,9] In February 2012, Southern Company and its partners received the first COL to build two new AP1000 reactors at Southern Company's Vogtle plant in Georgia. The reactors are expected to come online in 2016 and 2017. The Vogtle reactors are the first to be approved under a new NRC licensing process (spelled out under Title 10 of the Code of Federal Regulations Part 52) that aims to improve the efficiency of the regulatory process by combining the construction permit with a COL.[10] In March 2012, South Carolina Electric & Gas Company and its partners also received a COL to build two new reactors at the V.C. Summer Station in Jenkinsville, South Carolina.[11]

The current federal loan guarantee program for new nuclear plants was included in EPACT05 (under Section 1703, Title XVII) with overwhelming bipartisan support. Congress intended for this program to spur clean-energy investments by leveraging public and private resources to overcome the cost hurdles associated with first-time deployment of advanced technologies, including Generation III+ reactors. In February 2010, DOE issued the first conditional loan guarantee for a nuclear energy project to the Vogtle plant.[12] Southern Company and DOE are currently negotiating the terms of the $8.3 billion loan guarantee.[13] The owners of the proposed Summer plant have also applied for, but not yet received, a loan guarantee under the Section 1703 program.

Beyond the Vogtle and Summer plants, there are likely to be—at most—a few more Generation III+ plants ordered in the United States for the foreseeable future, given current market conditions and the array of challenges (described later in this report) that confront new nuclear plant construction.

Internationally, the outlook is quite different: a number of countries intend to grow their nuclear fleet or enter the market for nuclear technology for the first time. Though enthusiasm for nuclear investments has been somewhat dimmed by the Fukushima accident, there still seems to be substantial international interest in the further deployment of nuclear power. In 2008, when the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD) last conducted its Nuclear Energy Outlook, it analyzed global growth scenarios ranging from 450 to 600 gigawatts of electricity through nuclear capacity by 2050, taking into account existing capacity and new additions.[14] Several years later, the lower-end projection seems more likely given the impacts of the worldwide economic crisis and the impacts of the Fukushima accident.[15]

In fact, Fukushima has caused, appropriately, an international pause as each country with existing or planned nuclear capacity takes time to reassess the safety of its currently operating plants and to review its commitment to future nuclear energy development. Some countries—Germany is a prominent example—have reversed course on their nuclear energy programs. In March 2011, Germany's 17 reactors generated approximately 25 percent of that country's electricity supply. After Fukushima, the German government immediately shut down eight reactors and reinstated its policy of phasing out nuclear energy altogether by 2022.[16] Italy and Switzerland have made similar decisions to phase out or delay the growth of their nuclear programs.[17] After Fukushima, the Japanese government reversed its policy goal of expanding nuclear power to 30 to 40 percent of electric generation.[18] As of May 2012, all 54 of Japan's nuclear power reactors had been shut down for scheduled maintenance; due to public opposition, to date, only one of these plants has been able to restart.[19,20]

Several other countries, by contrast, have reaffirmed their intentions to continue expanding or developing a nuclear energy program after Fukushima. These countries include China, India, South Korea, and Russia. Together, they are expected to account for 80 percent of new nuclear plant construction globally over the next decade or longer. China alone accounts for 40 percent of planned new construction globally, with 26 new reactors under development.[21] Thus, global growth in nuclear energy is still expected to be positive overall.

Figure 2. Global Nuclear Reactors Under Construction and Planned

Source: World Nuclear Association. WNA Reactor Database. Accessed June 25, 2012. Available at: http://world-nuclear.org/NuclearDatabase/Default.aspx?id=27232.

Strategic Goals to Maintain U.S. Leadership in Global Nuclear Energy Markets

This section, building on key findings from our public event series, outlines five strategic goals that emerged from the Nuclear Initiative's activities as well as available policy levers for maintaining U.S. leadership in nuclear energy domestically and internationally.

Strategic Goal: Ensuring a strong U.S. nuclear energy sector should be a high priority for federal energy and national security policy. Nuclear energy is critical to maintaining a reliable, affordable, and clean electric power sector, and a strong domestic nuclear industry strengthens America's position in international nonproliferation matters.

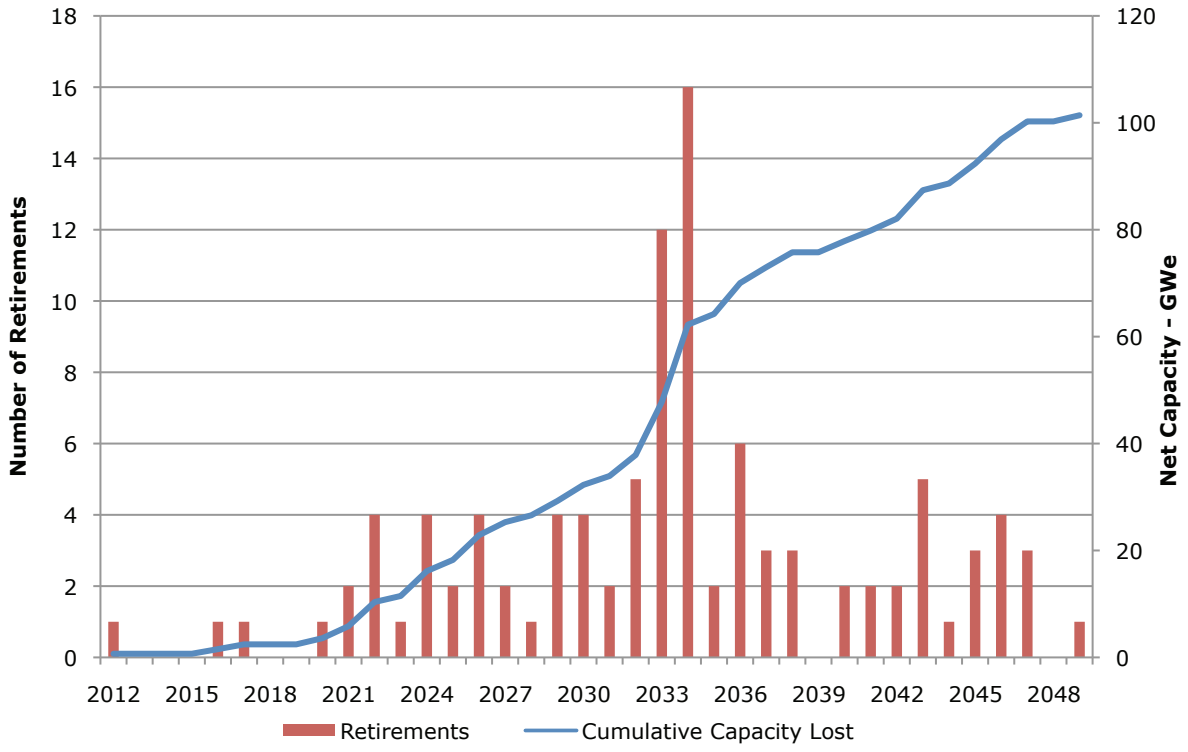
Electric utilities in the United States face a changing market environment, one that features low natural gas prices, flattening electric demand, and the prospect of further environmental regulations.[22] In this context of substantial uncertainty about the future, fuel diversity is especially important as a way to help ensure that the electric power sector can deliver reliable, affordable, and secure energy services over long timeframes. Market signals alone are unlikely to result in a diverse fuel mix, so helping to maintain and improve a range of electricity supply options remains a role for federal policy. In particular, U.S. policy should be aimed at helping to preserve nuclear energy as an important technology option for near- or longer-term deployment.

The nation's current nuclear fleet already provides affordable and highly reliable base-load power across large regions of the United States. Maintaining or building on this existing generation base will enhance supply diversity and promote broadly held clean-energy objectives.

Of the 104 reactors currently operating in the United States, 73 have received a 20-year extension of their original 40-year operating license. Thirteen additional license-extension applications are currently under review, and most remaining plants are expected to apply for license extensions over the next five years that would allow them to operate for an additional 60 years.[23] The original decision to license plants for a 40-year operating life was determined as a matter of policy and does not reflect inherent technical characteristics. Meanwhile, many plants will approach the end of their extended license periods beginning in

2029 and owners will need to evaluate whether to apply for a second 20-year license extension.[24]

Figure 3. Expected U.S. Reactor Retirements and Net Capacity Lost



Note: This figure assumes all reactors that have received license extensions and all those with applications currently under review operate for a full 60 years, with no additional extensions.

Source: U.S. Nuclear Regulatory Commission. List of Power Reactor Units. Available at: http://www.nrc.gov/reactors/operating/list-power-reactor-units.html.

If a significant number of plants begin retiring after 40 or 60 years of operation, new plants will need to be constructed to maintain current levels of zero-carbon base-load power. But current market conditions—chief among them low natural gas prices—make it very difficult, if not impossible, to finance and construct new Generation III+ nuclear power plants. Given that natural gas prices are projected to remain low by recent standards for the next 10 to 20 years, competing generation options (including coal and renewables, as well as nuclear) face increasingly daunting financing and deployment hurdles.

The discovery of vast, affordable domestic natural gas resources offers significant benefits for the electric power sector and for the U.S. economy as a whole. However, our country's electricity supply mix should be balanced across a variety of fuels and sources to improve resiliency and insulate consumers from price volatility driven by any one technology or fuel. Economic competition with natural gas should not be the only near-term factor that

determines which technologies and resources remain part of our supply mix. Nuclear power plants are very long-lived assets that take many years and extensive financing to plan, license, and construct. Therefore, it is widely believed that some level of federal policy support is necessary to successfully deploy new nuclear power plants. Given the importance of nuclear energy as a reliable, large-scale, low-carbon resource as well as the importance of continued U.S. leadership on global nuclear security and nonproliferation issues, we urge federal policy makers to consider policy levers that would keep the civil nuclear industry strong at home and competitive in future international markets.

Strategic Goal: In order to maintain U.S. leadership in nuclear safety and security, the industry and the U.S. Nuclear Regulatory Commission should continue efforts to strengthen nuclear plant safety and security, particularly in light of lessons learned from Fukushima.

Since the March 11, 2011 earthquake and tsunami in Japan, the NRC and the nuclear industry have been actively reviewing practices and regulations to ensure that safety can be maintained through extreme events. Immediately after the emergency at the Fukushima reactors began, regulators and plant operators inspected critical safety systems at each U.S. reactor.[25] The NRC established a 90-day task force, composed of six senior staff members, to conduct a systematic and methodical review of U.S. processes and regulations. Their charge was to determine whether the agency should make additional improvements to its regulatory system in light of the events that occurred at Fukushima, and to make policy recommendations to the NRC accordingly.

The task force concluded that, given the low likelihood of an event beyond the design basis of a U.S. nuclear power plant and existing mitigation capabilities at those facilities, the continued operation of U.S. nuclear plants and current licensing activities do not pose an imminent risk to the public health and safety. The task force's report made several recommendations to enhance U.S. reactor safety; it also outlined an implementation strategy that includes nearer-term actions as well as longer-term rulemaking and implementation efforts.

In March 2012, the NRC voted to issue orders in three high-priority areas: (1) protection of equipment critical to accident mitigation and additional equipment to support all reactors at a given site simultaneously; (2) reliable hardened vents for reactors with the type of containment design of the Fukushima reactors; and (3) spent fuel pool instrumentation. Additional rulemaking will likely follow on several longer-term issues, including the development of a probabilistic, risk-informed regulatory approach.

The nuclear industry, lead by the Institute of Nuclear Power Operators (INPO), has also conducted its own review of operations and released reports detailing lessons learned and proposed changes to improve safety operations in response to Fukushima. Because it will take months to years for NRC orders and new regulations to take effect, the industry is moving ahead with voluntary efforts to strengthen emergency-response capabilities. Recently, each of the U.S. nuclear owners and operators approved an initiative to purchase

and pre-stage additional emergency equipment to ensure that nuclear facilities are able to respond to all potential extreme events. By March 31, 2012, each company had ordered or contracted for additional emergency equipment. This equipment is part of the industry's "FLEX approach" to mitigating scenarios beyond a plant's design basis and will add redundancy to key safety systems. The industry believes that the actions it is currently taking voluntarily will be in line with eventual requirements established by the NRC.

We commend the NRC and industry for their efforts to maintain and even improve the resilience of nuclear plants in the United States and around the world, and we urge timely implementation of changes in physical equipment and operations prompted by the experience of Fukushima. We strongly encourage efforts to continuously improve.

Strategic Goal: A key factor in terms of the outlook for a robust domestic nuclear industry and continued safety performance is progress on the management and disposal of spent nuclear fuel. The administration and Congress should act quickly to implement the recommendations of the Blue Ribbon Commission on America's Nuclear Future and launch an effective, long-term strategy for managing and disposing of the nation's spent nuclear fuel and high-level radioactive waste.

Despite decades of scientific research and billions of dollars of investment, the federal government's program for managing spent nuclear fuel is at a standstill. Current law designates Yucca Mountain in Nevada as the site of the first U.S. repository for spent fuel and high-level waste, but the Obama administration halted work on the Yucca repository in response to the considerable public controversy that surrounded this designation. In an attempt to break the stalemate, President Obama directed Energy Secretary Steven Chu to establish a high-level commission—known as the Blue Ribbon Commission on America's Nuclear Future, or BRC—to devise a new strategy for managing the nation's sizable and growing inventory of nuclear waste.[26] (The BRC's recommendations are summarized in a box on page 16 of this report.) Months after the BRC released its report, the administration and Congress have only begun to assess the steps that will need to be taken in order to implement the proposed new strategy. We support ongoing efforts by the administration and Congress to implement the BRC's recommendations and encourage all stakeholders to work with a greater sense of urgency to break the current stalemate.

For many years, the U.S. government has failed to act on its responsibility to take title of spent nuclear fuel and provide for the ultimate disposal of this material. In the United States, nearly all commercial (as opposed to defense-related) spent nuclear fuel is stored on-site at the nation's 104 currently operating reactors and at nine shut-down reactor sites. Most (about three-quarters) of the current inventory of commercial spent fuel is stored in specially designed pools. These pools, though currently managed safely, were never intended to provide storage for extended periods. As pools have approached capacity, utilities have had to add aboveground dry cask storage to supplement wet pool storage at many reactor sites.

One of many concerns as the Fukushima crisis unfolded was the integrity of the spent fuel pools located at each reactor. Though reports now conclude that there was minimal damage to the pools or to the spent fuel being held in the pools, public scrutiny of current nuclear waste-management practices has increased.

While we are confident that current fuel storage arrangements are safe, the federal government's inaction and failure to meet contractual commitments for timely waste acceptance is costing taxpayers many millions of dollars annually in damages paid to utilities. The Department of Justice estimates that total damages will reach $20.8 billion if waste acceptance begins in 2020.[27] Meanwhile, ratepayers continue to pay into the Nuclear Waste Fund for every kilowatt-hour of nuclear-generated electricity, despite the fact that these revenues are not being set aside for waste-management purposes in the way Congress originally intended. In addition, American taxpayers remain liable for billions of dollars in damages, which are currently being paid out of the federal government's judgment fund, for the government's failure to follow through. These liabilities are projected to grow at an increasing rate if no solution to the waste issue is in place by the time the next wave of reactors retires.

We are encouraged that the administration and members of Congress have begun to pay close attention to the issue of nuclear waste management and to the BRC's recommendations in particular. In February 2012, Energy Secretary Chu announced that the DOE was forming an internal working group, the Management and Disposition Task Force, to assess the BRC's recommendations.[28] The report is due to be released by the end of July 2012; we urge the administration to act with the necessary urgency to implement the task force's recommended strategy.

Importantly, the Senate Committee on Appropriations Fiscal Year 2013 spending bill included funding to begin implementing the Commission's recommendations.[29] The bill authorizes DOE to conduct a pilot program to establish one or more interim storage facilities for spent nuclear fuel and high-level waste. It also directs DOE, as part of this pilot program, to adopt many of the principles recommended by the BRC, including giving priority to the removal of spent fuel from shut-down reactor sites and employing a consent-based process to identify and negotiate with states and local communities. As co-chairs of the Nuclear Initiative, we believe that interim storage is an essential near-term step, regardless of where the final geologic repository is located. We sent letters of support to a bipartisan group of Senate appropriators and urged the Energy and Water Development subcommittee to continue efforts to implement the full recommendations of the BRC.[30]

Key Recommendations of The Blue Ribbon Commission on America's Nuclear Future

The Blue Ribbon Commission on America's Nuclear Future (BRC), co-chaired by former Representative Lee H. Hamilton and former National Security Advisor General Brent Scowcroft, released a final report in January 2012 detailing a comprehensive set of recommendations for an effective, long-term strategy to safely manage and dispose of the nation's spent nuclear fuel and high-level radioactive waste.[31] (The Nuclear Initiative's own Pete Domenici served on the commission.) The report reflected nearly two years of work by the commission and three subcommittees, including more than two dozen meetings to receive testimony from experts and stakeholders, and site visits to domestic and international nuclear waste-management facilities. The BRC put forward eight key recommendations for the White House and Congress:

1. Establish a new process for siting future nuclear waste-management facilities that emphasizes consent-based negotiations and engagement of local, state, and tribal stakeholders.
2. Promptly develop one or more geologic disposal facilities.
3. Promptly develop one or more consolidated storage facilities (interim storage).
4. Create a new organization independent of DOE to manage all efforts related to the storage and disposal of spent nuclear fuel and high-level wastes from defense activities.
5. Dramatically change the treatment of the Nuclear Waste Fund, the one-mil-per-kilowatt-hour fee nuclear utility ratepayers pay to fund nuclear waste management, through immediate policy changes by DOE and eventual legislative changes by Congress.
6. Begin advanced preparation for large-scale transportation operations that will eventually move spent nuclear fuel and high-level waste to consolidated storage and disposal facilities.
7. Support continued U.S. innovation in nuclear energy technology and skilled workforce development.
8. Support continued U.S. leadership in key areas, including nuclear technology and innovation, safety, waste management, nonproliferation, and security.

At the June 2012 Nuclear Initiative event on nuclear waste management, the Senate Committee on Energy and Natural Resources' chair, Senator Jeff Bingaman, and ranking member, Senator Lisa Murkowski, discussed their ongoing collaboration with Senator Dianne Feinstein and Senator Lamar Alexander, their counterparts on the Senate Appropriations Committee's Subcommittee on Energy and Water Development, to create comprehensive bipartisan legislation on nuclear waste management.[32] Senator Bingaman emphasized the importance of having a unified, systematic approach that links interim storage to a final repository. Senator Murkowski expressed concern that inaction is hurting both the future of nuclear power in the United States and our country's fiscal situation. Murkowski acknowledged that while many legislators are focused solely on reviving the Yucca Mountain repository option, she is also looking at new options and strategies, particularly those that can achieve local support.

We believe that implementing the legislative and procedural changes recommended by the BRC will substantially increase the likelihood of successfully opening a permanent repository for spent nuclear fuel and high-level waste, regardless of whether or not Yucca Mountain is one of the repository sites. Political disagreements about the viability of Yucca Mountain should not hinder efforts to implement these needed changes. Even if Yucca Mountain is eventually opened as a permanent waste repository, one or more additional repositories would be necessary under current law to accommodate the volume of waste that already exists and will continue to be produced. (The Nuclear Waste Policy Act explicitly limits the amount of waste that can be stored at Yucca.)

Meaningful progress on spent nuclear fuel management and disposal is essential to maintaining a viable domestic nuclear industry. We urge the Obama administration and Congress to continue efforts to develop a robust new, long-term strategy to manage and ultimately dispose of the nation's spent nuclear fuel and high-level radioactive waste.

Strategic Goal: Continued strong U.S. leadership in global nuclear security matters is central to protecting our national security interests. In particular, U.S. leadership in nuclear technology and operations can strengthen U.S. influence with respect to other countries' nuclear programs and the evolution of the international nonproliferation regime, while also supporting U.S. competitiveness in a major export market.

Nuclear power technologies are distinct from other potential exports in energy or in other sectors where America's competitive advantage may also be declining. Because of the potential link between commercial technology and weapons development, nuclear power is directly linked to national security concerns, including the threat of proliferation. Although reactors themselves do not pose significant proliferation risks, both uranium-enrichment and spent fuel–processing technologies can be misused for military purposes. If U.S. nuclear energy leadership continues to diminish, our nation will be facing a situation in which decisions about the technological capabilities and location of fuel-cycle facilities throughout the world will be made without significant U.S. participation. Leadership is important in both

commercial and diplomatic arenas, and it requires a vibrant domestic industry; an effective, independent regulator; access to competitive and innovative technologies and services; and the ability to offer practical solutions to safety, security, and nonproliferation challenges (an international fuel bank, for example, could help address concerns about the proliferation of uranium-enrichment capabilities).

COMMERCIAL NUCLEAR OPERATIONS

As the world's largest commercial nuclear operator and dominant weapons state, the United States has traditionally been the clear leader on international nuclear issues. Today, the United States still accounts for approximately one-quarter of commercial nuclear reactors in operation around the world and one-third of global nuclear generation.[33] This position is likely to shift in coming decades, as new nuclear investments go forward in other parts of the world while slowing or halting in the United States. In past decades, the United States was also a significant exporter of nuclear materials and technologies, but this dominance too has slowly declined.

At present, however, the U.S. safety and security infrastructure and regulatory framework remain without peer and U.S. expertise and guidance on operational and regulatory issues continues to be sought around the world. The domestic nuclear industry established the INPO in the wake of the Three Mile Island accident in 1979 in a collective effort to hold all industry players accountable to the highest standards for safe and reliable commercial operations. Similarly, the NRC is seen as the gold standard for commercial nuclear regulation. As long as other countries seek to learn from the experience and expertise of U.S. firms and regulators, the United States will enjoy greater access to international nuclear programs. A substantial reduction in domestic nuclear energy activities could erode U.S. international standing.

COMPETITIVE COMMERCIAL NUCLEAR EXPORTS

As an active participant in commercial markets, the United States has considerable leverage internationally through the 123 Agreements (in reference to Section 123 of the Atomic Energy Act) and Consent Rights on nuclear technologies exported by the U.S. nuclear industry. These mechanisms provide a direct and effective source of leverage over other countries' fuel-cycle decisions. U.S. diplomatic influence is also important, but absent an active role in commercial markets, it may not be sufficient to project U.S. influence and interests with respect to nuclear nonproliferation around the world. At an October 2011 Nuclear Initiative workshop on "Effective Approaches for U.S. Participation in a More Secure Global Nuclear Market," Deputy Secretary of Energy Daniel B. Poneman framed commerce and security not as competing objectives but as "inextricably intertwined."[34] He also highlighted several ways in which a robust domestic nuclear energy industry can further our country's nonproliferation goals. Deputy Secretary Poneman emphasized the importance of U.S. leadership not only in the commercial marketplace but in international nonproliferation organizations like the International Atomic Energy Agency (IAEA) as well.

In addition, BPC's Nuclear Initiative recognizes that a nuclear accident is a low-probability event that would have high consequences regionally or globally. Many countries that have expressed interest in, or the intention to, develop domestic nuclear power lack important infrastructure, education, and regulatory institutions. We believe that, if these programs move forward, the United States has a critical commercial and advisory role to play.

However, domestic exporters of U.S. nuclear technology, fuels, and services face a truly global and highly competitive market. Commercial nuclear technology is now available from a variety of suppliers, and there are many more companies, several of which have the direct backing of their country's government, competing with U.S. firms. Industry and other stakeholders believe that U.S. nuclear technology companies are at a competitive disadvantage in international markets due to complex and overlapping federal regulations. Several presenters at the BPC Nuclear Initiative event noted that multiple federal agencies, including the Department of Commerce, DOE, and the Department of State have jurisdiction over commercial nuclear trade, global safety and security, and nonproliferation.

In an attempt to ameliorate current competitive disadvantages, the Obama administration recently created a new position within the National Security Council to coordinate civilian nuclear policy. We support the creation of this new position to improve coordination of executive branch policy for nuclear energy policy and international affairs. We believe continued efforts to improve coordination between government and industry stakeholders and to more efficiently apply federal export regulations will allow U.S. companies to compete more effectively in the global nuclear marketplace.

LEADERSHIP ON INTERNATIONAL ISSUES RELATED TO THE NUCLEAR FUEL CYCLE

Leadership in technological and policy developments related to the management of the nuclear fuel cycle is another important component of U.S. leadership on nuclear issues more broadly. As discussed above, several countries have expressed interest in, or the intent to become, new entrants in the use of commercial nuclear power. The spread of nuclear technologies and knowledge presents inherent proliferation risks, and technologies and expertise related to fuel enrichment and reprocessing are especially sensitive. We believe that existing domestic and international policies to discourage the spread of fuel-cycle technologies are sound and we support efforts to maintain and expand these policies.

We also believe that international fuel assurances and spent fuel take-back capabilities would give new-entrant countries a powerful incentive to forgo their own enrichment and reprocessing activities. This is particularly true given the fact that most current and proposed national nuclear energy programs are too small to justify indigenous fuel-cycle programs, at least in economic terms.[35]

For many years, the United States and other countries and organizations, including the IAEA, have explored options for providing an assured nuclear fuel supply to countries that choose not to develop their own enrichment capacities. We strongly support continued U.S. leadership to establish multinational fuel-cycle facilities that would allow new-entrant countries to reliably develop domestic nuclear industries without increasing proliferation

risks. In addition, the ability to offer full fuel-cycle services would enhance the competitiveness of U.S.-based nuclear energy firms as new entrants look for more comprehensive service packages beyond reactor design and construction.

In particular, the ability to take advantage of spent fuel take-back services may provide a strong incentive for countries to participate in multinational fuel arrangements and could allow for more secure, long-term stewardship of spent fuel. Of course, to offer this service, the United States and its partners would have to develop effective spent fuel management and disposal capabilities of their own.

Strategic Goal: Historically, the United States has been a leader in nuclear technology research and commercialization. To extend this tradition and assure further innovation, the United States must continue to support research and development efforts within the nuclear industry, the national labs, and U.S. universities.

We believe that progress currently underway in a few technical areas will be especially helpful in allowing the United States to maintain its leadership role in nuclear technology and operations. In particular, we believe that SMRs represent an exciting frontier for nuclear technology and a promising opportunity to demonstrate U.S.-based scientific capability and manufacturing potential.[36] As part of our event series, the Nuclear Initiative convened a diverse group of expert stakeholders to discuss the technical potential and commercial risks associated with SMRs. Assistant Secretary for Nuclear Energy Lyons discussed the SMR Licensing Technical Support Program, a five-year industry cost-sharing effort to achieve design certification for two SMR designs and to support early stages of deployment.[37] DOE's projected budget for this program, which has received considerable bipartisan support in Congress, is $452 million over five years. These funds will be leveraged to raise additional contributions from industry.[38] We believe the SMR program offers the best opportunity, building on the successful Nuclear Power 2010 program, to commercialize innovative nuclear technologies, and we strongly encourage continued support for it and related research, development, and deployment (RD&D) programs.

Currently, the United States is also a leader in the development and deployment of Generation III+ advanced passive reactor designs. Beginning in 2002, DOE actively supported the development of advanced passive reactors through the Nuclear Power 2010 program, a government and industry cost-sharing effort that focused on overcoming major technical and regulatory barriers to the deployment of new nuclear power plants. The program supported design certification and first-of-a-kind engineering for two Generation III+ reactor designs (the AP1000 and the Economic Simplified Boiling-Water Reactor), as well as three early site permits and two COLs.

In December 2011, the NRC unanimously certified the first Generation III+ reactor design, the Westinghouse AP1000. This approval and the subsequent decision to build two new reactors using the AP1000 design at Southern Company's Vogtle site sets an important precedent for additional nuclear plant construction in the United States and internationally.

Four AP1000 reactors are currently under construction in China and several U.S. utilities are pursuing licenses to build more reactors of this type. Besides the Westinghouse AP1000 reactor, three additional passive reactor designs are under review by the NRC: GE Hitachi's Economic Simplified Boiling-Water Reactor, AREVA Nuclear Power's U.S. Evolutionary Power Reactor, and Mitsubishi Heavy Industries' U.S. Advanced Pressurized-Water Reactor.[39] Demand for advanced passive designs may grow further in light of the Fukushima accident. Countries that are planning to build new reactors, including China, may choose to build additional advanced passive reactors rather than conventional Generation II or III reactors.

Continued leadership in the development of advanced nuclear technologies presents an important export opportunity for the U.S. nuclear industry and for our nation's economy. The Commerce Department estimates that the international market for nuclear equipment and services will grow to $500–$740 billion over the next ten years.[40] Perhaps more importantly, as previously discussed, U.S. commercial strength in this area provides substantial co-benefits in terms of national security.

Beyond the near-term opportunities described above, we believe it is critical to sustain federal support for advanced nuclear RD&D at our national laboratories and universities. The international status of the United States in nuclear technology development remains strong and is built on a foundation of research conducted at such institutions. Most federal resources invested in advanced research at national laboratories, most notably at the lead nuclear energy laboratory, Idaho National Laboratory, as well as at a number of universities. Given the strategic importance of U.S. leadership in nuclear technology, we believe that nuclear energy must remain a priority area for federal energy research and development investment.

Several prominent recent studies, including the BRC report discussed previously and the Massachusetts Institute of Technology's "Future of Nuclear Power" report, have also emphasized the critical role of nuclear energy RD&D.[41] We agree with the BRC's recommendations that federal RD&D funding should be balanced between opportunities for near-term and long-term technology improvements and that the NRC should continue efforts to develop a regulatory framework to accommodate the licensing of advanced nuclear energy systems.[42] We also believe that our national labs must develop more streamlined and cost-effective ways to maintain and improve existing infrastructure so that ongoing research investments are as productive as possible. As previously emphasized, fees currently being collected from nuclear utilities for the express purpose of managing and disposing of spent fuel must be made available for this intended function so that rising costs for spent fuel management are not taken from a stagnant overall nuclear energy allocation. Finally, the federal government should continue to provide support for graduate students in nuclear energy research programs as an investment in the human capital and technical expertise needed to sustain a leadership role in the future.

Conclusion

Over the course of the last year, BPC's Nuclear Initiative event series has sparked many productive public conversations regarding nuclear energy in the United States. These discussions have reaffirmed the strategic importance of nuclear energy for our domestic energy sector and our national security interests, but they have also highlighted the many challenges facing the nuclear energy industry in the United States. Our hope is that a clear-eyed understanding of these opportunities and challenges will help policy makers identify and pursue effective actions to support continued U.S. leadership in nuclear energy.

As a starting point, policy makers and the public must understand the important role that nuclear energy currently plays in our electric power sector as well as the significant and perhaps vital option value it holds as part of a reliable, affordable, clean, and low-carbon energy future. For nuclear power to play this role, the industry and key regulatory agencies like the NRC must continue to improve nuclear plant safety and security and work to incorporate lessons learned—both from daily operations and from extreme events like Fukushima. Similarly, demonstrable progress must be made toward implementing an effective strategy for managing and disposing of spent nuclear fuel and high-level waste.

In addition, policy makers and the public must understand the clear linkages that exist between a strong domestic industry and competitive U.S. nuclear suppliers on the one hand and U.S. leadership in international nuclear markets and nonproliferation issues on the other hand. America's history of global leadership in this technology area was built on many different factors, including the domestic industry's extensive operating experience, the influence of the highly-respected NRC, technology advances achieved through domestic research and development programs, and a sustained commitment to nonproliferation principles. Maintaining excellence in each of these areas is the only way to assure continued U.S. leadership—both technologically and diplomatically—on nuclear issues of vital interest to our long-term energy and national security.

Appendix A. Event Series Agendas and Participants

Evolving Nuclear Technology and Regulation: Lessons Learned from Fukushima

August 3, 2011

AGENDA

9:00 AM Opening Remarks and Introduction

Senator Pete Domenici
BPC Senior Fellow
Co-chair, BPC Nuclear Initiative

9:05 AM Keynote Address
The Honorable George Apostolakis
Commissioner, U.S. Nuclear Regulatory Commission

9:30 AM Moderated Panel Discussion
Warren "Pete" Miller, Ph.D. (moderator)
Co-chair, BPC Nuclear Initiative
Former Assistant Secretary for Nuclear Energy, U.S. Department of Energy

Tom Cochran, Ph.D.
Senior Scientist Consultant, Nuclear Program
Natural Resources Defense Council

Michael Corradini, Ph.D.
Director, Wisconsin Institute of Nuclear Systems
University of Wisconsin

Jim Ferland
President, Americas
Westinghouse Electric Company

Charles "Chip" Pardee
Chief Operating Officer
Exelon Generation

11:00 AM Conclusion of Event

Effective Approaches for U.S. Participation in a More Secure Global Nuclear Market

October 3, 2011

AGENDA

9:00 AM Introduction

Senator Pete Domenici
BPC Senior Fellow
Co-Chair, BPC Nuclear Initiative

9:10 AM Keynote Address

General (ret.) James L. Jones
Co-Chair, BPC Energy Project
Former National Security Advisor

9:30 AM Panel One - The International Stage

Global development of new nuclear technology poses both a challenge and an opportunity for the United States. As a greater number of countries express interest in nuclear technology, the United States and the international community must ensure that future expansion does not increase the threat of proliferation. At the same time, the expected global growth of commercial nuclear infrastructure provides an opportunity for the United States to increase its export capacity while retaining its influence in nonproliferation matters.

Richard Meserve, Ph.D.
President, Carnegie Institution for Science

Janice Dunn-Lee
Deputy Director-General, OECD Nuclear Energy Agency

Jeff Merrifield
Senior Vice President, Shaw Power

Sharon Squassoni
Director and Senior Fellow, Proliferation Prevention Program
Center for Strategic and International Studies

11:00 AM Panel Two - Challenges to the Global Nonproliferation Regime and Levers for U.S. Influence

A sensible domestic and foreign policy framework can help balance the challenge and opportunity the United States faces. The second panel will address several key questions including:

- What is the role of U.S. commercial nuclear exports in nonproliferation efforts?
- What are the respective roles of government and industry in nonproliferation efforts?

George Perkovich
Vice President for Studies
Carnegie Endowment for International Peace

Melissa Mann
Manager, Marketing and Sales
Urenco, Inc.

Paul Longsworth
Vice President, New Ventures
Fluor

Corey Hinderstein
Vice President, International Program
Nuclear Threat Initiative

12:30 PM Lunch and Keynote Address
Daniel B. Poneman
Deputy Secretary of Energy, U.S. Department of Energy

1:30 PM Panel Three – Policies to Allow an Internationally Competitive Domestic Nuclear Industry

The final panel will explore the global market and policy factors constraining U.S. participation in growing international nuclear activities. Participants will discuss how domestic and foreign policies can expand opportunities for U.S. manufacturing and exports.

Richard J. Myers
Vice President, Policy Development, Planning and Supplier Programs
Nuclear Energy Institute

Pawel Pietrasienski, Ph.D.
Minister Counselor, Embassy of the Republic of Poland

Ganpat Mani
President and CEO, Converdyn

Ruth Ravitz Smith
Senior Vice President, Government Relations
GE Hitachi

3:00 PM **Keynote Address**
Ellen Tauscher
Under Secretary for Arms Control and International Security
U.S. Department of State

3:30 **Closing Remarks**
Warren "Pete" Miller, Ph.D.
Co-Chair, BPC Nuclear Initiative

Preparing for Deployment of Small Modular Reactors

March 16, 2011

AGENDA

9:00 AM Welcome and Introduction

Senator Pete Domenici

BPC Senior Fellow

Co-chair, BPC Nuclear Initiative

9:15 AM Keynote Address

Pete Lyons, Ph.D.

Assistant Secretary for Nuclear Energy, U.S. Department of Energy

9:45 AM Presentation

Mike Fowler
Director, Advanced Technology
Clean Air Task Force

10:05 AM Panel Discussion

Warren "Pete" Miller, Ph.D. (moderator)

Co-chair, BPC Nuclear Initiative

Former Assistant Secretary for Nuclear Energy, U.S. Department of Energy

Michael R. Johnson

Director, Office of New Reactors

U.S. Nuclear Regulatory Commission

William R. McCollum

Chief Operating Officer

Tennessee Valley Authority

Victor H. Reis, Ph.D.
Senior Advisor, Office of the Undersecretary for Science
US. Department of Energy

Near-Term Progress on Nuclear Waste Management: Implementing the Recommendations of the Blue Ribbon Commission

June 6, 2012

AGENDA

1:30 PM Welcome and Introduction
Senator Pete Domenici and Warren "Pete" Miller, Ph.D.
Co-chairs, BPC Nuclear Initiative

1:35 PM Keynote Remarks

Senator Jeff Bingaman (D-NM)

Chair, U.S. Senate Committee on Energy and Natural Resources

Senator Lisa Murkowski (R-AK)
Ranking Member, U.S. Senate Committee on Energy and Natural Resources

1:55 PM Q&A with Senators Bingaman and Murkowski

2:15 PM Moderated Panel Discussion
Warren "Pete" Miller, Ph.D. (Moderator)

Co-chair, BPC Nuclear Initiative

Former Assistant Secretary for Nuclear Energy, U.S. Department of Energy

Marshall Cohen

Senior Director, State and Local Government Affairs

Nuclear Energy Institute

Joseph S. Hezir

EOP Foundation, Inc.

The Honorable Marge Kilkelly

Chair, Maine Yankee Community Advisory Panel on Spent Nuclear Fuel Storage and Removal

3:00 PM Audience Q&A

3:20 PM Closing Remarks

Senator Pete Domenici

BPC Senior Fellow

Co-chair, BPC Nuclear Initiative

Endnotes

[1] For more information about BPC's Nuclear Initiative, see http://bipartisanpolicy.org/projects/nuclear-initiative.

[2] During the past several years, the majority of these applicants have asked the NRC to temporarily suspend review of their license applications.

[3] In February 2012, Southern Company and its partners received the first COL to build two new AP1000 reactors at its Vogtle plant in Georgia. The reactors are expected to come online in 2016 and 2017. In March 2012, the South Carolina Electric & Gas Company and its partners also received a COL to build two new reactors at the V.C. Summer Station in Jenkinsville, South Carolina.

[4] U.S. Energy Information Administration. *Annual Energy Review*. Table 8.2a Electricity Net Generation. Released October 19, 2011.

[5] Nuclear Energy Institute. Press Release. U.S. Nuclear Industry Posted Strong Safety Performance in 2011, WANO Results Show. Released April 10, 2012. Available at: http://nei.org/newsandevents/newsreleases/us-nuclear-industry-posted-strong-safety-performance-in-2011-wano-results-show.

[6] Nuclear Energy Institute. Resources and Stats (using U.S. Nuclear Regulatory Commission data). Cumulative Capacity Additions at U.S. Nuclear Facilities (1977-2016). June 2012. Available at: http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/graphicsandcharts/cumulativecapacityadditionsatusnuclearfacilities/.

[7] U.S. Nuclear Regulatory Commission. For information on Advanced Reactors, visit http://www.nrc.gov/reactors/new-reactors.html. At the applicants' request, review of many of these COLs has been suspended.

[8] U.S. Nuclear Regulatory Commission. Design Certification Application Review – AP1000 Amendment. Available at: http://www.nrc.gov/reactors/new-reactors/design-cert/amended-ap1000.html.

[9] Compared with existing reactor designs, passive safety systems do not require operator intervention or active controls to respond to loss of auxiliary power or other accident events. For example, passive systems may instead rely on gravity or natural convection.

[10] For a summary of all Vogtle plant milestones, see http://www.southerncompany.com/nuclearenergy/milestones.aspx.

[11] South Carolina Electric & Gas Company Press Release. NRC Approves COLs for SCE&G, Santee Cooper Nuclear Units. Released March 30, 2012. Available at: http://www.sceg.com/en/news-room/current-news/nrc-approves-cols-for-sceg-santee-cooper-nuclear-units.htm.

[12] Southern Company Press Release. Southern Company Receives DOE Support for Nation's First Nuclear Units in 30 Years. Released February 16, 2010. Available at: http://www.southerncompany.com/news/dyn_pressroom.aspx?s=43&item=2044.

[13] *The Augusta Chronicle*. Government's offer of Vogtle loan guarantee extended. June 6, 2012. Available at: http://chronicle.augusta.com/latest-news/2012-06-06/governments-offer-vogtle-loan-guarantee-extended?v=1339003482.

[14] Organization for Economic Cooperation and Development. Nuclear Energy Agency. Nuclear Energy Outlook 2008. Executive summary available at: http://www.oecd-nea.org/neo/summaries/english.pdf.

[15] Janice Dunn-Lee, former director-general of the OECD Nuclear Energy Agency. Remarks at Bipartisan Policy Center Nuclear Initiative, October 3, 2011. Available at: http://bipartisanpolicy.org/events/2011/10/effective-approaches-us-participation-more-secure-global-nuclear-market.

[16] World Nuclear Association. Country Briefings. Nuclear Power in Germany. Updated June 2012. Available at: http://www.world-nuclear.org/info/inf43.html.

[17] World Nuclear Association. Country Briefings. Nuclear Power in Switzerland. Updated April 2012. Available at: http://www.world-nuclear.org/info/inf86.html. Also, Nuclear Power in Italy. Updated April 2012. http://www.world-nuclear.org/info/inf101.html.

[18] World Nuclear Association. Country Briefings. Nuclear Power in Japan. Updated June 2012. Available at: http://www.world-nuclear.org/info/inf79.html.

[19] Reuters News. Japan switches off last nuclear power plant; will it cope? May 4, 2012. Available at: http://www.reuters.com/article/2012/05/04/us-japan-nuclear-idUSBRE8430BO20120504.

[20] In June 2012, the prime minister gave permission to Kansai Electric Power Company to restart its Unit 2 Ohi plant. Unit 3 is expected to come back online in early July and Unit 4 later in July. World Nuclear News. Ohi reactors cleared for restart. June 18, 2012. Available at: http://www.world-nuclear-news.org/RS-Ohi_reactors_cleared_for_restart-1806124.html.

[21] World Nuclear Association. World Nuclear Power Reactors & Uranium Requirements. June 2012. Available at: http://www.world-nuclear.org/info/reactors.html.

[22] For a recent discussion of electric power sector dynamics in the context of coal-plant retirements, see *Environmental Regulation and Electric System Reliability*, a June 2011 Bipartisan Policy Center staff report. Available at: http://bipartisanpolicy.org/library/report/environmental-regulation-and-electric-system-reliability.

[23] U.S. Nuclear Regulatory Commission. Status of License Renewable Application and Industry Activities. Available at: http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html#plant.

[24] U.S. Energy Information Administration. Annual Energy Outlook 2010. Issues in Focus - U.S. nuclear power plants: Continued life or replacement after 60? Available at: http://www.eia.gov/forecasts/archive/aeo10/pdf/issues.pdf.

[25] The inspections, completed April 29, 2011, yielded no "significant" safety issues, but did unearth numerous safety shortcomings in areas such as fire safety, station blackout responses, and response procedures and capabilities for events outside of design basis parameters, including floods, earthquakes, and fire disasters. U.S. Nuclear Regulatory Commission, Summary of Observations: Temporary Instruction 2515/183. Available at: http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/Summary-of-Observations-TI-2515-183.pdf (accessed June 19, 2012).

[26] The Blue Ribbon Commission on America's Nuclear Future charter. Available at: http://brc.gov/index.php?q=page/charter.

[27] U.S. Department of Justice. Response to Request for Information from the Blue Ribbon Commission on America's Nuclear Future. December 20, 2011. Available at: http://www.brc.gov/sites/default/files/comments/attachments/doj_response.12.20.11_0.pdf.

[28] Dr. Pete Lyons, assistant secretary for nuclear energy, will oversee the task force under the leadership of former Assistant Deputy Under Secretary Phil Niedzielski-Eichner.

[29] U.S. Senate Committee on Appropriations Press Release. Committee Approves FY13 Agriculture and Energy Appropriations Bills. Released April 26, 2012. Available at: http://www.appropriations.senate.gov/news.cfm?method=news.view&id=beb437d6-d9f4-4801-93c8-24c84ae34b40.

[30] Bipartisan Policy Center. Letters to the Senate Committee on Appropriations from BPC Nuclear Initiative Co-Chairs Pete V. Domenici and Dr. Warren F. Miller. Released April 26, 2012. Available at: http://bipartisanpolicy.org/library/energy-project/letters-senate-committee-appropriations-bpc-nuclear-initiative-co-chairs-pete.

[31] The final report is available at: http://brc.gov.

[32] For more information about the Nuclear Initiative's June 6 event, see http://bipartisanpolicy.org/events/2012/06/near-term-progress-nuclear-waste-management-implementing-recommendations-blue-ribbon-.

[33] World Nuclear Association. Nuclear Power in the World Today. April 2012. Available at: http://www.world-nuclear.org/info/inf01.html.

[34] BPC Nuclear Initiative Event. Effective Approaches for U.S. Participation in a More Secure Global Nuclear Market. October 2, 2011. Available at: http://bipartisanpolicy.org/events/2011/10/effective-approaches-us-participation-more-secure-global-nuclear-market.

[35] Sharon Squassoni, director and senior fellow, Proliferation Prevention Program, Center for Strategic and International Studies. Remarks at Bipartisan Policy Center, Nuclear Initiative event, October 3, 2011. Available at: http://bipartisanpolicy.org/events/2011/10/effective-approaches-us-participation-more-secure-global-nuclear-market.

[36] The Nuclear Initiative commissioned a white paper from the Clean Air Task Force that describes several advance reactor technologies that may be candidates for relatively near-term deployment. The paper is available at: http://bipartisanpolicy.org/sites/default/files/CATF%20Nuclear%20Decarbonization%20Option.pdf.

[37] For more information, see Assistant Secretary Pete Lyons's presentation to the Bipartisan Policy Center's Nuclear Initiative. March 16, 2012. Available at: http://bipartisanpolicy.org/events/2012/03/preparing-deployment-small-modular-reactors.

[38] The U.S. Senate Committee on Appropriations FY13 Agriculture and Energy Appropriations Bills includes continued support for the DOE SMR Licensing Technical Support Program.

[39] U.S. Nuclear Regulatory Commission. Design Certification Applications for New Reactors. Available at: http://www.nrc.gov/reactors/new-reactors/design-cert.html.

[40] U.S. Department of Commerce. The Commercial Outlook for U.S. Small Modular Nuclear Reactors. February 2011. Available at: http://www.trade.gov/publications/abstracts/the-commercial-outlook-for-us-small-modular-nuclear-reactors.asp.

[41] Massachusetts Institute of Technology. Update of the MIT 2003 Future of Nuclear Power: An Interdisciplinary MIT Study. 2009. Available at: http://web.mit.edu/nuclearpower/pdf/nuclearpower-update2009.pdf.

[42] Blue Ribbon Commission on America's Nuclear Future. Report to the Secretary of Energy. January 2012. Available at: http://www.brc.gov.

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