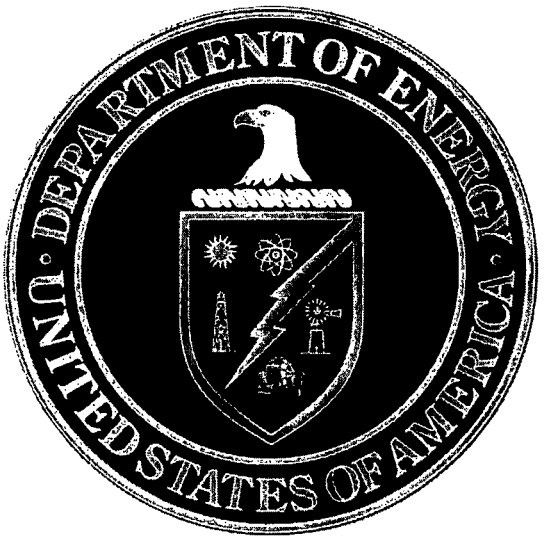
STRATEGY FOR THE MANAGEMENT AND DISPOSAL OF USED NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE



JANUARY 2013

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In 2010, I chartered the *Blue Ribbon Commission on America's Nuclear Future* ("BRC" or "Commission") to conduct a comprehensive review and recommend a plan of action for the management and disposal of the nation's used nuclear fuel and high-level radioactive waste, also referred to as the back-end of the nuclear fuel cycle. Representative Lee Hamilton and General Brent Scowcroft, two distinguished individuals with decades of public service and governing experience, co-chaired the Commission and led a panel of leading scientists, nuclear energy experts, industry leaders, and former elected officials.

Nuclear power is an integral part of our "all-of-the-above" energy strategy. It provides twenty percent of our nation's electricity supply, and the Administration is promoting the safe use of nuclear power through support for new nuclear power plants incorporating state-of-the-art passive safety features as well as a cost-shared program providing technical support for licensing new small reactor designs. Nuclear energy is an important contributor to our nation's energy security, and promotes clean-energy jobs. Nuclear energy production also provides important environmental benefits by producing little carbon dioxide or conventional air pollutant emissions.

An unfailing commitment to protect public health and safety, security, and the environment is essential to ensuring that nuclear power remains part of our diversified clean-energy portfolio. As part of that commitment, safe, long-term management and disposal of used nuclear fuel and high-level radioactive waste must remain a national priority.

Beyond sustaining an important domestic energy source, progress on a disposal solution can also support the clean-up of those sites that hosted production of defense nuclear materials during the Cold War, and help advance key national-security and non-proliferation objectives. More than 40 percent of the Navy's surface and submarine combatant fleet, for example, is now nuclear-powered. The used nuclear fuel it generates likewise requires a permanent disposal solution.

Since the end of the Cold War, significant quantities of weapons-capable plutonium and highly enriched uranium have become surplus to our national security needs. Some of these nuclear materials will be modified so they can be used in reactors as fuel, but then will be destined for a repository.

Finally, global demand for nuclear energy continues to grow, with commensurate risks in terms of safety, weapons proliferation, and terrorism if this growth occurs outside a vigorous safety and security framework. America's ability to influence the mitigation of these risks is strengthened when we demonstrate the commitment and ability to perform here at home.

For nearly two years, the Commission conducted a comprehensive review and ultimately made recommendations for addressing one of our nation's most intractable challenges. Its work provides a strong foundation for development of a new strategy to manage used nuclear fuel and high-level radioactive waste. We will work with Congress to build a new national program based on this foundation.

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INTRODUCTION AND SUMMARY

The *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* is a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel[1] and high-level radioactive waste from civilian nuclear power generation, defense, national security and other activities.

The Strategy addresses several important needs. First, it serves as a statement of Administration policy regarding the importance of addressing the disposition of used nuclear fuel and high-level radioactive waste; it lays out the overall design of a system to address that issue; and it outlines the reforms needed to implement such a system. Second, it presents the Administration's response to the final report and recommendations made by the *Blue Ribbon Commission on America's Nuclear Future* ("BRC"). It also responds to direction in the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2012, to develop a strategy for the management of used nuclear fuel and nuclear waste in response to the BRC's recommendations. Third, this strategy represents an initial basis for discussions among the Administration, Congress and other stakeholders on a sustainable path forward for disposal of nuclear waste.

The Administration endorses the key principles that underpin the BRC's recommendations. The BRC's report and recommendations provide a starting point for this Strategy, which translates many of the BRC's principles into an actionable framework within which the Administration and Congress can build a national program for the management and disposal of the nation's used nuclear fuel and high-level radioactive waste.[2] The BRC report and the Strategy build on the body of physical and social science work completed during the prior decades and benefit from the lessons learned not only from our nation's experiences, but also from those of other countries.

This Strategy includes a phased, adaptive, and consent-based approach to siting and implementing a comprehensive management and disposal system. At its core, this Strategy endorses a waste management system containing a pilot interim storage facility; a larger, full-scale interim storage facility; and a geologic repository in a timeframe that demonstrates the federal commitment to addressing the

[1] The term "used nuclear fuel" as used in the BRC charter and in this document is intended to be synonymous with the term "spent nuclear fuel" as used in the Nuclear Waste Policy Act and the Standard Contracts.

[2] The BRC recommendations are available here and are summarized as follows:

1. A new, consent-based approach to siting future nuclear waste management facilities.
2. A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
3. Access to the funds nuclear utility ratepayers are providing for the purpose of nuclear waste management.
4. Prompt efforts to develop one or more geologic disposal facilities.
5. Prompt efforts to develop one or more consolidated storage facilities.
6. Prompt efforts to prepare for the eventual large-scale transport of used nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available.
7. Support for continued U.S. innovation in nuclear energy technology and for workforce development.
8. Active U.S. leadership in international efforts to address safety, waste management, non-proliferation, and security concerns.

nuclear waste issue, builds capability to implement a program to meet that commitment, and prioritizes the acceptance of fuel from shut-down reactors. A consent-based siting process could result in more than one storage facility and/or repository, depending on the outcome of discussions with host communities; the Nuclear Waste Policy Act of 1982 (NWPA) envisaged the need for multiple repositories as a matter of equity between regions of the country. As a starting place, this Strategy is focused on just one of each facility.

With the appropriate authorizations from Congress, the Administration currently plans to implement a program over the next 10 years that:

- Sites, designs and licenses, constructs and begins operations of a pilot interim storage facility by 2021 with an initial focus on accepting used nuclear fuel from shut-down reactor sites;
- Advances toward the siting and licensing of a larger interim storage facility to be available by 2025 that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; and
- Makes demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a geologic repository by 2048.

Full implementation of this program will require legislation to enable the timely deployment of the system elements noted above. Legislation should also include the requirements for consent-based siting; a reformed funding approach that provides sufficient and timely resources; and the establishment of a new organization to implement the program, the structure of which should balance greater autonomy with the need for continued Executive and Legislative branch oversight. The Administration looks forward to engaging Congress on comprehensive legislation to move forward on this important national responsibility.

In the meantime, the Administration, through the Department of Energy (DOE), is undertaking activities within existing Congressional authorization to plan for the eventual transportation, storage, and disposal of used nuclear fuel. Activities range from examining waste management system design concepts, to developing plans for consent-based siting processes, to conducting research and development on the suitability of various geologies for a repository. These activities are designed to not limit the options of either the Administration or Congress and could be transferred to the new waste management and disposal organization when it is established.

BACKGROUND

The NWPA established a broad policy framework for the permanent disposal of used nuclear fuel and high-level radioactive waste derived from nuclear power generation. The NWPA authorized the government to enter into contracts with reactor operators – the generators and current owners of used nuclear fuel – providing that, in exchange for the payment of fees, the government would assume responsibility for permanent disposal. The fees were to ensure that the reactor owners and power

generators pay the full cost of the disposal of their used nuclear fuel and high-level radioactive waste.

The federal government did not meet its contractual obligation to begin accepting used nuclear fuel by 1998. As a result of litigation by contract holders, the government was found in partial breach of contract, and is now liable for damages to some utilities to cover the costs of on-site, at-reactor storage.

Currently more than 68,000 metric tons heavy metal (MTHM) of used nuclear fuel are stored at 72 commercial power plants around the country with approximately 2,000 MTHM added to that amount every year. The sooner that legislation enables progress on implementing this Strategy, the lower the ultimate cost will be to the taxpayers. This document outlines a strategy that is intended to limit, and then end, liability costs by making it possible for the government to begin performing on its contractual obligations.

The NWPA specified a process for evaluating sites for a repository. The Administration concurs with the conclusion of the BRC that a fundamental flaw of the 1987 amendments to the NWPA was the imposition of a site for characterization, rather than directing a siting process that is, as the BRC recommends, "explicitly adaptive, staged, and consent-based..." In practical terms, this means encouraging communities to volunteer to be considered to host a nuclear waste management facility while also allowing for the waste management organization to approach communities that it believes can meet the siting requirements. Under such an arrangement, communities could volunteer to provide a consolidated interim storage facility and/or a repository in expectation of the economic activity that would result from the siting, construction, and operation of such a facility in their communities.

In addition to commercial used nuclear fuel, high-level radioactive wastes that are the by-products of the production of the nation's nuclear weapons and used fuel from the Navy's nuclear powered combat vessels also require a defined disposal path. These wastes are currently stored at sites in Idaho, South Carolina, and Washington. Also, significant quantities of weapons-capable plutonium and highly enriched uranium have become surplus to our national security needs, and in some form will be destined for disposal in a repository.

STRATEGY ELEMENTS

This Strategy provides a basis for the Administration to work with Congress to design and implement a program to meet the government's obligation to take title to and permanently dispose of used nuclear fuel and high-level radioactive waste. It also provides near-term steps to be implemented by DOE pending enactment of new legislation. The key elements of this Strategy are captured in Figure 1.

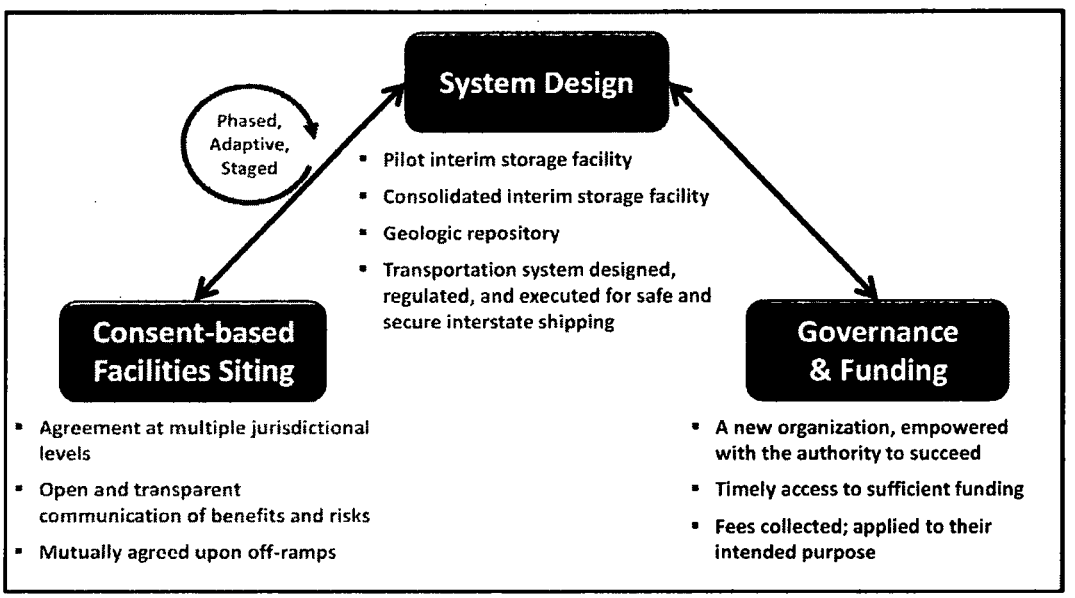

Figure 1. Key Strategy Elements

System Design

The Administration supports an approach to system design that integrates consent-based siting principles and makes progress in demonstrating the federal commitment to addressing used nuclear fuel and high-level radioactive waste disposal, including building the capability to begin executing that commitment within the next 10 years. The Administration supports a nuclear waste management system with the following elements:

- A pilot interim storage facility with limited capacity capable of accepting used nuclear fuel and high-level radioactive waste and initially focused on serving shut-down reactor sites;
- A larger, consolidated interim storage facility, potentially co-located with the pilot facility and/or with a geologic repository, that provides the needed flexibility in the waste management system and allows for important near-term progress in implementing the federal commitment; and
- A permanent geologic repository for the disposal of used nuclear fuel and high-level radioactive waste.

The objective is to implement a flexible waste management system incrementally in order to ensure safe and secure operations, gain trust among stakeholders, and adapt operations based on lessons learned. As will be addressed in the following section on implementation, the Administration agrees with the Blue Ribbon Commission that a consent-based siting process offers the promise of sustainable decisions for both storage and disposal facilities. Figure 2 below portrays a set of possible pathways to developing system facilities and capabilities.

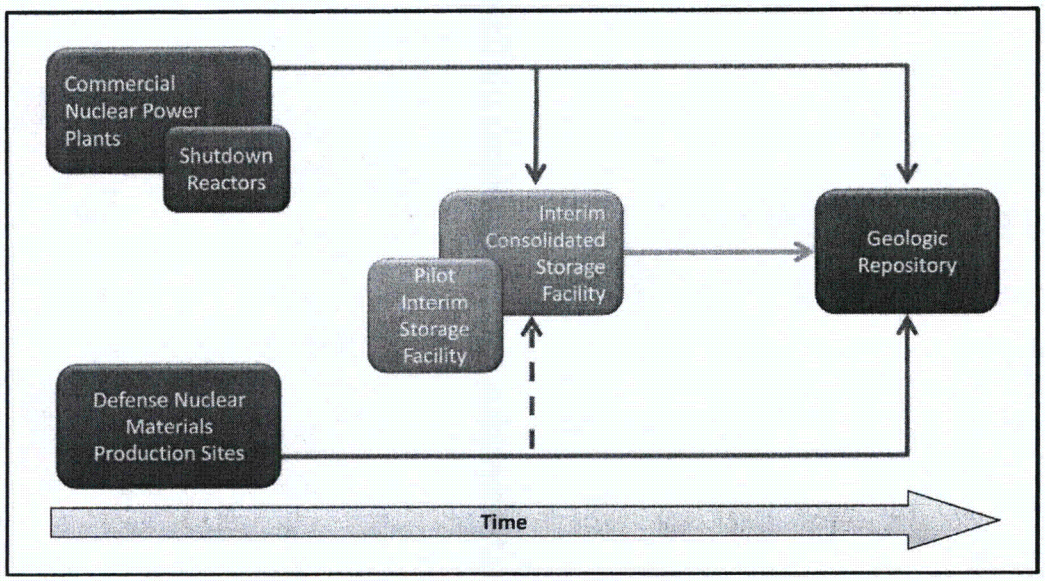

Figure 2. Possible system pathways

This system would initially be focused on acceptance of used nuclear fuel from shut-down reactors; such fuel provides an opportunity to build waste handling capability as well as to relieve surrounding communities and utility contract holders of the burdens associated with long-term storage of used nuclear fuel at a shut-down reactor. Following these initial efforts, capacity will be developed to enable the acceptance and transportation of used nuclear fuel at rates greater than that at which utilities are currently discharging it in order to gradually work off the current inventory. The Administration remains committed to addressing the Cold War legacy; and, in addition to ongoing efforts, will consider transportation and interim storage of government-owned used nuclear fuel and high-level radioactive waste at interim storage facilities.

Interim Storage

The BRC recommended that "one or more consolidated (interim) storage facilities be developed to start the orderly transfer of used nuclear fuel from reactor sites to safe and secure centralized facilities independent of the schedule for operating a permanent repository." The Administration agrees that interim storage should be included as a critical element in the waste management system and has several benefits, including flexibility in system planning and execution and the opportunity to move expeditiously to fulfill government contractual responsibilities.

The Administration also agrees with the BRC that a linkage between opening an interim storage facility and progress toward a repository is important so that states and communities that consent to hosting a consolidated interim storage facility do not face the prospect of a *de facto* permanent facility without consent. However, this linkage should not be such that it overly restricts forward movement on a pilot or larger storage facility that could make progress against the waste management mission. The NWPA currently constrains the development of a storage facility by limiting the start of construction of such a facility until after the Nuclear Regulatory Commission (NRC) has issued a license for construction of a

repository. This restriction has effectively eliminated the possibility of having an interim storage facility as an integral component of a waste management system.

Consistent with legislation recently under consideration in Congress, the Administration supports the development of a pilot interim storage facility with an initial focus on accepting used nuclear fuel from shut-down reactor sites. Acceptance of used nuclear fuel from shut-down reactors provides a unique opportunity to build and demonstrate the capability to safely transport and store used nuclear fuel, and therefore to make progress on demonstrating the federal commitment to addressing the used nuclear fuel issue. A pilot would also build trust among stakeholders with regard to the consent-based siting process and commitments made with a host community for the facility itself, with jurisdictions along transportation routes, and with communities currently hosting at-reactor storage facilities if enabled by appropriate legislation. The Administration would plan to undertake activities necessary to enable the commencement of operations at this facility in 2021, including conducting a consent-based siting process with interested parties, undertaking the requisite analyses associated with siting such a facility, and initiating engineering and design activities as warranted. Full execution of this plan depends on enactment of revised legislative authority.

Beyond a pilot-scale facility, the Administration supports the development of a larger consolidated interim storage facility with greater capacity and capabilities that will provide flexibility in operation of the transportation system and disposal facilities. In addition, a larger-scale facility could take possession of sufficient quantities of used nuclear fuel to make progress on the reduction of long-term financial liabilities. Depending on the outcome of a consent-based process, this facility could have a capacity of 20,000 MTHM or greater, and could be co-located with the pilot facility or the eventual geologic repository. In the context of the overall waste management system, the Administration supports the goal of siting, designing, licensing, constructing and commencing operations at a consolidated interim storage facility by 2025.

In addition to commercial used nuclear fuel, pilot-scale and larger interim storage facilities could provide similar benefits for government-owned and managed used nuclear fuel and high-level radioactive waste, such as demonstration of capability and flexibility in system operations. Therefore, the feasibility of accepting these wastes at interim storage facilities will be considered.

Transportation

The BRC found that existing standards and regulations for the transportation of used nuclear fuel and high-level radioactive waste administered by DOE, NRC, the U.S. Department of Transportation, and state, local, and tribal governments are proven and functioning well. Consistent with the recommendations of the BRC on this issue, the Administration is moving ahead with initial planning for engagement and technical assistance for transportation operations for state and local governments.

As described in the Ongoing Activities section of this document, the Department is proceeding with planning activities for the development of transportation capabilities and storage facilities to facilitate the acceptance of used nuclear fuel at a pilot interim storage facility within the next 10 years and later

at a larger consolidated interim storage facility. The Administration will undertake the transportation planning and acquisition activities necessary to initiate this process with the intent to transfer them to a separate organizational entity if and when it is authorized by Congress and in operation. Outreach and communication, route analysis, and emergency response planning activities consistent with existing NWPA requirements would be conducted during this time. The Administration agrees with the BRC that the relationships and processes built with other federal agencies, state agencies, and local governments to support logistics of shipments to the Waste Isolation Pilot Plant (WIPP) have been successful and the infrastructure and lessons learned from this experience will be utilized moving forward.

Geologic Disposal

There is international consensus that geologic repositories represent the best known method for permanently disposing of used nuclear fuel and high-level radioactive waste, without putting a burden of continued care on future generations. The BRC recommended that the U.S. undertake "an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geologic facilities for the safe disposal of used fuel and high-level nuclear waste." The Administration agrees that the development of geologic disposal capacity is currently the most cost-effective way of permanently disposing of used nuclear fuel and high-level radioactive waste while minimizing the burden on future generations. As noted by the BRC, the linkage between storage and disposal is critical to maintaining confidence in the overall system. Therefore, efforts on implementing storage capabilities within the next 10 years will be accompanied by actions to engage in a consent-based siting process and begin to conduct preliminary site investigations for a geologic repository. The Administration's goal is to have a repository sited by 2026; the site characterized, and the repository designed and licensed by 2042; and the repository constructed and its operations started by 2048. Consistent with this effort, the Administration understands the need for the Environmental Protection Agency to develop a set of generic, non-site-specific, repository safety standards to gain public confidence that any future repository will protect public health and the environment. This will be an important early step in any repository siting effort.

The ability to retrieve used nuclear fuel and high-level radioactive waste from a geologic repository for safety purposes or future reuse has been a subject of repository design debate for many years. A recently completed technical review by Oak Ridge National Laboratory found that approximately 98 percent of the total current inventory of commercial used nuclear fuel by mass can proceed to permanent disposal without the need to ensure post-closure recovery for reuse based on consideration of the viability of economic recovery of nuclear materials, research and development (R&D) needs, time frames in which recycling might be deployed, the wide diversity of types of used nuclear fuel from past operations, and possible uses to support national security interests.[3] This assessment does not preclude any decision about future fuel cycle options, but does indicate that retrievability it is not necessary for purposes of future reuse.

[3] J. C. WAGNER et al., Categorization of Used Nuclear Fuel Inventory in Support of a Comprehensive National Nuclear Fuel Cycle Strategy, ORNL/TM-2012/308 (FCRD-FCT-2012-00232), Oak Ridge National Laboratory, Oak Ridge, Tenn., December 2012.

Disposal of defense wastes alongside commercial wastes is the current policy in accordance with the 1985 decision to use a single repository for both commercial and defense wastes. The issue of "commingling" of wastes in a repository will be the subject of analysis moving forward.

Advanced Fuel Cycles

The BRC concluded that "it is premature at this point for the United States to commit irreversibly to any particular fuel cycle as a matter of government policy..." and pointed out that "it is... very likely that disposal will be needed to safely manage at least some portion of the existing commercial [used nuclear fuel] inventory." Even if a closed fuel cycle were to be adopted in the future, permanent geologic disposal will still be required for residual high-level radioactive waste. Cost, nonproliferation, national security, environmental concerns, and technology limitations are some of the concerns that would need to be addressed before any future decision to close the U.S. fuel cycle through the use of recycling would be made. These factors reinforce the likelihood that the once-through fuel cycle will continue at least for the next few decades. Nevertheless, consistent with past practice and the BRC's recommendations, DOE will continue to conduct research on advanced fuel cycles to inform decisions on new technologies that may contribute to meeting the nation's future energy demands while supporting non-proliferation and used nuclear fuel and high-level radioactive waste management objectives.

International Cooperation

International cooperation has been a cornerstone of both U.S. fuel cycle R&D efforts as well as actions to reduce the global proliferation of nuclear materials. Recently, several countries, led by the U.S. and others, have come together to establish frameworks within which multi-national fuel cycle facilities could enable wider access to the benefits of nuclear power while reducing proliferation risks. The BRC recommended that the U.S. develop the capability "to accept used fuel from foreign commercial reactors, in cases where the President would choose to authorize such imports for reasons of U.S. national security." The focus of the present Strategy is on a clear path for the safe and permanent disposal of U.S. used nuclear fuel and high-level radioactive waste; however, the Administration will continue to evaluate the BRC's recommendation and will discuss with Congress the pros and cons of including it in the new waste disposal program.

Implementation

Critical elements for successful implementation of this Strategy include the establishment of a consent-based siting process, a new organization to execute the waste management mission and implementation of a process for long-term, stable funding. The design of both the new organization and the funding source should strike an appropriate balance between independence of the new organization and the need for oversight by Congress and the Executive branch.

Consent-based Siting

The BRC recommends a siting process that is consent-based, transparent, phased, adaptive, standards- and science-based, and governed by legally-binding agreements between the federal government and host jurisdictions. Indeed, promising experiences in other countries indicate that a consent-based process, developed through engagement with states, tribes, local governments, key stakeholders, and the public, offers a greater probability of success than a top down approach to siting. One of the consequences of a consent-based siting process could be the need to have more than one storage facility and/or repository. Multiple communities with differing interests and strengths may propose options leading to system configurations that involve multiple facilities. However, this Strategy focuses on one pilot storage, consolidated interim storage, and repository.

The BRC offered the view that "a good gauge of consent would be the willingness of the host [jurisdictions] to enter into legally binding agreements...that can protect the interests of their citizens." Defining consent, deciding how that consent is codified, and determining whether or how it is ratified by Congress are critical first steps toward siting the storage facilities and repository discussed above. As such, they are among the near-term activities to be undertaken by the Administration in consultation with Congress and others. Legislation recently under consideration by Congress includes requirements for consent at multiple levels, including Congressional ratification. The Department is currently gathering information from the siting of nuclear facilities in the U.S. and elsewhere in order to better understand critical success factors in these efforts and to facilitate the development of a future siting process for a repository and storage facilities.

This Strategy endorses the proposition that prospective host jurisdictions must be recognized as partners. Public trust and confidence is a prerequisite to the success of the overall effort, as is a program that remains stable over many decades; therefore, public perceptions must be addressed regarding the program's ability to transport, store, and dispose of used nuclear fuel and high-level radioactive waste in a manner that is protective of the public's health, safety, and security and protective of the environment.

Management and Disposal Organization

A new waste management and disposal organization (MDO) is needed to provide the stability, focus, and credibility to build public trust and confidence. Managing waste and used fuel is a governmental responsibility and there are multiple possible structures for this new organization. The MDO would be charged with the management and disposal of commercial used nuclear fuel and the associated interface with the utilities. The government will continue to manage its own high-level radioactive waste and used nuclear fuel until it is transferred to an MDO for storage and/or disposal. The BRC recommended the establishment of new, single-purpose organization "to provide the stability, focus, and credibility that are essential to get the waste program back on track." The BRC recommended a specific model in a congressionally-chartered federal corporation. The Administration agrees that a new organizational entity is needed and believes that there are several viable organizational models that can

possess the critical attributes described below.

As part of the development of this Strategy, the Department of Energy commissioned work by the RAND Corporation to examine organizational alternatives for addressing used nuclear fuel and high-level radioactive wastes.[4] RAND assessed lessons learned from the history of the previous DOE organization and analyzed alternative organizational models currently in use both in and out of government. The study's authors concluded that a federal government corporation and an independent government agency are two promising models for a new organization to manage and dispose of used nuclear fuel and high-level radioactive waste, as both models can achieve the critical attributes of accountability, transparent decision-making, autonomy, a public interest mission, and organizational stability. The study also examined the attributes of federally-chartered private corporations and determined that this model is not a good option because obligations to stockholders and the profit motive could result in weakened public accountability and poor political credibility. The RAND study noted that "The success of any future MDO will be driven by many factors and unforeseen circumstances. The organizational form is only one of these factors and perhaps not even the most important one." Rather, of key importance is the flexibility the U.S. government has in crafting a new organization and the specific characteristics with which that organization is endowed.

Whatever form the new organization takes, organizational stability, leadership continuity, oversight and accountability, and public credibility are critical attributes for future success. The Administration will work with Congress to ensure that the MDO authorization provides adequate authority and leadership to execute its mission, with appropriate oversight and controls. Pending enactment of new legislation to establish the MDO, DOE's existing offices retain responsibility to maintain progress in implementing this Strategy. Once the MDO is established, the Administration will carefully evaluate the appropriate activities to be transferred. DOE will take necessary steps to advance the program while taking every precaution to avoid compromising the later ability of the newly established MDO to succeed.

In addition, the mission of the MDO will need to be carefully defined. For example, funding made available to the MDO should be used only for the management and disposal of radioactive waste. While this could include the management and disposal of waste resulting from the processing of defense materials, the MDO itself should not be authorized to perform research on, fund or conduct activities to reprocess or recycle used nuclear fuel. These limitations on the MDO mission are consistent with the recommendations of the BRC.

Funding

With regard to funding, the BRC noted that "...the success of a revitalized nuclear waste management program will depend on making the revenues generated by the nuclear waste fee and the balance in the

[4] *Choosing a New Organization for Management and Disposition of Commercial and Defense High-Level Radioactive Materials*, RAND Corporation, Washington, DC, MG-1230-DOE, 2012. The report is available free for downloading at www.rand.org/pubs/monographs/MG1230.html.

NWF available when needed and in the amounts needed to implement the program." The Administration agrees that providing adequate and timely funding is critical to the success of the nuclear waste mission.

The NWPA established a self-financing mechanism for the nation's commercial nuclear material management system. Congress intended at the time to ensure a stable, ongoing source of funding for the program and also one that would not burden taxpayers. Under the NWPA, the government currently assesses utilities a fee equal to one mill ($0.001) for each kilowatt-hour of electricity sold from nuclear power plants in exchange for agreeing to accept and permanently dispose of utilities' used nuclear fuel. Fees collected total approximately $750 million per year. This fee income is credited to the Nuclear Waste Fund (NWF, or the "Fund"), a fund held in the U.S. Treasury in which monies in excess of appropriations are invested in non-marketable Treasury securities, and the interest earnings are credited to the Fund. The current balance of the Fund is estimated at $28 billion.

Subsequent to passage of the NWPA, a series of broader budgeting acts passed by Congress have had the effect of disconnecting the revenues from the expenditures necessary for a waste disposal solution. All NWF spending is subject to annual appropriations and is required to compete with other priorities within budget caps imposed on all government discretionary spending, while continued collection of the full amount of fees is credited on the mandatory side of the budget as offsetting receipts. As a result, even though the intent of the NWPA was to make the balances of the NWF available when needed to cover the government's cost to dispose of the used nuclear fuel, there is a disconnect that makes access to funding difficult.

Moving forward, the key challenge is to ensure that past and future fee receipts and accrued interest are made available to meet mission requirements in a timely and dependable manner. To achieve this goal, reform of the current funding arrangement is necessary and should consist of the following elements: ongoing discretionary appropriations, access to annual fee collections provided in legislation either through their reclassification from mandatory to discretionary or as a direct mandatory appropriation of the fees, and eventual access to the balance or "corpus" of the NWF.

First, future funding arrangements should include a role for the Appropriations Committees of Congress through ongoing discretionary appropriations, funded within the discretionary spending limits. Ongoing engagement with the Appropriations committees ensures annual oversight and increases the likelihood of a sustained Congressional commitment to the nuclear waste mission. Annual appropriations could be used to fund expenses that are regular and recurring, such as program management costs, including administrative expenses, salaries and benefits, and studies.

Second, access to annual fee collections could support activities such as the development of interim storage facilities, establishment of the transportation system, siting and characterization of a geologic repository, and execution of regulatory development and oversight. This access could be accomplished either through legislative reclassification of fee collections from mandatory to discretionary, or as a direct mandatory appropriation of the fees, or some combination thereof. Legislative reclassification of fee collections from mandatory to discretionary would allow the fees to offset NWF discretionary

appropriations, so that appropriation of the fees no longer would have to compete with other discretionary priorities. Instead, fees would be provided in amounts needed only above the annual appropriations described above and would also be limited by the amount of fee income, as envisioned by the NWPA. This approach could be preferable if additional Appropriator involvement was desired or deemed necessary and regular annual appropriations of that magnitude could be identified.

Alternatively, a direct mandatory appropriation of the annual fees could be coupled with direct access to the corpus of the NWF, as further discussed below. Under this arrangement, spending could be controlled through annual mandatory spending caps set by Congress or by tying funding levels to specific system development milestones in legislation. With continued oversight by the Appropriations Committees, these mandatory spending caps could be adjusted, as deemed necessary and appropriate. Implementation of either or a combination of both of these approaches will require substantial consultation with Authorizing, Budget, and Appropriations Committees of Congress; the Administration is committed to working with Congress to find a mutually agreeable solution to this issue.

Third, regardless of how access to the annual fees is provided, the substantial corpus of the NWF will be needed at an appropriate time in the future, particularly to support the development of a geologic repository. The cost of constructing repository facilities could outstrip the annual fee collections and other discretionary appropriations discussed above. Direct access to the corpus of the NWF through mandatory appropriations could be carefully managed by limiting its use to specific capital expenditures, tied to performance triggers, such as meeting licensing actions and major construction milestones, or subject to hard spending caps.

The cost of the government's growing liability for partial breach of contracts with nuclear utilities is paid from the Judgment Fund of the U.S. Government. While payments are extensively reviewed by DOE, and must be authorized by the Attorney General prior to disbursement by the Department of the Treasury, as mandatory spending they are not subject to Office of Management and Budget or Congressional approval. Past payments are included in full in the budget, but the budget does not reflect full estimates of the future cost of these liabilities and does not fully reflect the potential future cost of continued insufficient action. Future budget projections would be improved by including the full cost of estimated liability payments in the baselines constructed by both CBO and OMB. If the full cost of the estimated liability payments is accurately reflected in the baseline program costs over the life of the project would eventually be offset by reductions in liabilities as the government begins to pick up sufficient waste from commercial sites. As a result, the projected long-term cost of insufficient action surpasses the cost of implementing the program in the short run.

Any new funding structure for this program will need to balance increased funding flexibility and rigorous spending oversight to help assure that the program is implemented in the most cost-effective manner possible, while still holding the MDO accountable to the President and Congress. Further, crafting the MDO funding structure will require a creative and nuanced approach to providing needed funds with involvement by the Administration and all of the appropriate committees of Congress, working together to achieve a viable solution within the current federal budget rules and procedures.

The President's fiscal year 2014 budget will include additional details regarding funding for the program of work described in this Strategy document.

ONGOING ACTIVITIES

Within DOE, the Office of Nuclear Energy's Office of Fuel Cycle Technology has initiated a planning project with the objective of pursuing activities that can be conducted within the constraints of the NWPA and will facilitate the development of an interim storage facility, of a geologic repository, and of the supporting transportation infrastructure. The activities being conducted can be transferred to a new MDO when established and will not constrain its options. This includes initiating planning for a large-scale transportation program; evaluating operational options for consolidated storage and furthering the design of a generic consolidated storage facility. The Department is also developing plans for initiating a consent-based siting process. The Department will continue with these activities and those listed below, within existing Congressional authorization, while the Administration and Congress work together on potential changes to the nuclear waste management program.

The BRC also urged the Department to evaluate options for transportation of used nuclear fuel from shut down reactors. In 2013, DOE is evaluating the inventory, transportation interface, and shipping status of used nuclear fuel at shut-down reactor sites. The Department has established cooperative agreements with state and regional groups and engaged tribal representatives to begin discussions on transportation planning and emergency response training consistent with NWPA Section 180(c). Further, the Department is considering how best to leverage the work of state and regional groups currently engaged in transportation planning and oversight of radioactive waste shipments to WIPP in New Mexico.

In FY 2013, the Department is undertaking disposal-related research and development work in the following areas: an evaluation of whether direct disposal of existing storage containers used at utility sites can be accomplished in various geologic media; an evaluation of various types and design features of back-filled engineered barriers systems and materials; evaluating geologic media for their impacts on waste isolation; evaluating thermal management options for various geologic media; establishing cooperative agreements with international programs; and developing a research and development plan for deep borehole disposal, consistent with BRC recommendations.

CONCLUSION

In this Strategy, the Administration has highlighted agreement with many of the principles of the BRC recommendations and has outlined actions that, with legislative authorization by Congress, can lead to a safe and responsible solution to managing the nation's nuclear waste. Indeed, action by Congress in the form of new authorizing legislation and appropriations is necessary for success of the waste management mission. Specifically, legislation is needed in the near term to permit or address the following activities over the next 10 years:

- Active engagement in a broad, national, consent-based process to site pilot and full-scale interim storage facilities, and site and characterize a geologic repository;
- Siting, design, licensing, and commencement of operations at a pilot-scale storage facility with an initial focus on accepting used nuclear fuel from shut-down reactor sites.;
- Significant progress on siting and licensing of a larger consolidated interim storage facility capable of providing system flexibility and an opportunity for more substantial progress in reducing government liabilities;
- Development of transportation capabilities (personnel, processes, equipment) to begin movement of fuel from shut-down reactors;
- Reformation of the funding approach in ways that preserve the necessary role for ongoing discretionary appropriations and also provide additional funds as necessary, whether from reclassified fees or from mandatory appropriation from the NWF or both; and
- Establishment of a new organization to run the program, the structure and positioning of which balance greater autonomy with the need for continued Executive and Legislative branch oversight.

This Strategy translates the BRC's report and recommendations into a set of broad steps that will ultimately benefit the entire nation. The Administration will work closely with Congress to develop a path forward that maximizes the likelihood of success. When executed, the new program will provide near-term and long-term solutions for managing the back-end of the nuclear fuel cycle, thereby resolving a longtime source of conflict in nuclear policy by providing safe, secure, and permanent disposal. Until the necessary new legislation has been enacted, the Administration will pursue components of the Strategy as described above pursuant to current law and in close coordination with Congress. Finally, in executing the program the federal government must work closely with potential host states, tribes, and communities whose engagement will be essential for successfully operating a comprehensive used nuclear fuel and high-level radioactive waste storage, transportation, and disposal system.

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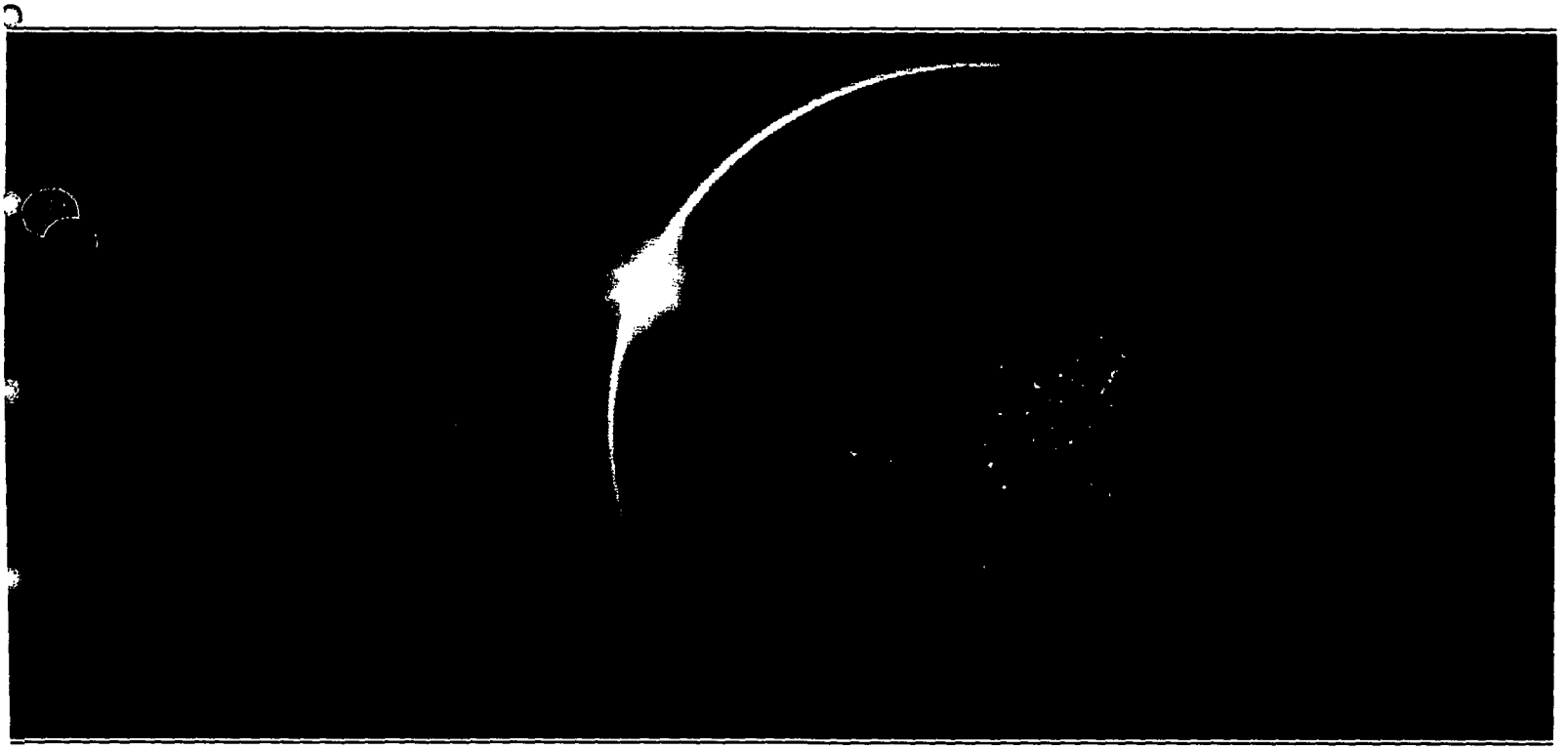
Annual Energy Outlook 2013

with Projections to 2040



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U.S. Energy Information Administration

For further information . . .

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The *AEO2013* is available on the EIA website at www.eia.gov/forecasts/aeo. Assumptions underlying the projections, tables of regional results, and other detailed results will also be available, at www.eia.gov/forecasts/aeo/assumptions. Model documentation reports for the National Energy Modeling System are available at website www.eia.gov/analysis/model-documentation.cfm and will be updated for the *AEO2013* during 2013.

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Annual Energy Outlook 2013

With Projections to 2040

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Preface

The *Annual Energy Outlook 2013 (AEO2013)*, prepared by the U.S. Energy Information Administration (EIA), presents long-term projections of energy supply, demand, and prices through 2040, based on results from EIA's National Energy Modeling System. EIA published an "early release" version of the *AEO2013* Reference case in December 2012.

The report begins with an "Executive summary" that highlights key aspects of the projections. It is followed by a "Legislation and regulations" section that discusses evolving legislative and regulatory issues, including a summary of recently enacted legislation and regulations, such as: Updated handling of the U.S. Environmental Protection Agency's (EPA) National Emissions Standards for Hazardous Air Pollutants for industrial boilers and process heaters [1]; New light-duty vehicle (LDV) greenhouse gas (GHG) and corporate average fuel economy (CAFE) standards for model years 2017 to 2025 [2]; Reinstatement of the Clean Air Interstate Rule (CAIR) [3] after the court's announcement of intent to vacate the Cross-State Air Pollution Rule (CSAPR) [4]; and Modeling of California's Assembly Bill 32, the Global Warming Solutions Act (AB 32) [5], which allows for representation of a cap-and-trade program developed as part of California's GHG reduction goals for 2020.

The "Issues in focus" section contains discussions of selected energy topics, including a discussion of the results in two cases that adopt different assumptions about the future course of existing policies, with one case assuming the elimination of sunset provisions in existing policies and the other case assuming the elimination of the sunset provisions and the extension of a selected group of existing public policies—CAFE standards, appliance standards, and production tax credits. Other discussions include: oil price and production trends in *AEO2013*; U.S. reliance on imported liquids under a range of cases; competition between coal and natural gas in electric power generation; high and low nuclear scenarios through 2040; and the impact of growth in natural gas liquids production.

The "Market trends" section summarizes the projections for energy markets. The analysis in *AEO2013* focuses primarily on a Reference case, Low and High Economic Growth cases, and Low and High Oil Price cases. Results from a number of other alternative cases also are presented, illustrating uncertainties associated with the Reference case projections for energy demand, supply, and prices. Complete tables for the five primary cases are provided in Appendixes A through C. Major results from many of the alternative cases are provided in Appendix D. Complete tables for all the alternative cases are available on EIA's website in a table browser at http://www.eia.gov/oiaf/aeo/tablebrowser.

AEO2013 projections are based generally on federal, state, and local laws and regulations in effect as of the end of September 2012. The potential impacts of pending or proposed legislation, regulations, and standards (and sections of existing legislation that require implementing regulations or funds that have not been appropriated) are not reflected in the projections. In certain situations, however, where it is clear that a law or regulation will take effect shortly after the *Annual Energy Outlook (AEO)* is completed, it may be considered in the projection.

AEO2013 is published in accordance with Section 205c of the U.S. Department of Energy (DOE) Organization Act of 1977 (Public Law 95-91), which requires the EIA Administrator to prepare annual reports on trends and projections for energy use and supply.

Projections by the U.S. Energy Information Administration (EIA) are not statements of what will happen but of what might happen, given the assumptions and methodologies used for any particular scenario. The *Annual Energy Outlook 2013 (AEO2013)* Reference case projection is a business-as-usual trend estimate, given known technology and technological and demographic trends. EIA explores the impacts of alternative assumptions in other scenarios with different macroeconomic growth rates, world oil prices, and rates of technology progress. The main cases in *AEO2013* generally assume that current laws and regulations are maintained throughout the projections. Thus, the projections provide policy-neutral baselines that can be used to analyze policy initiatives.

While energy markets are complex, energy models are simplified representations of energy production and consumption, regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development. Behavioral characteristics are indicative of real-world tendencies rather than representations of specific outcomes.

Energy market projections are subject to much uncertainty. Many of the events that shape energy markets are random and cannot be anticipated. In addition, future developments in technologies, demographics, and resources cannot be foreseen with certainty. Many key uncertainties in the *AEO2013* projections are addressed through alternative cases.

EIA has endeavored to make these projections as objective, reliable, and useful as possible; however, they should serve as an adjunct to, not a substitute for, a complete and focused analysis of public policy initiatives.

Updated *Annual Energy Outlook 2013* Reference case (April 2013)

The *AEO2013* Reference case included as part of this complete report, released in April 2013, was updated from the *AEO2012* Reference case released in June 2012. The Reference case was updated to reflect new legislation or regulation enacted since that time or to incorporate modeling changes. Major changes made in the Reference case include:

- Extension of the projection period through 2040, an additional five years beyond *AEO2012*.
- Adoption of a new Liquid Fuels Market Module (LFMM) in place of the Petroleum Market Module used in earlier *AEOs* provides for more granular and integrated modeling of petroleum refineries and all other types of current and potential future liquid fuels production technologies. This allows more direct analysis and modeling of the regional supply and demand effects involving crude oil and other feedstocks, current and future processes, and marketing to consumers.
- A shift to the use of Brent spot price as the reference oil price. *AEO2013* also presents the average West Texas Intermediate spot price of light, low-sulfur crude oil delivered in Cushing, Oklahoma, and includes the U.S. annual average refiners' acquisition cost of imported crude oil, which is more representative of the average cost of all crude oils used by domestic refiners.
- A shift from using regional natural gas wellhead prices to using representative regional natural gas spot prices as the basis of the natural gas supply price. Due to this change, the methodology for estimating the Henry Hub price was revised.
- Updated handling of data on flex-fuel vehicles (FFVs) to better reflect consumer preferences and industry response. FFVs are necessary to meet the renewable fuels standard, but the phasing out of CAFE credits for their sale and limited demand from consumers reduce their market penetration.
- A revised outlook for industrial production to reflect the impacts of increased shale gas production and lower natural gas prices, which result in faster growth for industrial production and energy consumption. The industries affected include, in particular, bulk chemicals and primary metals.
- Incorporation of a new aluminum process flow model in the industrial sector, which allows for diffusion of technologies through choices made among known commercial and emerging technologies based on relative capital costs and fuel expenditures and provides for a more realistic representation of the evolution of energy consumption than in previous *AEOs*.
- An enhanced industrial chemical model, in several respects: the baseline liquefied petroleum gas (LPG) feedstock data have been aligned with 2006 survey data; use of an updated propane-pricing mechanism that reflects natural gas price influences in order to allow for price competition between LPG feedstock and petroleum-based (naphtha) feedstock; and specific accounting in the Industrial Demand Model for propylene supplied by the LFMM.
- Updated handling of the EPA's National Emissions Standards for Hazardous Air Pollutants for industrial boilers and process heaters to address the maximum degree of emissions reduction using maximum achievable control technology. An industrial capital expenditure and fuel price adjustment for coal and residual fuel has been applied to reflect risk perception about the use of those fuels relative to natural gas.
- Augmentation of the construction and mining models in the Industrial Demand Model to better reflect *AEO2013* assumptions regarding energy efficiencies in off-road vehicles and buildings, as well as the productivity of coal, oil, and natural gas extraction.
- Adoption of final model year 2017 to 2025 GHG emissions and CAFE standards for LDVs, which increases the projected fuel economy of new LDVs to 47.3 mpg in 2025.
- Updated handling of the representation of purchase decisions for alternative fuels for heavy-duty vehicles. Market factors used to calculate the relative cost of alternative-fuel vehicles, specifically natural gas, now represent first buyer-user behavior and slightly longer breakeven payback periods, significantly increasing the demand for natural gas fuel in heavy trucks.
- Updated modeling of LNG export potential, which includes a rudimentary assessment of pricing of natural gas in international markets.
- Updated power generation unit costs that capture recent cost declines for some renewable technologies, which tend to lead to greater use of renewable generation, particularly solar technologies.
- Reinstatement of CAIR after the court's announcement of intent to vacate CSAPR.
- Modeling of California's AB 32, that allows for representation of a cap-and-trade program developed as part of California's GHG reduction goals for 2020. The coordinated regulations include an enforceable GHG cap that will decline over time. *AEO2013* reflects all covered sectors, including emissions offsets and allowance allocations.
- Incorporation of the California Low Carbon Fuel Standard, which requires fuel producers and importers who sell motor gasoline or diesel fuel in California to reduce the carbon intensity of those fuels by 10 percent between 2012 and 2020 through the increased sale of alternative low-carbon fuels.

Future analyses using the *AEO2013* Reference case will start from the version of the Reference case released with this complete report.

Endnotes for Preface

Links current as of March 2013

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5. California Legislative Information, "Assembly Bill No. 32: California Global Warming Solutions Act of 2006" (Sacramento, CA: September 27, 2006), http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf.

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Appendixes

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Executive summary

The projections in the U.S. Energy Information Administration's *Annual Energy Outlook 2013 (AEO2013)* focus on the factors that shape the U.S. energy system over the long term. Under the assumption that current laws and regulations remain unchanged throughout the projections, the *AEO2013* Reference case provides a basis for examination and discussion of energy production, consumption, technology, and market trends and the direction they may take in the future. *AEO2013* also includes alternative cases (see Appendix E, Table E1), which explore important areas of uncertainty for markets, technologies, and policies in the U.S. energy economy. Many of the implications of the alternative cases are discussed in the Issues in focus section of *AEO2013*.

Key results highlighted in the *AEO2013* Reference and alternative cases include:

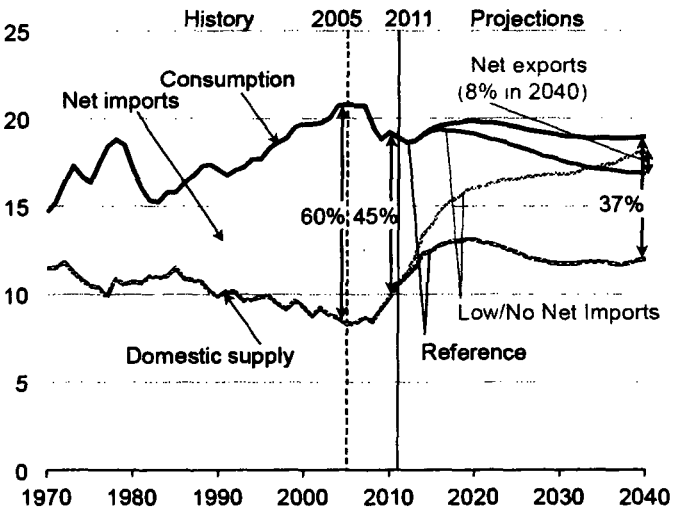
- Continued strong growth in domestic crude oil production over the next decade—largely as a result of rising production from tight formations—and increased domestic production of natural gas;
- The potential for even stronger growth in domestic crude oil production under alternative conditions;
- Evolving natural gas markets that spur increased use of natural gas for electric power generation and transportation and an expanding natural gas export market;
- A decline in motor gasoline consumption over the projection period, reflecting the effects of more stringent corporate average fuel economy (CAFE) standards, as well as growth in diesel fuel consumption and increased use of natural gas to power heavy-duty vehicles; and
- Low electricity demand growth, and continued increases in electricity generation capacity fueled by natural gas and renewable energy, which when combined with environmental regulations put pressure on coal use in the electric power sector. In some cases, coal's share of total electricity generation falls below the natural gas share through the end of the projection period.

Oil production, particularly from tight oil plays, rises over the next decade, leading to a reduction in net import dependence

Crude oil production has increased since 2008, reversing a decline that began in 1986. From 5.0 million barrels per day in 2008, U.S. crude oil production increased to 6.5 million barrels per day in 2012. Improvements in advanced crude oil production technologies continues to lift domestic supply, with domestic production of crude oil increasing in the Reference case before declining gradually beginning in 2020 for the remainder of the projection period. The projected growth results largely from a significant increase in onshore crude oil production, particularly from shale and other tight formations, which has been spurred by technological advances and relatively high oil prices. Tight oil development is still at an early stage, and the outlook is highly uncertain. In some of the *AEO2013* alternative cases, tight oil production and total U.S. crude oil production are significantly above their levels in the Reference case.

The net import share of U.S. petroleum and other liquids consumption (including crude oil, petroleum liquids, and liquids derived from nonpetroleum sources) grew steadily from the mid-1980s to 2005 but has fallen in every year since then (Figure 1). In the Reference case, U.S. net imports of petroleum and other liquids decline through 2019, while still providing approximately one-third of total U.S. supply. The net import share of U.S. petroleum and other liquids consumption continues to decline in the Reference case, falling to 34 percent in 2019 before increasing to 37 percent in 2040.

Figure 1. Net import share of U.S. liquids supply in two cases, 1970-2040 (million barrels per day)



The U.S. could become a net exporter of liquid fuels under certain conditions. An article in the Issues in focus section considers four cases that examine the impacts of various assumptions about U.S. dependence on imported liquids. Two cases (Low Oil and Gas Resource and High Oil and Gas Resource) vary only the supply assumptions, and two cases (Low/No Net Imports and High Net Imports) vary both the supply and demand assumptions. The different assumptions in the four cases generate wide variation from the liquid fuels import dependence values in the *AEO2013* Reference case. In the Low/No Net Imports case, the United States ends its reliance on net imports of liquid fuels in the mid-2030s, with net exports rising to 8 percent of total U.S. liquid fuel production in 2040. In contrast, in the High Net Imports case, net petroleum import dependence is above 44 percent in 2040, which is higher than the Reference case level of 37 percent but still well below the 2005 level of 60 percent.

While other combinations of assumptions or unforeseen technology breakthroughs might produce a comparable outcome, the assumptions in the Low/No Imports case illustrate the magnitude and type of changes that would be

required for the United States to end its reliance on net imports of liquid fuels, which began after World War II and has continued to the present day. Some of the assumptions in the Low/No Net Imports case, such as increased fuel economy for light-duty vehicles (LDVs) after 2025 and wider access to offshore resources, could be influenced by possible future energy policies. However, other assumptions in this case, such as the greater availability of onshore technically recoverable oil and natural gas resources, depend on geological outcomes that cannot be influenced by policy measures. In addition, economic trends, consumer preferences and behaviors, and technological factors also may be unaffected, or only modestly affected, by policy measures.

In the High Oil and Gas Resource case, changes due to the supply assumptions alone cause net import dependence to decline to 7 percent in 2040, with U.S. crude oil production rising to 10.2 million barrels per day in 2040, or 4.1 million barrels per day above the Reference case level. Tight oil production accounts for more than 77 percent (or 3.2 million barrels per day) of the difference in production between the two cases. Production of natural gas plant liquids in the United States also exceeds the Reference case level.

One of the most uncertain aspects of this analysis is the potential effect of different scenarios on the global market for liquid fuels, which is highly integrated. Strategic choices made by leading oil-exporting countries could result in U.S. price and quantity changes that differ significantly from those presented here. Moreover, regardless of how much the United States reduces its reliance on imported liquids, consumer prices will not be insulated from global oil prices if current policies and regulations remain in effect and world markets for delivery continue to be competitive.

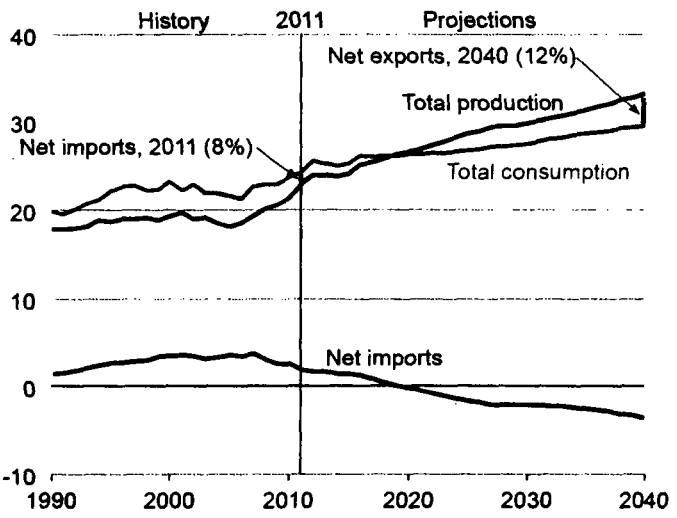
The United States becomes a net exporter of natural gas

U.S. dry natural gas production increases 1.3 percent per year throughout the Reference case projection, outpacing domestic consumption by 2019 and spurring net exports of natural gas (Figure 2). Higher volumes of shale gas production are central to higher total production volumes and a transition to net exports. As domestic supply has increased in recent years, natural gas prices have declined, making the United States a less attractive market for imported natural gas and more attractive for export.

U.S. net exports of natural gas grow to 3.6 trillion cubic feet in 2040 in the Reference case. Most of the projected growth in U.S. exports consists of pipeline exports to Mexico, which increase steadily as growing volumes of imported natural gas from the United States fill the widening gap between Mexico's production and consumption. Declining natural gas imports from Canada also contribute to the growth in U.S. net exports. Net U.S. imports of natural gas from Canada decline sharply from 2016 to 2022, then stabilize somewhat before dropping off again in the final years of the projection, as continued growth in domestic production mitigates the need for imports.

Continued low levels of liquefied natural gas (LNG) imports in the projection period, combined with increased U.S. exports of domestically sourced LNG, position the United States as a net exporter of LNG by 2016. U.S. exports of domestically sourced LNG (excluding exports from the existing Kenai facility in Alaska) begin in 2016 and rise to a level of 1.6 trillion cubic feet per year in 2027. One-half of the U.S. exports of LNG originate from the Lower 48 states and the other half from Alaska. The prospects for exports are highly uncertain, however, depending on many factors that are difficult to gauge, such as the development of new production capacity in foreign countries, particularly from deepwater reservoirs, shale gas deposits, and the Arctic. In addition, future U.S. exports of LNG depend on a number of other factors, including the speed and extent of price convergence in global natural gas markets and the extent to which natural gas competes with liquids in domestic and international markets.

Figure 2. Total U.S. natural gas production, consumption, and net imports in the Reference case, 1990-2040 (trillion cubic feet)



In the High Oil and Gas Resource case, with more optimistic resource assumptions, U.S. LNG exports grow to more than 4 trillion cubic feet in 2040. Most of the additional exports originate from the Lower 48 states.

Coal's share of electric power generation falls over the projection period

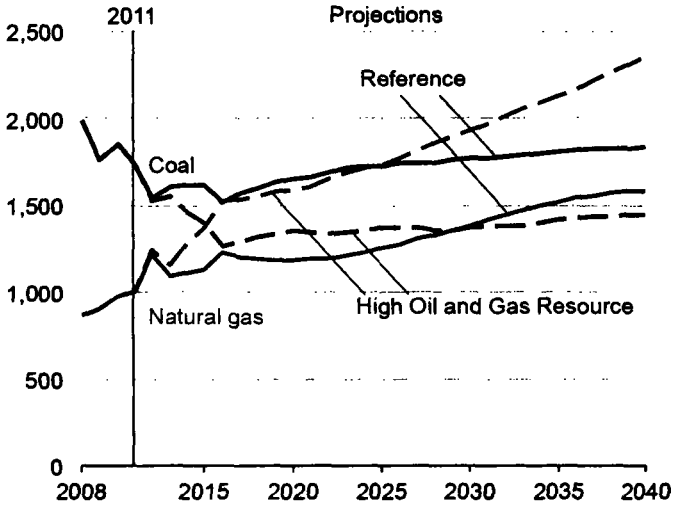
Although coal is expected to continue its important role in U.S. electricity generation, there are many uncertainties that could affect future outcomes. Chief among them are the relationship between coal and natural gas prices and the potential for policies aimed at reducing greenhouse gas (GHG) emissions. In 2012, natural gas prices were low enough for a few months for power companies to run natural gas-fired generation plants more economically than coal plants in many areas. During those months, coal and natural gas were nearly tied in providing the largest share of total electricity generation, something that had never happened before. In the Reference case, existing coal plants recapture some of the market they recently lost to natural gas plants because natural gas prices

rise more rapidly than coal prices. However, the rise in coal-fired generation is not sufficient for coal to maintain its generation share, which falls to 35 percent by 2040 as the share of generation from natural gas rises to 30 percent.

In the alternative High Oil and Natural Gas Resource case, with much lower natural gas prices, natural gas supplants coal as the top source of electricity generation (Figure 3). In this case, coal accounts for only 27 percent of total generation in 2040, while natural gas accounts for 43 percent. However, while natural gas generation in the power sector surpasses coal generation in 2016 in this case, more coal energy than natural gas energy is used for power generation until 2035 because of the higher average thermal efficiency of the natural gas-fired generating units. Coal use for electric power generation falls to 14.7 quadrillion Btu in 2040 in the High Oil and Natural Gas Resource case (compared with 18.7 quadrillion Btu in the Reference case), while natural gas use rises to 15.1 quadrillion Btu in the same year (Figure 4). Natural gas use for electricity generation is 9.7 quadrillion Btu in 2040 in the Reference case.

Coal's generation share and the associated carbon dioxide (CO_2) emissions could be further reduced if policies aimed at reducing GHG emissions were enacted (Figure 5). For example, in the GHG15 case, which assumes a fee on CO_2 emissions that starts at $15 per metric ton in 2014 and increases by 5 percent per year through 2040, coal's share of total generation falls to 13 percent in 2040. Energy-related CO_2 emissions also fall sharply in the GHG15 case, to levels that are 10 percent, 15 percent, and 24 percent lower than projected in the Reference case in 2020, 2030, and 2040, respectively. In 2040, energy-related CO_2 emissions in the GHG15 case are 28 percent lower than the 2005 total. In the GHG15 case, coal use in the electric power sector falls to only 6.1 quadrillion Btu in 2040, a decline of about two-thirds from the 2011 level. While natural gas use in the electric power sector initially displaces coal use in this case, reaching more than 10 quadrillion Btu in 2016, it falls to 8.8 quadrillion Btu in 2040 as growth in renewable and nuclear generation offsets natural gas use later in the projection period.

Figure 3. Electricity generation from coal and natural gas in two cases, 2008-2040 (billion kilowatthours)



With more efficient light-duty vehicles, motor gasoline consumption declines while diesel fuel use grows, even as more natural gas is used in heavy-duty vehicles

The *AEO2013* Reference case incorporates the GHG and CAFE standards for LDVs [6] through the 2025 model year. The increase in vehicle efficiency reduces LDV energy use from 16.1 quadrillion Btu in 2011 to 14.0 quadrillion Btu in 2025, predominantly motor gasoline (Figure 6). LDV energy use continues to decline through 2036, then levels off until 2039 as growth in population and vehicle miles traveled offsets more modest improvement in fuel efficiency.

Figure 4. Coal and natural gas use in the electric power sector in three cases, 2011, 2025, and 2040 (quadrillion Btu)

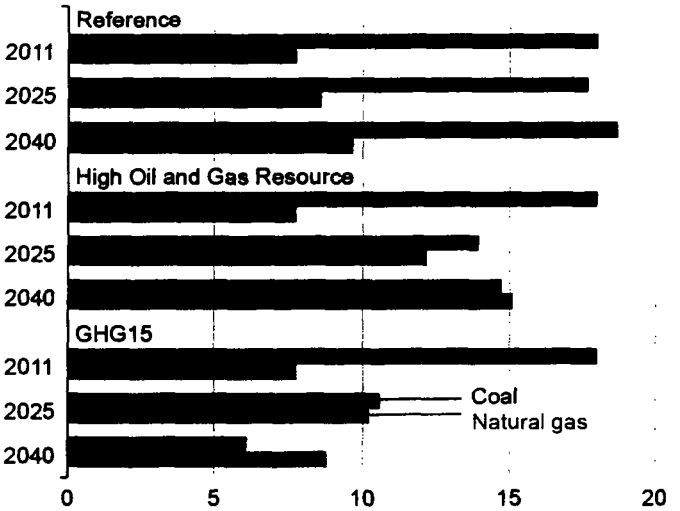
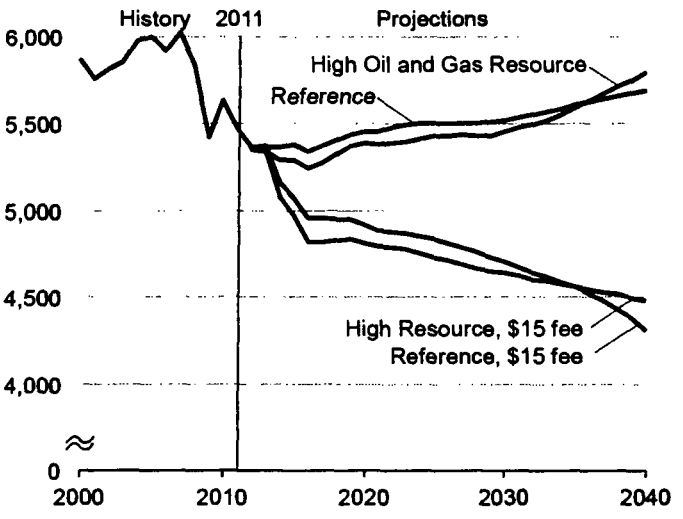


Figure 5. Energy-related carbon dioxide emissions in four cases, 2000-2040 (million metric tons)



Furthermore, the improved economics of natural gas as a fuel for heavy-duty vehicles result in increased use that offsets a portion of diesel fuel consumption. The use of petroleum-based diesel fuel is also reduced by growing consumption of diesel produced with gas-to-liquids (GTL) technology. Natural gas use in vehicles (including natural gas used in the production of GTL) totals 1.4 trillion cubic feet in 2040 in the Reference case, displacing 0.7 million barrels per day of other motor fuels [7]. Diesel fuel use nonetheless increases at a relatively strong rate, with freight travel demand supported by increasing industrial production.

Natural gas consumption grows in industrial and electric power sectors as domestic production also serves an expanding export market

Relatively low natural gas prices, maintained by growing shale gas production, spur increased use in the industrial and electric power sectors, particularly over the next decade. In the Reference case, natural gas use in the industrial sector increases by 16 percent, from 6.8 trillion cubic feet per year in 2011 to 7.8 trillion cubic feet per year in 2025. After 2025, the growth of natural gas consumption in the industrial sector slows, while total U.S. consumption continues to grow (Figure 7). This additional growth is mostly for use in the electric power sector. Although natural gas continues to capture a growing share of total electricity generation, natural gas consumption by power plants does not increase as sharply as generation because new plants are very efficient (needing less fuel per unit of power output). The natural gas share of generation rose from 16 percent of generation in 2000 to 24 percent in 2011 and increases to 27 percent in 2025 and 30 percent in 2040. Natural gas use in the residential and commercial sectors remains nearly constant, as increasing end-use demand is balanced by increasing end-use efficiency.

Natural gas consumption also grows in other markets in the Reference case, including heavy-duty freight transportation (trucking) and as a feedstock for GTL production of diesel and other fuels. Those uses account for 6 percent of total U.S. natural gas consumption in 2040, as compared with almost nothing in 2011.

Natural gas use in the electric power sector grows even more sharply in the High Oil and Natural Gas Resource case, as the natural gas share of electricity generation grows to 39 percent, reaching 14.8 trillion cubic feet in 2040, more than 55 percent greater than in the Reference case. Industrial sector natural gas consumption growth is also stronger in this case, with growth continuing after 2025 and reaching 13.0 trillion cubic feet in 2040 (compared to 10.5 trillion cubic feet in 2040 in the Reference case). Much of the industrial growth in the High Oil and Natural Gas Resource case is associated with natural gas use for GTL production and increased lease and plant use in natural gas production.

Renewable fuel use grows at a faster rate than fossil fuel use

The share of U.S. electricity generation from renewable energy grows from 13 percent in 2011 to 16 percent in 2040 in the Reference case. Electricity generation from solar and, to a lesser extent, wind energy sources grows as their costs decline, making them more economical in the later years of the projection. However, the rate of growth in renewable electricity generation is sensitive to several factors, including natural gas prices and the possible implementation of policies to reduce GHG emissions. If future natural gas prices are lower than projected in the Reference case, as illustrated in the High Oil and Gas Resource case, the share of renewable generation would grow more slowly, to only 14 percent in 2040. Alternatively, if broad-based policies to reduce GHG emissions were enacted, renewable generation would be expected to grow more rapidly. In three cases that assume GHG emissions fees that range from $10 to $25 per metric ton in 2014 and rise by 5 percent per year through 2040 (GHG10, GHG15, and GHG25), the

Figure 6. Transportation energy consumption by fuel, 1990-2040 (quadrillion Btu)

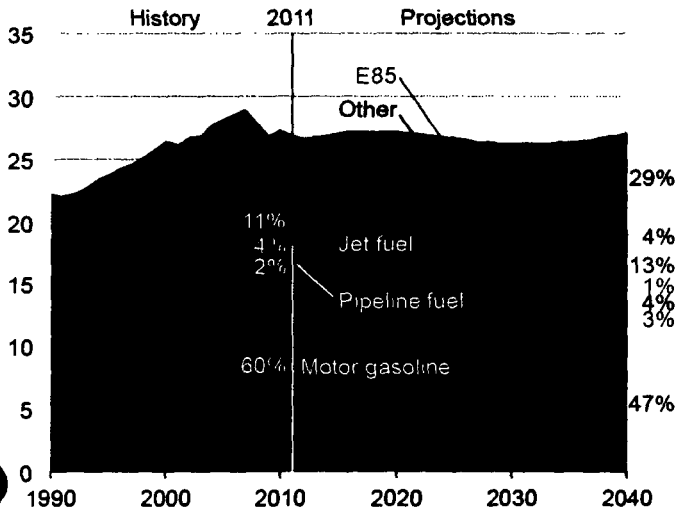


Figure 7. U.S. dry natural gas consumption by sector, 2005-2040 (trillion cubic feet)

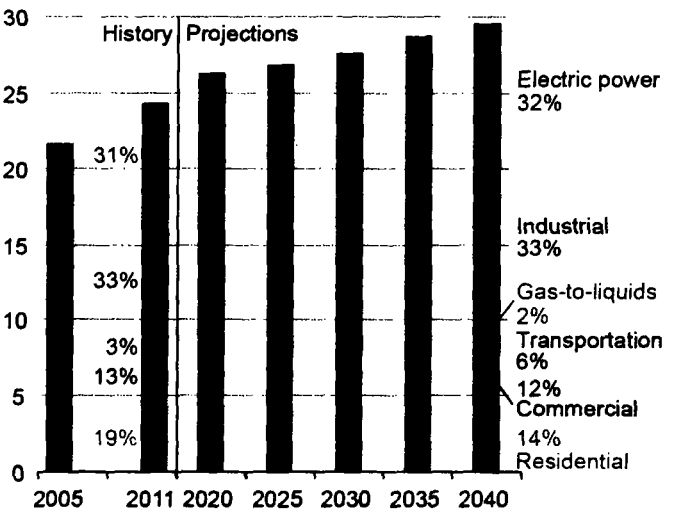
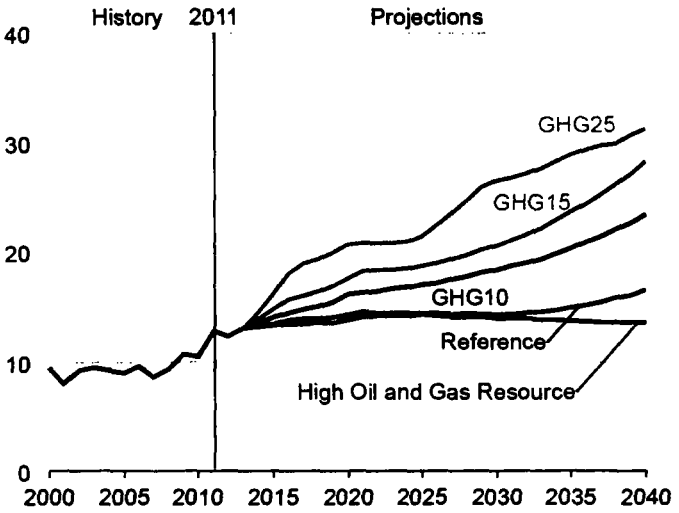


Figure 8. Renewable energy share of U.S. electricity generation in five cases, 2000-2040 (percent)



renewable share of total U.S. electricity generation in 2040 ranges from 23 percent to 31 percent (Figure 8).

The *AEO2013* Reference case reflects a less optimistic outlook for advanced biofuels to capture a rapidly growing share of the liquid fuels market than earlier *Annual Energy Outlooks*. As a result, biomass use in the Reference case totals 5.9 quadrillion Btu in 2035 and 7.1 quadrillion Btu in 2040, up from 4.0 quadrillion Btu in 2011.

Endnotes for Executive summary

Links current as of March 2013

6. U.S. Environmental Protection Agency and National Highway Traffic Safety Administration, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," *Federal Register*, Vol. 77, No. 199 (Washington, DC: October 15, 2012), https://www.federalregister.gov/articles/2012/10/15/2012-21972/2017-and-later-model-year-light-duty-vehicle-greenhouse-gas-emissions-and-corporate-average-fuel.
7. Liquid motor fuels include diesel and liquid fuels from gas-to-liquids (GTL) processes. Liquid fuel volumes from GTL for motor vehicle use are estimated based on the ratio of onroad diesel and gasoline to total diesel and gasoline.

In the High Coal Cost case, only a limited amount of shifting from coal to natural gas occurs in this region, which has a large amount of existing coal-fired capacity and access to multiple sources of coal, including western basins as well as the Illinois and Appalachian basins. Higher transportation rates in this case deter the use of Western coal in favor of more locally sourced Interior and Appalachian coal. The ability to switch coal sources to moderate fuel expenditures reduces the economic incentive to build new NGCC plants, even with coal prices that are higher than those in the Reference case. The NGCC share of the region's total capacity does increase in the High Oil and Gas Resource case relative to the Reference case, to 16 percent in 2040. In all the cases, however, coal-fired generating capacity makes up more than 42 percent of the total in 2040.

The different capacity factors of coal-fired steam turbines and NGCC capacity contribute to a shift in the generation fuel shares, but the lower levels of natural gas-fired capacity in the region limit the impacts relative to those seen in the Southeast. The natural gas share of total generation in the region grows from 6 percent in 2011 to 8 percent in 2040 in the Reference case, 10 percent in 2040 in the High Coal Cost case, and 18 percent in 2040 the High Oil and Gas Resource case. Coal's share of the region's electric power sector generation declines from 66 percent in 2011 to 64 percent in 2040 in the Reference case, and to 54 percent in both the High Coal Cost case and the High Oil and Gas Resource case. In the High Coal Cost case, much of the coal-fired generation is replaced with biomass co-firing rather than natural gas, because without the lower natural gas prices in the High Oil and Gas Resource case, it is more economical to use biomass in existing coal-fired units than to build and operate new natural gas-fired generators.

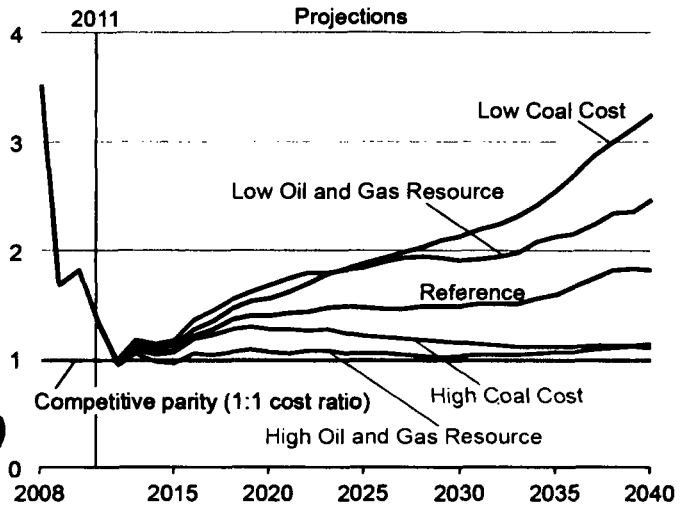
Other factors affecting competition

In addition to relative fuel prices, a number of factors influence the competition between coal-fired steam turbines and natural gas-fired combined-cycle units. One factor in the dispatch-level competition is the availability of capacity of each type. In New England, for example, competition between coal and natural gas is not discussed, because very little coal-fired capacity exists or is projected to be built in that region, even in the *AEO2013* alternative fuel price cases. New England is located far from coal sources, and a regional cap on GHG emissions is in place, which makes investment in new coal-fired capacity unlikely. In the southeastern United States, however, there is more balance between natural gas-fired and coal-fired generating resources.

Further limitations not discussed above include:

- **Start-up and shutdown costs.** In general, combined-cycle units are considered to be more flexible than steam turbines. They can ramp their output up and down more easily, and their start-up and shutdown procedures involve less time and expense. However, plants that are operated more flexibly (i.e., ramping up and down and cycling on and off) often have higher maintenance requirements and higher maintenance costs.
- **Emission rates and allowance costs.** Another component of operating costs not mentioned above is the cost of buying emissions allowances for plants covered by the Acid Rain Program and Clean Air Interstate Rule. In recent years, allowance prices have dropped to levels that make them essentially negligible, although for many years they were a significant component of operating costs.
- **Transmission constraints on the electricity grid and other reliability requirements.** Certain plants, often referred to as reliability must-run plants, are located in geographic areas where they are required to operate whenever they are available. In other cases, transmission limitations on the grid at any given time may determine maximum output levels for some plants.

Figure 34. Ratio of average per megawatthour fuel costs for natural gas combined-cycle plants to coal-fired steam turbines in the RFC west subregion in five cases, 2008-2040



5. Nuclear power in *AEO2013*

In 2011, approximately 19 percent of the nation's electricity was generated by 104 operating commercial nuclear reactors, totaling 101 gigawatts of capacity. In the *AEO2013* Reference case, annual generation from nuclear power grows by 14.3 percent from the 2011 total to 903 gigawatthours in 2040. However, the nuclear share of the overall generation mix declines to 17 percent as growth in nuclear generation is outpaced by the increases in generation from natural gas and renewables. The Reference case projects the addition of 19 gigawatts of nuclear capacity from 2011 to 2040, in comparison with the addition of 215 gigawatts of natural gas capacity and 104 gigawatts of renewable capacity.

Nuclear capacity is added both through power uprates at existing nuclear power plants and through new builds. Uprates at existing plants account for 8.0 gigawatts of nuclear capacity additions in the Reference case and new construction adds 11.0 gigawatts of capacity over the projection period. About 5.5 gigawatts of new capacity results from Watts Bar Unit 2, Summer Units 2 and 3, and Vogtle Units 3 and 4, all of which are projected to be online by 2020. The *AEO2013* Reference

case includes the retirement of 0.6 gigawatts at Oyster Creek in 2019, as well as retirements of an additional 6.5 gigawatts of capacity toward the end of the projection. *AEO2013* also includes several alternative cases that examine the impacts of different assumptions about the long-term operation of existing nuclear power plants, new builds, deployment of new technologies, and the impacts on electricity markets of different assumptions about future nuclear capacity.

Uprates

Power uprates increase the licensed capacity of existing nuclear power plants and enable those plants to generate more electricity [*83*]. The U.S. Nuclear Regulatory Commission (NRC) must approve all uprate projects before they are undertaken and verify that the reactors will still be able to operate safely at the proposed higher levels of output. Power uprates can increase plant capacity by up to 20 percent of the original licensed capacity, depending on the magnitude and type of uprate project. Capital expenditures may be small (e.g., installing a more accurate sensor) or significant (e.g., replacing key plant components, such as turbines).

EIA relied on both reported data and estimates to define the uprates included in *AEO2013*. Reported data comes from the Form EIA-860 [*84*], which requires all nuclear power plant owners to report plans to build new plants or make modifications (such as an uprate) to existing plants within the next 10 years. In 2011, nuclear power plants reported plans to complete a total of 1.5 gigawatts of uprate projects over the next 10 years.

In addition to the reported uprates, EIA included an additional 6.5 gigawatts of uprates over the projection period. The inclusion of potential uprate capacity is based on interactions with EIA stakeholders who have significant experience in implementing power plant uprates.

New Builds

Building a new nuclear power plant is a complex operation that can take more than a decade to complete. Projects generally require specialized high-wage workers, expensive materials and components, and engineering construction expertise, which can be provided by only a select group of firms worldwide. In the current economic environment of low natural gas prices and flat demand for electricity, the overall market conditions for new nuclear plants are challenging.

Nuclear power plants are among the most expensive options for new electric generating capacity [*85*]. The *AEO2013* Reference case assumes that the overnight capital costs (the cost before interest) associated with building a nuclear power plant in 2012 were $5,429 (2011 dollars) per kilowatt, which translates to almost $12 billion for a dual-unit 2,200-megawatt power plant. The estimate does not include such additional costs as financing, interest carried forward, and peripheral infrastructure updates [*86*]. Despite its cost, deployment of new nuclear capacity supports the long-term resource plans of many utilities by allowing fuel diversification and by providing a hedge against potential future GHG regulations or higher natural gas prices.

Incentive programs encourage the construction of new reactors in the United States. At the federal level, the Energy Policy Act of 2005 (EPACT2005) established a Loan Guarantee Program for new nuclear plants that are completed and operational by 2020 [*87*]. A total of $18.5 billion is available, of which $8.3 billion has been conditionally committed to the construction of Southern Company's Vogtle Units 3 and 4 [*88*]. EPACT2005 also provided a PTC of $18 per megawatt hour for electricity produced during the first 8 years of plant operation [*89*]. To be eligible for this credit, new nuclear plants must be operational by 2021, and the credit is limited to the first 6 gigawatts of new nuclear capacity. In addition to federal incentives, several states provide a favorable regulatory environment for new nuclear plants by allowing plant owners to recover their investments through retail electricity rates.

In addition to reported plans to build new nuclear power plants, another 5.5 gigawatts of unplanned capacity is built in the later years of the Reference case projection. Higher natural gas prices, growth in electricity demand, and the need to displace retired nuclear and coal-fired capacity all play a role in the growth at the end of the projection period in the Reference case.

Retirements

NRC has the authority to issue initial operating licenses for commercial nuclear power plants for a period of 40 years. Decisions to apply for operating license renewals are made entirely by nuclear power plant owners, and typically they are based on economics and the ability to meet NRC requirements.

In April 2012, Oyster Creek Unit 1 became the first commercial nuclear reactor to have operated for 40 years, followed by Nine Mile Point Unit 1 in August, R. E. Ginna in September, and Dresden Unit 2 in December 2012. Two additional plants, H.B. Robinson Unit 2 and Point Beach Unit 1, will complete 40 years of operation in 2013. As of December 2012, the NRC had granted license renewals to 72 of the 104 operating U.S. reactors, allowing them to operate for a total of 60 years. Currently, the NRC is reviewing license renewal applications for 13 reactors, and 15 more applications for license renewals are expected between 2013 and 2019.

NRC regulations do not limit the number of license renewals a nuclear power plant may be granted. The nuclear power industry is preparing applications for license renewals that would allow continued operation beyond 60 years. The first such application, for permission to operate a commercial reactor for a total of 80 years is tentatively scheduled to be submitted in 2015. Aging plants may face a variety of issues that could lead to a decision not to apply for a second license renewal, including both economic and regulatory issues—such as increased operation and maintenance (O&M) costs and capital expenditures to meet NRC requirements. Industry research is focused on identifying challenges that aging facilities might encounter and formulating potential

approaches to meet those challenges [90, 91]. Typical challenges involve degradation of structural materials, maintaining safety margins, and assessing the structural integrity of concrete [92].

The outcome of pending research and market developments will be important to future decisions regarding life extensions beyond 60 years. The *AEO2013* Reference case assumes that the operating lives of most of the existing U.S. nuclear power plants will be extended at least through 2040. The only planned retirement included in the Reference case is the announced early retirement of the Oyster Creek nuclear power station in 2019, as reported on Form EIA-860. The Reference case also assumes an additional 7.1 gigawatts of nuclear power capacity retirements by 2040, representing about 7 percent of the current fleet. These generic retirements reflect uncertainty related to issues associated with long-term operations and age management.

In March 2012, the NRC issued three orders [93] that require nuclear power plants to implement requirements related to lessons learned from the accident at Japan's Fukushima Daiichi nuclear power plant in March 2011. Compliance assessments are underway currently at U.S. nuclear power plants. The requirements of the orders must be implemented by December 2016 and will remain in place until they are superseded by rulemaking. Given the evolving nature of NRC's regulatory response to the accident at Fukushima Daiichi, the Reference case does not include any retirements that could result from new NRC requirements that may involve plant modifications to meet such requirements.

Small Modular Reactors

Small Modular Reactor (SMR) technology differs from traditional, large-scale light-water reactor technology in both reactor size and plant scalability. SMRs are typically smaller than 300 megawatts and can be built in modular arrangements. Traditional reactors are generally 1,000 megawatts or larger. The initial estimates for scalable SMRs range from 45 to 225 megawatts. SMRs are small enough to be fabricated in factories and can be shipped to sites via barge, rail, or truck. Those factors may reduce both capital costs and construction times. Smaller SMRs offer utilities the flexibility to scale nuclear power production as demand changes.

The actual construction of a large nuclear power plant can take up to a decade. During construction, the plant owner may incur significant interest costs and risk further cost increases because of delays and cost overruns. SMRs have the potential to mitigate some of the risks, based on their projected construction period of 3 years. Moody's credit rating agency has described large nuclear power plants as bet-the-farm endeavors for most companies, given the size of the investment and length of time needed to build a nuclear power facility [94], as highlighted by comparisons of the costs of building nuclear power plants with the overall sizes of the companies building them. *AEO2013* assumes that the overnight cost of a 2,200-megawatt nuclear power plant is approximately $12 billion, which is a significant share of the market capitalization of some of the nation's largest electric power companies. For example, the largest publicly traded company that owns nuclear power plants in the United States has a market capitalization of about $50 billion [95].

Although SMRs may offer several potential advantages, there are key issues that remain to be resolved. SMRs are not yet licensed by the NRC. While there are many similarities between SMRs and traditional large reactors, there are several key differences identified by the NRC that will need to be reviewed before a design certification is issued. Until the situation is clarified, there will be substantial uncertainty about the final costs of SMRs. In addition, the NRC must develop a regulatory infrastructure to support licensing review of the SMR designs. The NRC has identified several potential policy and technical issues associated with SMR licensing [96]. In August 2012, the NRC provided a report to Congress that addressed the licensing of reactors, including SMRs [97, 98].

Ultimately, the path to commercialization for SMRs is to develop the infrastructure to manufacture the modules in factories and then ship the completed units to plant sites. Performing a majority of the construction in factories could standardize the assembly process and result in cost savings, as has occurred with U.S. Navy shipbuilding, where construction cost savings have been achieved by centralizing much of the production in a controlled factory setting [99].

In March 2012, DOE announced its intention to provide $450 million in funding to assist in the initial development of SMR technology [100]. Through cost-sharing agreements with private industry, DOE solicited proposals for promising SMR projects that have the potential to be licensed by the NRC and achieve commercial operation by 2022. In November 2012, DOE announced the selection of Babcock & Wilcox [101], in partnership with the Tennessee Valley Authority (TVA) and Bechtel International, to share the costs of preparing a license application for up to four SMRs at TVA's Clinch River site in Oak Ridge, Tennessee.

Alternative nuclear cases

In the *AEO2013* Low Nuclear case, uprates currently under review by, or expected to be submitted to, the NRC are not included unless they have been reported to EIA. No nuclear power plants are assumed to receive second license renewals in the Low Nuclear case; all plants are assumed to retire after roughly 60 years of operation, except for those specifically discussed below. Other than the 5.5 gigawatts of new capacity already planned, no new nuclear power plants are assumed to be built.

In addition to the retirement of Oyster Creek in 2019, the Low Nuclear case includes the retirement of Kewaunee in 2013. Nuclear power plants that are in long-term shutdown also are assumed to be retired, including San Onofre Nuclear Generating Station (SONGS) Unit 3 and Crystal River Unit 3. Both plants have been in extended shutdown for more than a year, and there is substantial uncertainty about the cost and feasibility of operating the facilities in the future. Southern California Edison is assessing the long-term viability of SONGS Unit 3 and has indicated that it will not be operating for some time, in light of ongoing steam generator

issues [*102, 103, 104*]. Crystal River Unit 3 has been offline since September 2009, as a result of cracks in the containment structure. As of October 2012, replacement power costs and the repairs to Unit 3 were initially estimated to be between $1.3 and $3.5 billion. However, repairs could eventually include replacement of the entire containment structure. Further repairs to Crystal River Unit 3 are being evaluated [*105, 106*]. In the Reference and High Nuclear cases, SONGS Unit 3 and Crystal River Unit 3 are assumed to return to service when maintenance and repairs have been completed.

The High Nuclear case assumes that all existing nuclear power plants receive their second license renewals and operate through 2040. Uprates in the High Nuclear case are consistent with those in the Reference case (8.0 gigawatts added by 2025). In addition to plants already under construction, the High Nuclear case assumes that nuclear power plants with active license applications at the NRC are constructed, provided that they have a tentatively scheduled Atomic Safety and Licensing Board hearing and will deploy a certified Nuclear Steam Supply System design. This assumption results in the planned addition of 13.3 gigawatts of new nuclear capacity, which is 7.8 gigawatts above what is assumed in the Reference case.

In the High Nuclear case, planned capacity additions are more than double those in the Reference case, but unplanned additions do not change noticeably. The additional planned capacity reduces the need for new unplanned capacity. The importance of natural gas prices for nuclear power plant construction is highlighted in the results of the Low Oil and Gas Resource case, where the average price of natural gas delivered to the electric power sector in 2040 is 26 percent higher than in the Reference case. The higher natural gas prices make nuclear power a more competitive source for new generating capacity, resulting in the addition of 26 gigawatts of unplanned nuclear power capacity from 2011 to 2040. In the High Oil and Gas Resource case, where the average price of natural gas delivered to the electric power sector in 2040 is 39 percent lower than in the Reference case, no unplanned nuclear capacity is built. Similarly, no unplanned nuclear capacity is added in the Low Nuclear case (Figure 35).

The Small Modular Reactor case assumes that SMRs will be the nuclear technology choice available after 2025, rather than traditional gigawatt-scale nuclear power plants. There is uncertainty surrounding SMR design certification and supply chain and infrastructure development, which makes it difficult to develop capital cost assumptions for SMRs. The Small Modular Reactor case assumes that SMRs have the same overnight capital costs per kilowatt as a traditional 1,100-megawatt unit, consistent with cost assumptions in the Reference case. This assumption was made for the purpose of assessing the impact on the amount of new nuclear capacity of a shorter construction period for SMRs than for traditional nuclear power plants.

In the High Nuclear case, nuclear generation in 2040 is 12 percent higher than in the Reference case, and the nuclear share of total generation is 19 percent, compared with 17 percent in the Reference case. The increase in nuclear generation offsets a decline in generation from natural gas (Figure 36) and renewable fuels, which are 5 percent and 2 percent lower in 2040, respectively, than in the Reference case. Coal-fired generation in the High Nuclear case is virtually the same as in the Reference case.

In the Low Nuclear case, generation from nuclear power in 2040 is 44 percent lower than in the Reference case, due to the loss of 45.4 gigawatts of nuclear capacity that is retired after 60 years of operation. As a result, the nuclear share of total generation falls to 10 percent in 2040. The loss of generation is made up primarily by increased generation from natural gas, which is 17 percent higher in the Low Nuclear case than in the Reference case in 2040. Generation from coal and generation from renewables in 2040 both are 2 percent higher than projected in the Reference case.

CO_2 emissions from the electric power sector are affected by the share of nuclear power in the generation mix. Unlike coal- and natural gas-fired plants, nuclear power plants do not emit CO_2. Consequently, CO_2 emissions from the electric power sector in 2040 are 5 percent lower in the Reference case than in the Low Nuclear case, as a result of switching from nuclear generation to

Figure 35. Nuclear capacity additions in five cases, 2011-2040 (gigawatts)

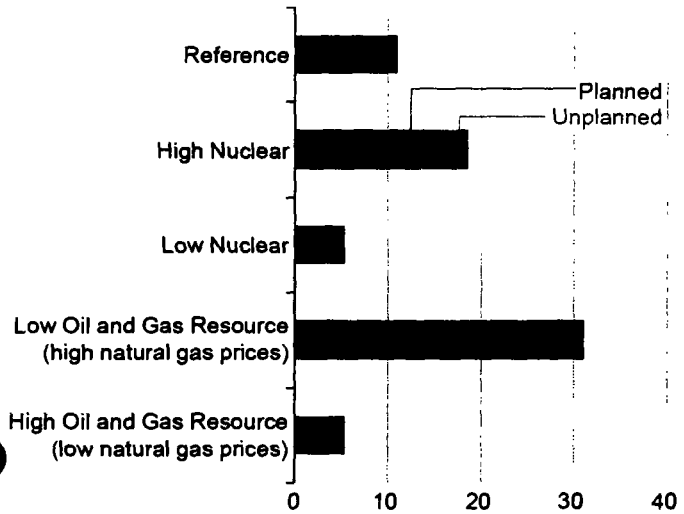
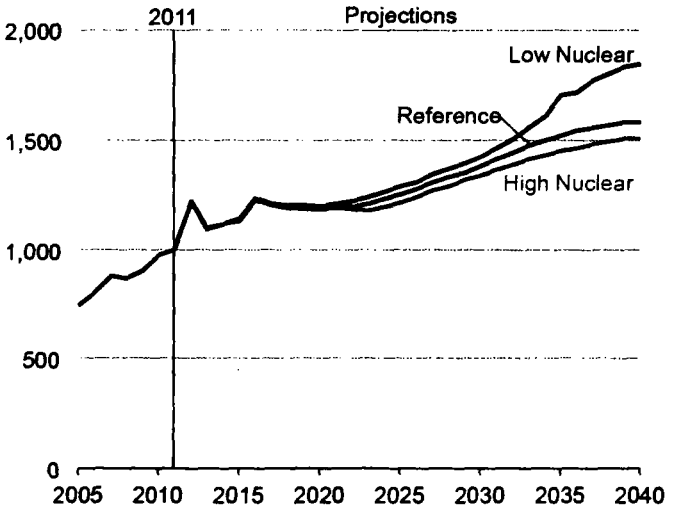


Figure 36. Electricity generation from natural gas in three cases, 2005-2040 (billion kilowatthours per year)



mostly natural gas and some coal [*107*]. In the High Nuclear case, CO_2 emissions from the power sector are 1 percent lower than projected in the Reference case, because the High Nuclear case results in slightly more generation from nuclear units than from fossil-fueled units (Figure 37).

Real average electricity prices in 2040 are 1 percent lower in the High Nuclear case than in the Reference case, as slightly less natural gas capacity is dispatched, reducing natural gas prices, which lowers the marginal price of electricity. In the Low Nuclear case, average electricity prices in 2040 are 5 percent higher than in the Reference case as a result of the retirement of a significant amount of nuclear capacity, which has relatively low operating costs, and its replacement with natural gas capacity, which has higher fuel costs that are passed through to consumers in retail electricity prices.

The impacts of nuclear plant retirements on retail electricity prices in the Low Nuclear case are more apparent in regions with relatively large amounts of nuclear capacity. For example, electricity prices in the Low Nuclear case are 9 percent higher in 2040 than in the Reference case for the SERC (Southeast) region, 8 percent higher for the MRO (Midwest) region, and 6 percent higher in the Northeast, Mid-Atlantic, and Ohio River Valley regions [*108*]. Even in regions where no nuclear capacity is retired, there are small increases in electricity prices compared to the Reference case, because higher demand for natural gas in regions where nuclear plants are retired increases the price of natural gas in all regions.

In the Small Modular Reactor case, shorter construction periods result in lower interest costs, which help to reduce the overall cost of nuclear construction projects. Figure 38 compares the resulting levelized costs for traditional large reactors and for SMRs in the Reference case. For SMRs, there is a savings of approximately $6 per megawatthour in the capital portion of the levelized cost. However, estimates of the fixed O&M costs for SMRs, derived from a University of Chicago study [*109*], are 40 percent higher than those assumed in *AEO2013* for a new large-scale plant on a dollar per megawatt basis. The higher O&M cost could offset, in part, the capital cost benefit of a shorter construction period. Therefore, the SMR case shows only a 1.4-percent reduction in overall levelized cost relative to the Reference case. The small difference results in about 2.3 gigawatts more new nuclear power capacity in the Small Modular Reactor case than projected in the Reference case. The sensitivity to small changes in cost is notable, given the high degree of uncertainty associated with SMR costs based on the maturity of the technology.

6. Effect of natural gas liquids growth

Background

NGL include a wide range of components produced during natural gas processing and petroleum refining. As natural gas production in recent years has grown dramatically, there has been a concurrent rapid increase in NGL production. NGL include ethane, propane, normal butane (n-butane), isobutane, and pentanes plus. The rising supply of some NGL components (particularly ethane and propane) has led to challenges, in finding markets and building the infrastructure necessary to move NGL to the new domestic demand and export markets. This discussion examines recent changes in U.S. NGL markets and how they might evolve under several scenarios. The future disposition of U.S. NGL supplies, particularly in international markets, is also discussed.

Recent growth in NGL production (Figure 39) has resulted largely from strong growth in shale gas production. The lightest NGL components, ethane and propane, account for most of the growth in NGL supply between 2008 and 2012. With the exception of propane, the main source of NGL is natural gas processing associated with growing natural gas production. That growth has led to

Figure 37. Carbon dioxide emissions from electricity generation in three cases, 2005-2040 (million metric tons carbon dioxide equivalent per year)

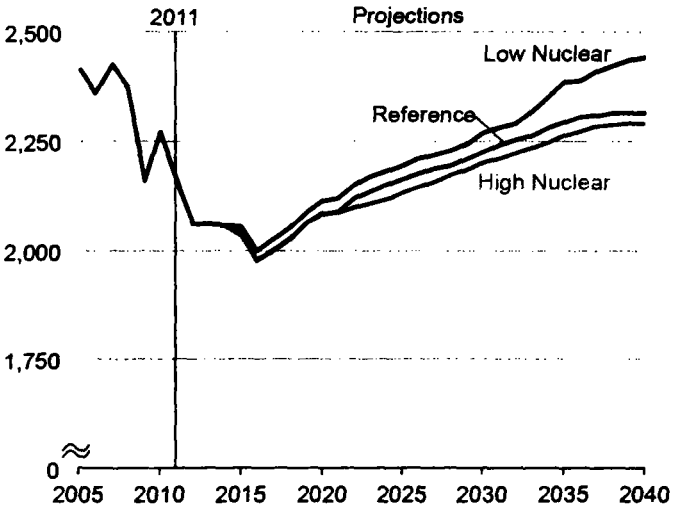
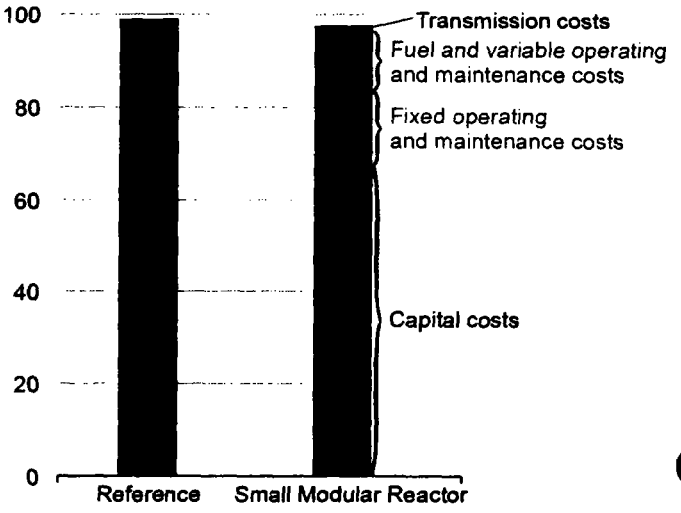


Figure 38. Levelized costs of nuclear electricity generation in two cases, 2025 (2011 dollars per megawatthour)



REPORT TO THE PRESIDENT

Rebuilding America's Infrastructure: Cutting Timelines and Improving Outcomes for Federal Permitting and Review of Infrastructure Projects

MAY 2013

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Executive Summary

Building 21st Century resilient infrastructure is vital to American competitiveness, regional economic growth and development, and local jobs. Accordingly, you made a commitment in your 2012 State of the Union Address to "cut the red tape that can slow down construction" of infrastructure projects. To fulfill this commitment, you signed Executive Order 13604, *Improving Performance of Federal Permitting and Review of Infrastructure Projects,* on March 22, 2012. This launched a Government-wide initiative to cut review and permit decision-making timelines, while improving outcomes for communities and the environment.

Efforts to implement EO 13604 are led by the office of the Chief Performance Officer (CPO), working closely with the Chair of the White House Council on Environmental Quality (CEQ) and an interagency Steering Committee comprised of Deputy Secretaries or their equivalent from the 12 Federal agencies with major permitting and review responsibilities.

Since we launched this comprehensive effort, agencies have expedited the review and permitting of 50 major infrastructure projects, including bridges, transit projects, railways, waterways, roads, and renewable energy generation projects, with time savings ranging from several months to several years. These include 14 priority projects that were identified per your memorandum of August 31, 2011 (*Speeding Infrastructure Development through More Efficient and Effective Permitting and Environmental Review*), and an additional 36 projects of National or Regional significance, identified in line with EO 13604.

Agencies now track progress of these projects using an online dashboard that facilitates transparency and accountability to the public, as well as interagency collaboration. As of the date of this report, the Federal permitting and review processes for more then 40 percent of these projects were complete.

Agencies have also identified a set of best practices that should become the standard for how the Federal Government conducts infrastructure permitting and review. This report describes those best practices, which range from expansion of IT tools to strategies for improving collaboration and integrating processes across Federal agencies. The report also presents case studies that show how different federal agencies successfully employed best practices.

Building on these results, in February, you announced a new goal of cutting timelines in half for major infrastructure projects, such as highways, bridges, railways, ports, waterways, pipelines and renewable energy, by modernizing and improving the efficiency of the Federal permitting process. By cutting through the red tape, we will more efficiently get projects through the Federal permit decision-making and review process, while creating new incentives for better outcomes for communities and the environment.

State, local, and tribal governments are critical partners in the effort to address our Nation's infrastructure needs and reach these goals. Close collaboration with states is essential because major infrastructure projects often involve both Federal and state agency permits. To strengthen Federal collaboration with States, municipalities, and Tribes, you recently announced a set of regional pilot teams focused on specific regional infrastructure priorities, including passenger rail, renewable energy, electricity transmission, oil and gas production, and drought mitigation.

Background

Implementation of EO 13604 has focused on major infrastructure projects such as roads and bridges, ports and other water resources projects, ecosystem restoration, rail and transit, pipelines, renewable energy generation, and aviation. The Federal Government has a variety of review and permitting responsibilities with respect to these projects, including protecting the quality of America's natural resources and environment, our national security, the health and safety of local communities, and the rights of citizens to engage in the permitting and review process. States, municipalities, and Tribes, as well as other stakeholders and members of the public, also frequently have permitting and review roles in large infrastructure projects.

Major infrastructure projects typically involve multi-year design, development, and construction timelines with complex approval processes that involve multiple jurisdictions and governmental agencies. The potential number and type of permits and reviews required varies depending on the nature of the project. Oftentimes, a project applicant may be required to obtain permits and approvals from multiple agencies with different statutory jurisdictions and processes, with no single organization in charge. Lack of coordination, as well as other inefficiencies—for example, some agencies' permitting processes are still paper-based—can be frustrating, time-consuming, and costly for the federal government, project developers, and other stakeholders. Furthermore, inefficiencies can divert attention from making improvements that can lead to better outcomes for communities and the environment.

Your initiative to improve the permitting and review process for Federal infrastructure projects has sought to improve coordination and cooperation—building on recommendations from your Council on Jobs and Competitiveness, as well as sector-specific initiatives launched at federal agencies, such as the Department of the Interior. Key steps in this effort have included:

- creating a Federal Infrastructure Permitting and Review Process Improvement Steering Committee (Steering Committee) chaired by the CPO;
- charging the Steering Committee with developing a concrete Federal Action Plan to coordinate, implement, and institutionalize improvements Government-wide;
- expanding the online Federal Infrastructure Permitting Dashboard to enhance transparency, accountability, and coordination;
- selecting Nationally and Regionally Significant Projects to demonstrate best practices;
- developing IT tools to modernize the Federal permitting and review process; and
- directing the CPO to develop metrics, track implementation, and issue an annual report on the results.

In June 2012, the Steering Committee completed a Federal Action Plan to improve the permitting and review process of major infrastructure projects. Grounded in a series of successful sector-specific and pilot efforts, the Federal Action Plan committed the Federal Government to across-the-board implementation of a series of best practices and called member agencies to develop their own plans to better track, measure and improve performance of its major infrastructure permitting and review processes.

Key Results

The Federal Action Plan included four core deliverables for achieving smart, on-time, and more efficient permitting and review decisions with better outcomes for communities and the environment:

1. identify and expedite a set of Nationally or Regionally Significant Projects;
2. publish these projects on an enhanced Federal Infrastructure Permitting Dashboard;
3. develop and track performance metrics to improve accountability and outcomes; and
4. publish agency-specific plans to improve internal processes.

The Federal Action Plan also requested that the Udall Foundation complete an initial qualitative assessment identifying ways in which more efficient, expedited permitting and review processes can support better outcomes for local communities and the environment.

Nationally and Regionally Significant Projects: Time Savings and On-Time Completion

Federal agencies have expedited a total of 50 major infrastructure projects pursuant to EO 13604. These include ports and waterways, large-scale renewable energy developments, oil and gas pipelines, railways, roadways, transit, aviation, and ecosystem restoration. Each project has an expedited schedule with clear project milestones, a designated coordinating agency, and is tracked on the public Federal Infrastructure Permitting Dashboard. Overall, 22 of the projects had completed the Federal permitting and review process as of the date of this report (21 were approved and one was denied).

Anticipated time savings for these projects range from several months to several years, depending on the project scale, complexity, and stage of Federal review. For example, transforming the U.S. Army Corps of Engineers Civil Works (Corps) project planning process is expected to reduce the average timeline for projects such as the Central Everglades Planning Project from ten years to three years or less. Similarly, close collaboration with State and local governments helped to reduce the timeline for the Tappan Zee Bridge by two to three years. Concurrent reviews on projects such as the Southwest Light Rail Transit project in Minneapolis and the Central Valley segment of the California High Speed Rail are expected to reduce project timelines by up to 30 percent.

Improving Collaboration through IT Tools

The Federal Infrastructure Permitting Dashboard, which was initially launched pursuant to your memorandum of August 31, 2011, has been expanded to include an internal IT platform to enable more effective Government-wide collaboration while continuing to provide public transparency through published project milestones and schedules. This IT platform enables project team members across Federal agencies to develop collaborative schedules, share project documents, and quickly communicate with each other. For example, a project manager from the DOI's Bureau of Land Management (BLM) in New Mexico can immediately identify a colleague at the Corps in a different state who may be responsible for assessing the aquatic resources impacts of the thousand-mile-long transmission line they are both working on.

The Dashboard is essential to institutionalizing best practices, improving accountability, and expanding the effort into regional operations. The Department of Transportation (DOT) has assumed a leadership role by hosting the public Dashboard, funding the interagency IT platform, and stewarding the ongoing technical maintenance and improvement of the system. The Office of Management and Budget (OMB) convenes an interagency Dashboard implementation team, together with the DOT, that meets weekly to monitor project schedules and overall Dashboard management, including usage policies and training.

The Dashboard tracks progress, supports accountability and identifies practices that work well and improve the review process. The accurate snapshot it provides of activities, project status, and goals has helped develop a more modern and efficient process, with benefits and lessons learned transferable to future projects facing similar permitting and review challenges. The goal is for the use of the Dashboard to become the norm for infrastructure project management.

Standardizing Use of the Dashboard

Some agencies are already standardizing the use of similar tracking systems and moving aggressively in this direction. For example, the Department of Energy (DOE) is extending the use of the Dashboard's collaboration platform to additional infrastructure projects that would benefit from enhanced interagency coordination and project scheduling tools. DOE is also working with DOT to move its eTrans system for managing transmission project timelines to the interagency IT platform.

Improving Transparency and Predictability: Tracking Agency Permit and Review Timelines

At the outset of this initiative, there was no comprehensive inventory of all major Federal agency permit and review responsibilities and associated decision-making timelines. Pursuant to the Federal Action Plan, each Federal agency has now identified its major permit and review responsibilities, and provided estimated timelines and a succinct description of the permit's purpose and applicable authorities. This inventory is publically available online on the Dashboard and searchable by infrastructure sector and agency. This accessible and transparent tool is critical to addressing private sector concerns regarding the transparency and predictability of infrastructure project timelines. The Dashboard helps project developers and other stakeholders quickly identify the permits, responsible agencies, review processes, and associated approximate timelines that may be applicable to a project.

Going forward, for the first time, all agencies with permitting and review responsibilities will implement electronic systems to track their performance on permits and reviews, managing and improving performance from year to year. Half of these agencies already have tracking systems in place, and the remaining agencies will implement electronic tracking systems no later than June 2013.

The Coast Guard is developing a performance management system that will track project status for activi- ties such as bridge permit applications, drawbridge regulations, civil penalties, and construction monitor- ing. This IT system will allow Coast Guard bridge offices nationwide to use real-time project data, improving their ability to measure project status against performance targets and milestones.

Agency Plans

Each Member Agency of the Steering Committee has submitted a detailed plan identifying how it will implement the Federal Action Plan and improve its internal permitting and review processes to reduce the aggregate time required to make permitting and review decisions while improving outcomes for communities and the environment. The implementation of agency plans is on track, with 89 percent of the action items and planned improvements identified by federal agencies completed on time as of January 1, 2013. The remaining agency actions are in progress, with current projected dates for completion outlined in published agency plans.

The National Oceanic and Atmospheric Administration (NOAA) collected information from headquarters and all regional offices regarding regulations, policy, guidance, and practices for Endangered Species Act, Magnuson Stevens Act, National Marine Sanctuaries Act, and Marine Mammal Protection Act consultations and permitting. This inventory located many formal and informal agreements and guidance documents for a range of infrastructure projects, including transportation projects and hydropower licensing projects. Some of these documents address issues which are national in scope, while others include specific procedures for commonly occurring consultations in particular regions. The policy documents address a number of specific infrastructure sectors and identify other Federal agency and state partners.

The Advisory Council on Historic Preservation (ACHP) and CEQ are developing a handbook to promote the integration of Section 106 of the National Historic Preservation Act (NHPA) and the National Environmental Policy Act (NEPA) review processes. Agencies will be able to use the handbook to inform efforts to integrate the NEPA and the NHPA Section 106 processes for projects that are time-sensitive and involve consultation with diverse stakeholders. This effort will expedite reviews by avoiding duplication of effort and allow for better outcomes by ensuring that the NEPA process included comprehensive consideration of historic properties in the early stages of project planning. The handbook will be finalized and available in the first quarter of 2013.

Improving Outcomes for Communities and the Environment

Improved coordination, concurrent review and decision-making processes, and greater transparency and predictability can not only create faster timelines, but also lead to better outcomes for communities and the environment. To identify methods for measuring these results, the Federal Action Plan required the development of a qualitative approach for assessing the effectiveness of integrated planning and early engagement. The Udall Foundation conducted telephone interviews of Dashboard project participants, with the goal of understanding how better coordination can create environmental and community benefits.

The results show that environmental and community benefits for each project will be unique, and must be assessed and documented on a case-by-case basis. Accordingly, the Udall Foundation will continue to develop brief case histories for each Dashboard project that completes the Federal review and permitting process, so as to identify environmental and community benefits that resulted from best practices. Examples of these innovations include green infrastructure, such as using porous pavement, employing green roofs and stormwater collection systems, restoring creeks and wetlands, and increasing the capacity of urban areas to absorb rainwater rather than discharge it into sewer systems.

Best Practices & Lessons Learned

Through the implementation of the Federal Action Plan, the development of agency plans, the work of coordinating the major infrastructure projects on the Dashboard, and the experiences gained from prior pilot and sector-specific efforts, OMB and Member Agencies have identified a series of best practices and lessons learned that, once institutionalized Government-wide, will lead to greater efficiency, shorter timelines, and enhanced outcomes for communities and the environment. These best practices include:

1. Expanding the use of IT tools
2. Assigning a "coordinating agency" to coordinate multiple agency reviews of a given project
3. Establishing timelines through integrated project planning
4. Implementing integrated and concurrent, rather than consecutive, agency reviews
5. Improving Federal interagency collaboration at every level
6. Creating application toolkits
7. Measuring results
8. Improving coordination with state, municipal, and tribal governments
9. Linking planning with permitting
10. Instituting a landscape- and watershed-level approach to mitigation

Expanding the Use of IT Tools

Expanding the use of IT tools to improve project management and support effective decision-making is essential to modernizing Federal permitting. Following the tenets of the *OpenGov* initiative, which requires Federal agencies to take steps to enhance transparency, collaboration using IT tools can make infrastructure project management more effective and efficient. These tools can make scientific data and other information more readily accessible and replace time-intensive and redundant processes, in turn reducing project timelines by months while equipping project teams with accurate, timely information to support sound permitting decisions.

The Fish and Wildlife Service is developing an Information, Planning, and Conservation IT system that enables users to identify species of concern, complete effects analyses, expedite environmental review and approval processes, and aid in coordinating conservation efforts across the landscape. By making this comprehensive set of data available early in the process, this tool will facilitate better siting and mitigation decisions, as well as speed up the decision-making process by months.

The Forest Service and Rural Utility Service are partnering with the Federal Geographic Data Committee and *OpenGov* Working Groups to explore ways to make geospatial data publicly available to inform and facilitate project siting and guidance. Land parcel information is the data needed to make land management decisions across all Federal lands. Once this process is developed and a site is created to publish land parcel data, other significant, standardized data sets could be added to the site.

The Forest Service, working closely with CEQ, developed *eMNEPA* (the electronic Modernization of NEPA), a modernized electronic platform for managing the often resource-intensive process of conducting environmental reviews under NEPA. The Forest Service saves approximately $8 million per year by not having to prepare, publish, mail, and file NEPA documents manually and by electronically responding to field data calls using this system. For example, one of the most resource-intensive processes has historically been collecting and responding to public comments—which often number in the thousands. *eMNEPA* includes a tool designed to manage the analysis of these comments, allowing the agency to respond more quickly to public input and allocate its scarce resources to the core work of analyzing project impacts.

The Environmental Protection Agency (EPA) released the *NEPAssist* public view, a web-based GIS application that facilitates more efficient and effective environmental reviews and project planning. *NEPAssist* draws information from publicly available Federal, state, and local datasets, allowing NEPA practitioners, stakeholders, and the public to view information about environmental conditions within the area of a proposed project quickly and easily. It can be used by Federal agencies to identify alternative project locations, to avoid and minimize impacts, and to identify potential mitigation areas. *NEPAssist* also responds to the needs of the general public for user-friendly web tools to access environmental data and to engage more effectively in the NEPA environmental review process, and to assist project developers' efforts to design projects that can avoid and minimize environmental impacts.

Assigning a Coordinating Agency

Every project on the Dashboard has a coordinating agency responsible for setting and managing the schedule for the project's permitting and review process. Having a single point of contact promotes accountability, improves communication and coordination, and provides all stakeholders with a primary resource for information about project progress.

The Department of Transportation (DOT) serves as the coordinating agency on two bridge projects of differing scope and scale on either side of the country:

DOT coordinated a project team with multiple Federal and state permitting and review agencies while expediting the Whittier Bridge Replacement Project in Massachusetts. DOT led the development of a schedule that coordinated concurrent Federal and state reviews, reducing the timeline to complete the permitting and review process by months. DOT, in partnership with the Massachusetts Department of Transportation, convened weekly calls with the project team to ensure the expedited schedule was maintained and obstacles were identified and overcome. Strong interagency coordination enabled the Coast Guard to issue the final bridge permit within weeks of the original target.

DOT also worked in close coordination with its state, local, and other Federal partners in the development of the schedule for the Columbia River Crossing project, connecting Vancouver, WA to Portland, OR. DOT (Federal Highway Administration and Federal Transit Administration) worked closely with Coast Guard, Army Corps of Engineers, as well as relevant states and regional offices to establish a Statement of Protocols which identified main points of contact, defined roles, established review timeframes, and detailed processes for dispute resolution. This high-level coordination resulted in a clear path forward on a major project that previously had been stalled.

Establishing Timelines through Integrated Project Planning

Public timelines give project developers the transparency and predictability they need to support business decisions, and give clarity to stakeholders about opportunities for public involvement. These timelines also promote accountability among the Federal agency teams responsible for managing the project's permitting and review process, encouraging them to quickly spot issues that could impact the overall project schedule so that they can be promptly resolved without confusion.

Integrated Project Plan

Per the Federal Action Plan, OMB developed Integrated Project Plan (IPP) guidance to provide a framework for establishing a comprehensive schedule for the permitting and review of complex projects based on early coordination and collaboration among Federal agencies and project sponsors/applicants. The guidance will enable project applicants to successfully design, develop, and deliver large, complex infrastructure projects with substantial interagency components, as well as to promote efficient, effective inter-agency coordination among Federal, state, tribal, and local agencies reviewing such projects. The IPP is being designed to set out the roles and responsibilities of agencies involved in reviewing proposed infrastructure projects, so as to identify opportunities for collaboration, concurrent reviews, and more efficient information collection. Investing this time at the beginning of a project, before fully committing to a particular course of action, facilitates more informed decision-making during project design and the permitting and review phases.

Integrated and Concurrent, rather than Consecutive, Reviews

Up-front identification of each of the permits and reviews required for a given infrastructure project enables the coordinating agency to work with other agency colleagues and the project developer to plan an integrated, concurrent review process. By identifying requirements early in the process, performing reviews concurrently, and ensuring that all requirements of the review and permitting process are addressed holistically, Federal agencies can reduce decision-making timelines by months or even years, depending on the complexity of the project, while further reducing the costs and duplication resulting from incomplete assessments of requirements or consecutive reviews.

The Transportation Rapid Response Team recently completed a preliminary study on the use of synchronized decision-making tools under NEPA and Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. For over twenty years the DOT and Army Corps of Engineers have had an agreement to align the NEPA and Department of Army permit decision-making processes, which has had promising results when deployed. The recent study sought to understand the extent to which such synchronized processes are used, identify opportunities to expand the use of synchronization tools, and potentially broaden the scope to include other environmental reviews such as Endangered Species Act consultation with the Fish & Wildlife Service and NOAA Fisheries Service, and consultations under Section 106 of the National Historic Preservation Act.

The Army Corps of Engineers has vastly improved the performance of its Civil Works Planning Program through a number of efforts, including modernizing the planning process. Over the last year, the Corps has deployed a new planning process referred to as "SMART Planning". The goal under SMART planning is to complete most feasibility-level studies within 3 years for $3 million dollars or less. The end product is a decision document that has been fully coordinated by three levels of the organization (Corps headquarters, the Corps division office, and the Corps district office) from study inception to completion. SMART Planning is risk-informed, decision focused planning that utilizes a six-step planning process to focus decision-making and scoping analyses on the information necessary for decisions. This collaborative approach is being used to shape two nationally and regionally significant Corps projects—the Central Everglades Planning Project and Charleston Harbor.

Improving Federal Interagency Collaboration at Every Level

Most permitting and review decisions are made at the regional or local level rather than at Federal agency headquarters. Accordingly, applying IT tools and best practices at the regional level is critical to effective and efficient permitting and review processes.

Weekly Tracking Call

OMB and DOT convene a weekly tracking call on which a representative from every agency with project milestones on the Dashboard reports on completed, delayed, missed and upcoming milestones. This pacing call supports improved coordination at both agency headquarters and at regional offices, while providing an early warning system that enables agency teams to proactively identify and correct delays that may arise. Agency participants on this call are also tasked with expanding and improving the project collaboration tool, including developing guidance and training materials to facilitate implementation and institutionalization throughout the Federal Government.

Creating Application Toolkits

Application toolkits include all necessary information about requirements, timelines, and application forms, and deliver greater clarity and predictability, lead to more comprehensive and informed applications, and enable Federal agencies to complete the permitting and review process faster with fewer delays.

Application Toolkit

Pursuant to the Federal Plan, the Rapid Response Team for Transmission (RRTT) and the Rapid Response Team for Renewable Energy (RE-RRT) are developing an Application Toolkit work plan and development schedule. These toolkits for electric transmission and renewable energy projects will be provided as an online public resource to provide information on siting and permitting renewable energy and electric transmission line projects to a broad stakeholder audience, including Federal, tribal, state, and local government agencies, project developers, and non-governmental organizations. Once completed, these application toolkits will provide a centralized location for stakeholders to access renewable energy and transmission line application processes, best practices, tools for outreach and engagement, and general information regarding natural, cultural, and visual resources, including assessment approaches and mitigation policies and practices. The toolkits give project sponsors clarity and predict- ability about the information required for, and timeframes associated with, Federal permitting and review decisions, and provide educational and training resources for Federal agency staff and external stakeholders.

Open Energy Information

Geothermal industry stakeholders identified the permitting process as one of the most significant barriers to geothermal power project development in the United States. Reducing the permitting time can significantly decrease total project costs, as well as investor risk and uncertainties. To solve this barrier, DOE's Geothermal Technologies Office developed an Open Energy Information (OpenEI) based tool. Available at http://en.openei.org/wiki/GRR, the tool outlines the permitting process for geothermal power projects on public, private and state-owned lands. The tool provides Federal, state, and local regulations, geothermal regulatory roadmap documents, and process flowcharts. By providing this information to the public, the tool enhances transparency and understanding for stakeholders involved in the geothermal permitting process, facilitates dialogue between agencies and stakeholders, and sets up a model for states that have not developed permitting regulations. DOE can also use the tool as a model to develop application toolkits focused on other industry sectors.

Measuring Results

Implementing tracking processes provides project developers and stakeholders with greater transparency and predictability, equips agency management with key information to identify and enhance processes, and allows agencies to better allocate resources.

The Department of Defense (DOD) has created a Siting Clearinghouse and published a new rule to expedite the review of infrastructure projects for impact to the military mission. This review affects the regulatory processes of other agencies, such as the Federal Aviation Administration (FAA), and major land holding agencies, such as Bureau of Land Management (BLM). A majority of projects submitted were wind turbine projects and associated energy infrastructure projects, including bulk power transmission lines. During calendar year 2012, 97 percent (1730 projects) were cleared as having no mission impact. Forty-three projects were identified as potentially affecting critical national security testing, training, or operational missions. To resolve these issues, DOD established four mitigation response teams, and opened discussions with developers on potential mitigation opportunities. DOD has also established an informal review process under which developers can request a preliminary review of mission compatibility issues.

Improving Coordination with State, Municipal, and Tribal Governments

The bulk of Federal review and permitting responsibilities are handled at regional offices rather than agency headquarters, and it is important for regional leadership to replicate the strategic collaboration that leadership at Federal agency headquarters have developed in implementing Executive Order 13604. In addition, effective collaboration between Federal agency regional leadership and the State, tribal, and local governments that share permitting and review responsibilities for infrastructure projects is essential to moving a project quickly and efficiently from planning to review and permitting process.

DOI's California Renewable Energy Policy Group

A successful model of Federal-state coordination is DOI's California Renewable Energy Policy Group (REPG). Jointly established by the Secretary of the Interior and Governor of California, the team includes representatives from Federal and state agencies with responsibilities for permitting renewable energy and transmission projects, including BLM, the Fish and Wildlife Service (FWS), the California Energy Commission, California Department of Fish and Wildlife, the California Independent Systems Operator, the California Public Utilities Commission, and the California State Lands Commission.

The Policy Group and REPG meet regularly to jointly review a common set of project applications, identifying and resolving issues early in the process; develop joint project permitting milestones which align Federal and state permitting processes; establish "Best Management Practices" for renewable energy development for project developers; and provide a venue for renewable energy stakeholders to speak directly to Federal and state policy leaders. The team has also created an innovative mitigation program with the National Fish and Wildlife Foundation to enable renewable energy project developers to address mitigation requirements through the use of a deposit account, leading to an increase in the transparency of project mitigation and allowing REPG to pool funds to acquire contiguous blocks of quality wildlife habitat.

Building on the success of the team's project-specific reviews, DOI and California also undertook a joint Federal-state long-term planning process to develop the Desert Renewable Energy Conservation Plan, which is expected to facilitate the review and approval of renewable energy projects, including solar thermal, utility-scale solar photovoltaic, wind, and other forms of renewable energy and associated infrastructure such as electric transmission lines necessary for renewable energy development, within about 22.5 million acres of the Colorado and Mojave deserts in California.

Linking Planning with Permitting

Federal agencies are developing innovative, science-based roadmaps designed to facilitate the review and permitting of major infrastructure projects and form a sound foundation for responsible infrastructure development on public lands. These roadmaps, which help to identify optimal locations for different types of infrastructure project development, as well as landscape and watershed-level mitigation opportunities, equip product developers to make better siting decisions, enable Federal agencies to make quick decisions, and create the opportunity to engage the appropriate stakeholders and enhance environmental outcomes.

Western Solar Plan

DOI recently completed a Western Solar Plan that provides a blueprint for utility-scale solar energy permitting in Arizona, California, Colorado, Nevada, New Mexico, and Utah. The plan establishes solar energy zones with access to existing or planned transmission lines, incentives for development within those zones, and a process through which to consider additional zones and solar projects. DOI undertook joint efforts with the states of California and Arizona to identify areas best suitable for the development of renewable energy in these states. On January 18, 2013, DOI announced the final decision for the Arizona Restoration Design Energy Project, while the California Desert Renewable Energy Conservation Plan is ongoing. These and other similar efforts will steer project applicants to the best location for siting projects and minimize multiple use conflicts and environmental impacts.

Landscape- and Watershed-Level Mitigation

Programmatic planning efforts like the Western Solar Plan can also allow for the more effective mitigation of the environmental impacts of major infrastructure projects. Because such projects can have a significant footprint, identifying appropriate environmental mitigation requirements upfront using a landscape or watershed level view of where a project is sited can lead to better outcomes for the environment and efficiencies in the mitigation process. To that end, resource management agencies are taking steps to move towards a holistic, watershed- or ecosystem-level approach that would allow project applicants to identify the most ecologically-effective mitigation measures in the project-planning phase.

Conservation Banking

Agencies like the Fish and Wildlife Service (FWS) are using conservation banking, an approach that permanently conserves habitat in a given area, to offset adverse impacts to species and habitats. In addition, the Bureau of Land Management (BLM) is implementing a Greater Sage-grouse Habitat Conservation Planning Strategy. This framework will allow BLM to incorporate science-based conservation measures for the Greater Sage grouse into agency resource management plans, and, in cooperation with the U.S. Forest Service (USFS) and state fish and wildlife agencies in the West, to give appropriate considerations to the principal threats to the sage-grouse identified by the FWS.

Going Forward

In February, you announced a new goal of cutting timelines in half for major infrastructure projects, such as highways, bridges, railways, ports, waterways, pipelines and renewable energy by modernizing Federal permitting and review regulations, policies, and procedures. By cutting through the red tape, we will more efficiently get projects through the Federal permit decision-making and review process, while creating new incentives for better outcomes for communities and the environment.

Advancing these efforts will also involve outreach to stakeholders in the environmental, community, and private sectors to further our commitment to collaboration and inform our best practices. These steps will enhance overall efficiencies and encourage transparency and predictability in infrastructure project management.

To institutionalize and expand best practices in agency regulations, policies, and procedures, OMB and CEQ will continue to work with Federal agencies to undertake a comprehensive review and modernization effort to bring the Federal permitting and review process into the 21st Century. This effort will include the development of a fast track procedure for infrastructure projects that can demonstrate how they will meet key permitting and review requirements early in the process. Fundamental to this effort will be the expansion of IT tools like geospatial systems that improve and streamline the planning process and replace burdensome paperwork.

State, local, and tribal governments are critical partners in the effort to address our Nation's infrastructure needs and reach these goals. To strengthen Federal collaboration with States, municipalities, and Tribes, you recently announced a set of regional pilot teams focused on specific regional infrastructure priorities. In the Pacific Northwest, DOI is leading a partnership with states to move faster on renewable energy, transmission and other infrastructure projects. DOT is working with other regional partners in the Northeast to develop passenger rail service in the Northeast Corridor. In the central U.S., USDA is leading an interagency team to work on projects that will help local communities deal with worsening drought. DOI will work in North Dakota and Montana to improve oil and gas production. Finally, DOI is developing a cross-discipline team to facilitate the development of electrical transmission in the West. These teams will strengthen collaboration, cut red tape, and reduce permitting timelines. These pilot teams will also serve as laboratories for further innovations.

THE PRESIDENT'S CLIMATE ACTION PLAN

Executive Office of the President

June 2013

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PRESIDENT OBAMA'S CLIMATE ACTION PLAN

"We, the people, still believe that our obligations as Americans are not just to ourselves, but to all posterity. We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations. Some may still deny the overwhelming judgment of science, but none can avoid the devastating impact of raging fires and crippling drought and more powerful storms.

The path towards sustainable energy sources will be long and sometimes difficult. But America cannot resist this transition, we must lead it. We cannot cede to other nations the technology that will power new jobs and new industries, we must claim its promise. That's how we will restore our economic vitality and our national treasure -- our forests and waterways, our croplands and snow-capped peaks. That is how we will preserve our planet, commanded to our care by God. That's what will lend meaning to the creed our fathers once declared.

-- President Obama, Second Inaugural Address, January 21, 2013

THE CASE FOR ACTION

While no single step can reverse the effects of climate change, we have a moral obligation to future generations to leave them a planet that is not polluted and damaged. Through steady, responsible action to cut carbon pollution, we can protect our children's health and begin to slow the effects of climate change so that we leave behind a cleaner, more stable environment.

In 2009, President Obama made a pledge that by 2020, America would reduce its greenhouse gas emissions in the range of 17 percent below 2005 levels if all other major economies agreed to limit their emissions as well. Today, the President remains firmly committed to that goal and to building on the progress of his first term to help put us and the world on a sustainable long-term trajectory. Thanks in part to the Administration's success in doubling America's use of wind, solar, and geothermal energy and in establishing the toughest fuel economy standards in our history, we are creating new jobs, building new industries, and reducing dangerous carbon pollution which contributes to climate change. In fact, last year, carbon emissions from the energy sector fell to the lowest level in two decades. At the same time, while there is more work to do, we are more energy secure than at any time in recent history. In 2012, America's net oil imports fell to the lowest level in 20 years and we have become the world's leading producer of natural gas – the cleanest-burning fossil fuel.

While this progress is encouraging, climate change is no longer a distant threat – we are already feeling its impacts across the country and the world. Last year was the warmest year ever in the contiguous United States and about one-third of all Americans experienced 10 days or more of 100-degree heat. The 12 hottest years on record have all come in the last 15 years. Asthma rates have doubled in the past 30 years and our children will suffer more asthma attacks as air pollution gets worse. And increasing floods, heat waves, and droughts have put farmers out of business, which is already raising food prices dramatically.

These changes come with far-reaching consequences and real economic costs. Last year alone, there were 11 different weather and climate disaster events with estimated losses exceeding $1 billion each across the United States. Taken together, these 11 events resulted in over $110 billion in estimated damages, which would make it the second-costliest year on record.

In short, America stands at a critical juncture. Today, President Obama is putting forward a broad-based plan to cut the carbon pollution that causes climate change and affects public health. Cutting carbon pollution will help spark business innovation to modernize our power plants, resulting in cleaner forms of American-made energy that will create good jobs and cut our dependence on foreign oil. Combined with the Administration's other actions to increase the efficiency of our cars and household appliances, the President's plan will reduce the amount of energy consumed by American families, cutting down on their gas and utility bills. The plan, which consists of a wide variety of executive actions, has three key pillars:

1) **Cut Carbon Pollution in America:** In 2012, U.S. carbon emissions fell to the lowest level in two decades even as the economy continued to grow. To build on this progress, the Obama Administration is putting in place tough new rules to cut carbon pollution – just like we have for other toxins like mercury and arsenic – so we protect the health of our children and move our economy toward American-made clean energy sources that will create good jobs and lower home energy bills.

2) **Prepare the United States for the Impacts of Climate Change:** Even as we take new steps to reduce carbon pollution, we must also prepare for the impacts of a changing climate that are already being felt across the country. Moving forward, the Obama Administration will help state and local governments strengthen our roads, bridges, and shorelines so we can better protect people's homes, businesses and way of life from severe weather.

3) **Lead International Efforts to Combat Global Climate Change and Prepare for its Impacts:** Just as no country is immune from the impacts of climate change, no country can meet this challenge alone. That is why it is imperative for the United States to couple action at home with leadership internationally. America must help forge a truly global solution to this global challenge by galvanizing international action to significantly reduce emissions (particularly among the major emitting countries), prepare for climate impacts, and drive progress through the international negotiations.

Climate change represents one of our greatest challenges of our time, but it is a challenge uniquely suited to America's strengths. Our scientists will design new fuels, and our farmers will grow them. Our engineers to devise new sources of energy, our workers will build them, and our businesses will sell them. All of us will need to do our part. If we embrace this challenge, we will not just create new jobs and new industries and keep America on the cutting edge; we will save lives, protect and preserve our treasured natural resources, cities, and coastlines for future generations.

What follows is a blueprint for steady, responsible national and international action to slow the effects of climate change so we leave a cleaner, more stable environment for future generations. It highlights progress already set in motion by the Obama Administration to advance these goals and sets forth new steps to achieve them.

CUT CARBON POLLUTION IN AMERICA

In 2009, President Obama made a commitment to reduce U.S. greenhouse gas emissions in the range of 17 percent below 2005 levels by 2020. The President remains firmly committed to achieving that goal. While there is more work to do, the Obama Administration has already made significant progress by doubling generation of electricity from wind, solar, and geothermal, and by establishing historic new fuel economy standards. Building on these achievements, this document outlines additional steps the Administration will take – in partnership with states, local communities, and the private sector – to continue on a path to meeting the President's 2020 goal.

I. Deploying Clean Energy

Cutting Carbon Pollution from Power Plants: Power plants are the largest concentrated source of emissions in the United States, together accounting for roughly one-third of all domestic greenhouse gas emissions. We have already set limits for arsenic, mercury, and lead, but there is no federal rule to prevent power plants from releasing as much carbon pollution as they want. Many states, local governments, and companies have taken steps to move to cleaner electricity sources. More than 35 states have renewable energy targets in place, and more than 25 have set energy efficiency targets.

Despite this progress at the state level, there are no federal standards in place to reduce carbon pollution from power plants. In April 2012, as part of a continued effort to modernize our electric power sector, the Obama Administration proposed a carbon pollution standard for new power plants. The Environmental Protection Agency's proposal reflects and reinforces the ongoing trend towards cleaner technologies, with natural gas increasing its share of electricity generation in recent years, principally through market forces and renewables deployment growing rapidly to account for roughly half of new generation capacity installed in 2012.

With abundant clean energy solutions available, and building on the leadership of states and local governments, we can make continued progress in reducing power plant pollution to improve public health and the environment while supplying the reliable, affordable power needed for economic growth. By doing so, we will continue to drive American leadership in clean energy technologies, such as efficient natural gas, nuclear, renewables, and clean coal technology.

To accomplish these goals, President Obama is issuing a Presidential Memorandum directing the Environmental Protection Agency to work expeditiously to complete carbon pollution standards for both new and existing power plants. This work will build on the successful first-term effort to develop greenhouse gas and fuel economy standards for cars and trucks. In developing the standards, the President has asked the Environmental Protection Agency to build on state leadership, provide flexibility, and take advantage of a wide range of energy sources and technologies including many actions in this plan.

Promoting American Leadership in Renewable Energy: During the President's first term, the United States more than doubled generation of electricity from wind, solar, and geothermal sources. To ensure America's continued leadership position in clean energy, President Obama has set a goal to double renewable electricity generation once again by 2020. In order to meet

this ambitious target, the Administration is announcing a number of new efforts in the following key areas:

- **Accelerating Clean Energy Permitting:** In 2012 the President set a goal to issue permits for 10 gigawatts of renewables on public lands by the end of the year. The Department of the Interior achieved this goal ahead of schedule and the President has directed it to permit an additional 10 gigawatts by 2020. Since 2009, the Department of Interior has approved 25 utility-scale solar facilities, nine wind farms, and 11 geothermal plants, which will provide enough electricity to power 4.4 million homes and support an estimated 17,000 jobs. The Administration is also taking steps to encourage the development of hydroelectric power at existing dams. To develop and demonstrate improved permitting procedures for such projects, the Administration will designate the Red Rock Hydroelectric Plant on the Des Moines River in Iowa to participate in its Infrastructure Permitting Dashboard for high-priority projects. Also, the Department of Defense – the single largest consumer of energy in the United States – is committed to deploying 3 gigawatts of renewable energy on military installations, including solar, wind, biomass, and geothermal, by 2025. In addition, federal agencies are setting a new goal of reaching 100 megawatts of installed renewable capacity across the federally subsidized housing stock by 2020. This effort will include conducting a survey of current projects in order to track progress and facilitate the sharing of best practices.

- **Expanding and Modernizing the Electric Grid:** Upgrading the country's electric grid is critical to our efforts to make electricity more reliable, save consumers money on their energy bills, and promote clean energy sources. To advance these important goals, President Obama signed a Presidential Memorandum this month that directs federal agencies to streamline the siting, permitting and review process for transmission projects across federal, state, and tribal governments.

Unlocking Long-Term Investment in Clean Energy Innovation: The Fiscal Year 2014 Budget continues the President's commitment to keeping the United States at the forefront of clean energy research, development, and deployment by increasing funding for clean energy technology across all agencies by 30 percent, to approximately $7.9 billion. This includes investment in a range of energy technologies, from advanced biofuels and emerging nuclear technologies – including small modular reactors – to clean coal. To continue America's leadership in clean energy innovation, the Administration will also take the following steps:

- **Spurring Investment in Advanced Fossil Energy Projects:** In the coming weeks, the Department of Energy will issue a Federal Register Notice announcing a draft of a solicitation that would make up to $8 billion in (self-pay) loan guarantee authority available for a wide array of advanced fossil energy projects under its Section 1703 loan guarantee program. This solicitation is designed to support investments in innovative technologies that can cost-effectively meet financial and policy goals, including the avoidance, reduction, or sequestration of anthropogenic emissions of greenhouse gases. The proposed solicitation will cover a broad range of advanced fossil energy projects. Reflecting the Department's commitment to continuous improvement in program management, it will take comment on the draft solicitation, with a plan to issue a final solicitation by the fall of 2013.

- **Instituting a Federal Quadrennial Energy Review:** Innovation and new sources of domestic energy supply are transforming the nation's energy marketplace, creating economic

opportunities at the same time they raise environmental challenges. To ensure that federal energy policy meets our economic, environmental, and security goals in this changing landscape, the Administration will conduct a Quadrennial Energy Review which will be led by the White House Domestic Policy Council and Office of Science and Technology Policy, supported by a Secretariat established at the Department of Energy, and involving the robust engagement of federal agencies and outside stakeholders. This first-ever review will focus on infrastructure challenges, and will identify the threats, risks, and opportunities for U.S. energy and climate security, enabling the federal government to translate policy goals into a set of analytically based, clearly articulated, sequenced and integrated actions, and proposed investments over a four-year planning horizon.

II. Building a 21st-Century Transportation Sector

Increasing Fuel Economy Standards: Heavy-duty vehicles are currently the second largest source of greenhouse gas emissions within the transportation sector. In 2011, the Obama Administration finalized the first-ever fuel economy standards for Model Year 2014-2018 for heavy-duty trucks, buses, and vans. These standards will reduce greenhouse gas emissions by approximately 270 million metric tons and save 530 million barrels of oil. During the President's second term, the Administration will once again partner with industry leaders and other key stakeholders to develop post-2018 fuel economy standards for heavy-duty vehicles to further reduce fuel consumption through the application of advanced cost-effective technologies and continue efforts to improve the efficiency of moving goods across the United States.

The Obama Administration has already established the toughest fuel economy standards for passenger vehicles in U.S. history. These standards require an average performance equivalent of 54.5 miles per gallon by 2025, which will save the average driver more than $8,000 in fuel costs over the lifetime of the vehicle and eliminate six billion metric tons of carbon pollution – more than the United States emits in an entire year.

Developing and Deploying Advanced Transportation Technologies: Biofuels have an important role to play in increasing our energy security, fostering rural economic development, and reducing greenhouse gas emissions from the transportation sector. That is why the Administration supports the Renewable Fuels Standard, and is investing in research and development to help bring next-generation biofuels on line. For example, the United States Navy and Departments of Energy and Agriculture are working with the private sector to accelerate the development of cost-competitive advanced biofuels for use by the military and commercial sectors. More broadly, the Administration will continue to leverage partnerships between the private and public sectors to deploy cleaner fuels, including advanced batteries and fuel cell technologies, in every transportation mode. The Department of Energy's eGallon informs drivers about electric car operating costs in their state – the national average is only $1.14 per gallon of gasoline equivalent, showing the promise for consumer pocketbooks of electric-powered vehicles. In addition, in the coming months, the Department of Transportation will work with other agencies to further explore strategies for integrating alternative fuel vessels into the U.S. flag fleet. Further, the Administration will continue to work with states, cities and towns through the Department of Transportation, the Department of Housing and Urban Development, and the Environmental Protection Agency to improve transportation options, and lower transportation costs while protecting the environment in communities nationwide.

III. Cutting Energy Waste in Homes, Businesses, and Factories

Reducing Energy Bills for American Families and Businesses: Energy efficiency is one of the clearest and most cost-effective opportunities to save families money, make our businesses more competitive, and reduce greenhouse gas emissions. In the President's first term, the Department of Energy and the Department of Housing and Urban Development completed efficiency upgrades in more than one million homes, saving many families more than $400 on their heating and cooling bills in the first year alone. The Administration will take a range of new steps geared towards achieving President Obama's goal of doubling energy productivity by 2030 relative to 2010 levels:

- **Establishing a New Goal for Energy Efficiency Standards:** In President Obama's first term, the Department of Energy established new minimum efficiency standards for dishwashers, refrigerators, and many other products. Through 2030, these standards will cut consumers' electricity bills by hundreds of billions of dollars and save enough electricity to power more than 85 million homes for two years. To build on this success, the Administration is setting a new goal: Efficiency standards for appliances and federal buildings set in the first and second terms combined will reduce carbon pollution by at least 3 billion metric tons cumulatively by 2030 – equivalent to nearly one-half of the carbon pollution from the entire U.S. energy sector for one year – while continuing to cut families' energy bills.

- **Reducing Barriers to Investment in Energy Efficiency:** Energy efficiency upgrades bring significant cost savings, but upfront costs act as a barrier to more widespread investment. In response, the Administration is committing to a number of new executive actions. As soon as this fall, the Department of Agriculture's Rural Utilities Service will finalize a proposed update to its Energy Efficiency and Conservation Loan Program to provide up to $250 million for rural utilities to finance efficiency investments by businesses and homeowners across rural America. The Department is also streamlining its Rural Energy for America program to provide grants and loan guarantees directly to agricultural producers and rural small businesses for energy efficiency and renewable energy systems.

  In addition, the Department of Housing and Urban Development's efforts include a $23 million Multifamily Energy Innovation Fund designed to enable affordable housing providers, technology firms, academic institutions, and philanthropic organizations to test new approaches to deliver cost-effective residential energy. In order to advance ongoing efforts and bring stakeholders together, the Federal Housing Administration will convene representatives of the lending community and other key stakeholders for a mortgage roundtable in July to identify options for factoring energy efficiency into the mortgage underwriting and appraisal process upon sale or refinancing of new or existing homes.

- **Expanding the President's Better Buildings Challenge:** The Better Buildings Challenge, focused on helping American commercial and industrial buildings become at least 20 percent more energy efficient by 2020, is already showing results. More than 120 diverse organizations, representing over 2 billion square feet are on track to meet the 2020 goal: cutting energy use by an average 2.5 percent annually, equivalent to about $58 million in energy savings per year. To continue this success, the Administration will expand the program to multifamily housing – partnering both with private and affordable

building owners and public housing agencies to cut energy waste. In addition, the Administration is launching the Better Buildings Accelerators, a new track that will support and encourage adoption of State and local policies to cut energy waste, building on the momentum of ongoing efforts at that level.

IV. Reducing Other Greenhouse Gas Emissions

Curbing Emissions of Hydrofluorocarbons: Hydrofluorocarbons (HFCs), which are primarily used for refrigeration and air conditioning, are potent greenhouse gases. In the United States, emissions of HFCs are expected to nearly triple by 2030, and double from current levels of 1.5 percent of greenhouse gas emissions to 3 percent by 2020.

To reduce emissions of HFCs, the United States can and will lead both through international diplomacy as well as domestic actions. In fact, the Administration has already acted by including a flexible and powerful incentive in the fuel economy and carbon pollution standards for cars and trucks to encourage automakers to reduce HFC leakage and transition away from the most potent HFCs in vehicle air conditioning systems. Moving forward, the Environmental Protection Agency will use its authority through the Significant New Alternatives Policy Program to encourage private sector investment in low-emissions technology by identifying and approving climate-friendly chemicals while prohibiting certain uses of the most harmful chemical alternatives. In addition, the President has directed his Administration to purchase cleaner alternatives to HFCs whenever feasible and transition over time to equipment that uses safer and more sustainable alternatives.

Reducing Methane Emissions: Curbing emissions of methane is critical to our overall effort to address global climate change. Methane currently accounts for roughly 9 percent of domestic greenhouse gas emissions and has a global warming potential that is more than 20 times greater than carbon dioxide. Notably, since 1990, methane emissions in the United States have decreased by 8 percent. This has occurred in part through partnerships with industry, both at home and abroad, in which we have demonstrated that we have the technology to deliver emissions reductions that benefit both our economy and the environment. To achieve additional progress, the Administration will:

- **Developing an Interagency Methane Strategy:** The Environmental Protection Agency and the Departments of Agriculture, Energy, Interior, Labor, and Transportation will develop a comprehensive, interagency methane strategy. The group will focus on assessing current emissions data, addressing data gaps, identifying technologies and best practices for reducing emissions, and identifying existing authorities and incentive-based opportunities to reduce methane emissions.

- **Pursuing a Collaborative Approach to Reducing Emissions:** Across the economy, there are multiple sectors in which methane emissions can be reduced, from coal mines and landfills to agriculture and oil and gas development. For example, in the agricultural sector, over the last three years, the Environmental Protection Agency and the Department of Agriculture have worked with the dairy industry to increase the adoption of methane digesters through loans, incentives, and other assistance. In addition, when it comes to the oil and gas sector, investments to build and upgrade gas pipelines will not only put more Americans to work, but also reduce emissions and enhance economic productivity. For example, as part of the Administration's effort to improve federal

permitting for infrastructure projects, the interagency Bakken Federal Executive Group is working with industry, as well as state and tribal agencies, to advance the production of oil and gas in the Bakken while helping to reduce venting and flaring. Moving forward, as part of the effort to develop an interagency methane strategy, the Obama Administration will work collaboratively with state governments, as well as the private sector, to reduce emissions across multiple sectors, improve air quality, and achieve public health and economic benefits.

Preserving the Role of Forests in Mitigating Climate Change: America's forests play a critical role in addressing carbon pollution, removing nearly 12 percent of total U.S. greenhouse gas emissions each year. In the face of a changing climate and increased risk of wildfire, drought, and pests, the capacity of our forests to absorb carbon is diminishing. Pressures to develop forest lands for urban or agricultural uses also contribute to the decline of forest carbon sequestration. Conservation and sustainable management can help to ensure our forests continue to remove carbon from the atmosphere while also improving soil and water quality, reducing wildfire risk, and otherwise managing forests to be more resilient in the fact of climate change. The Administration is working to identify new approaches to protect and restore our forests, as well as other critical landscapes including grasslands and wetlands, in the face of a changing climate.

V. Leading at the Federal Level

Leading in Clean Energy: President Obama believes that the federal government must be a leader in clean energy and energy efficiency. Under the Obama Administration, federal agencies have reduced greenhouse gas emissions by more than 15 percent – the equivalent of permanently taking 1.5 million cars off the road. To build on this record, the Administration is establishing a new goal: The federal government will consume 20 percent of its electricity from renewable sources by 2020 – more than double the current goal of 7.5 percent. In addition, the federal government will continue to pursue greater energy efficiency that reduces greenhouse gas emissions and saves taxpayer dollars.

Federal Government Leadership in Energy Efficiency: On December 2, 2011, President Obama signed a memorandum entitled "Implementation of Energy Savings Projects and Performance-Based Contracting for Energy Savings," challenging federal agencies, in support of the Better Buildings Challenge, to enter into $2 billion worth of performance-based contracts within two years. Performance contracts drive economic development, utilize private sector innovation, and increase efficiency at minimum costs to the taxpayer, while also providing long-term savings in energy costs. Federal agencies have committed to a pipeline of nearly $2.3 billion from over 300 reported projects. In coming months, the Administration will take a number of actions to strengthen efforts to promote energy efficiency, including through performance contracting. For example, in order to increase access to capital markets for investments in energy efficiency, the Administration will initiate a partnership with the private sector to work towards a standardized contract to finance federal investments in energy efficiency. Going forward, agencies will also work together to synchronize building codes – leveraging those policies to improve the efficiency of federally owned and supported building stock. Finally, the Administration will leverage the "Green Button" standard – which aggregates energy data in a secure, easy to use format – within federal facilities to increase their ability to manage energy consumption, reduce greenhouse gas emissions, and meet sustainability goals.

PREPARE THE UNITED STATES FOR THE IMPACTS OF CLIMATE CHANGE

As we act to curb the greenhouse gas pollution that is driving climate change, we must also prepare for the impacts that are too late to avoid. Across America, states, cities, and communities are taking steps to protect themselves by updating building codes, adjusting the way they manage natural resources, investing in more resilient infrastructure, and planning for rapid recovery from damages that nonetheless occur. The federal government has an important role to play in supporting community-based preparedness and resilience efforts, establishing policies that promote preparedness, protecting critical infrastructure and public resources, supporting science and research germane to preparedness and resilience, and ensuring that federal operations and facilities continue to protect and serve citizens in a changing climate.

The Obama Administration has been working to strengthen America's climate resilience since its earliest days. Shortly after coming into office, President Obama established an Interagency Climate Change Adaptation Task Force and, in October 2009, the President signed an Executive Order directing it to recommend ways federal policies and programs can better prepare the Nation for change. In May 2010, the Task Force hosted the first National Climate Adaptation Summit, convening local and regional stakeholders and decision-makers to identify challenges and opportunities for collaborative action.

In February 2013, federal agencies released Climate Change Adaptation Plans for the first time, outlining strategies to protect their operations, missions, and programs from the effects of climate change. The Department of Transportation, for example, is developing guidance for incorporating climate change and extreme weather event considerations into coastal highway projects, and the Department of Homeland Security is evaluating the challenges of changing conditions in the Arctic and along our Nation's borders. Agencies have also partnered with communities through targeted grant and technical-assistance programs—for example, the Environmental Protection Agency is working with low-lying communities in North Carolina to assess the vulnerability of infrastructure investments to sea level rise and identify solutions to reduce risks. And the Administration has continued, through the U.S. Global Change Research Program, to support science and monitoring to expand our understanding of climate change and its impacts.

Going forward, the Administration will expand these efforts into three major, interrelated initiatives to better prepare America for the impacts of climate change:

I. Building Stronger and Safer Communities and Infrastructure

By necessity, many states, cities, and communities are already planning and preparing for the impacts of climate change. Hospitals must build capacity to serve patients during more frequent heat waves, and urban planners must plan for the severe storms that infrastructure will need to withstand. Promoting on-the-ground planning and resilient infrastructure will be at the core of our work to strengthen America's communities. Specific actions will include:

Directing Agencies to Support Climate-Resilient Investment: The President will direct federal agencies to identify and remove barriers to making climate-resilient investments; identify and remove counterproductive policies that increase vulnerabilities; and encourage and support smarter, more resilient investments, including through agency grants, technical assistance, and other programs, in sectors from transportation and water management to conservation and

disaster relief. Agencies will also be directed to ensure that climate risk-management considerations are fully integrated into federal infrastructure and natural resource management planning. To begin meeting this challenge, the Environmental Protection Agency is committing to integrate considerations of climate change impacts and adaptive measures into major programs, including its Clean Water and Drinking Water State Revolving Funds and grants for brownfields cleanup, and the Department of Housing and Urban Development is already requiring grant recipients in the Hurricane Sandy–affected region to take sea-level rise into account.

Establishing a State, Local, and Tribal Leaders Task Force on Climate Preparedness: To help agencies meet the above directive and to enhance local efforts to protect communities, the President will establish a short-term task force of state, local, and tribal officials to advise on key actions the federal government can take to better support local preparedness and resilience-building efforts. The task force will provide recommendations on removing barriers to resilient investments, modernizing grant and loan programs to better support local efforts, and developing information and tools to better serve communities.

Supporting Communities as they Prepare for Climate Impacts: Federal agencies will continue to provide targeted support and assistance to help communities prepare for climate-change impacts. For example, throughout 2013, the Department of Transportation's Federal Highway Administration is working with 19 state and regional partners and other federal agencies to test approaches for assessing local transportation infrastructure vulnerability to climate change and extreme weather and for improving resilience. The Administration will continue to assist tribal communities on preparedness through the Bureau of Indian Affairs, including through pilot projects and by supporting participation in federal initiatives that assess climate change vulnerabilities and develop regional solutions. Through annual federal agency "Environmental Justice Progress Reports," the Administration will continue to identify innovative ways to help our most vulnerable communities prepare for and recover from the impacts of climate change. The importance of critical infrastructure independence was brought home in the Sandy response. The Federal Emergency Management Agency and the Department of Energy are working with the private sector to address simultaneous restoration of electricity and fuels supply.

Boosting the Resilience of Buildings and Infrastructure: The National Institute of Standards and Technology will convene a panel on disaster-resilience standards to develop a comprehensive, community-based resilience framework and provide guidelines for consistently safe buildings and infrastructure – products that can inform the development of private-sector standards and codes. In addition, building on federal agencies' "Climate Change Adaptation Plans," the Administration will continue efforts to increase the resilience of federal facilities and infrastructure. The Department of Defense, for example, is assessing the relative vulnerability of its coastal facilities to climate change. In addition, the President's FY 2014 Budget proposes $200 million through the Transportation Leadership Awards program for Climate Ready Infrastructure in communities that build enhanced preparedness into their planning efforts, and that have proposed or are ready to break ground on infrastructure projects, including transit and rail, to improve resilience.

Rebuilding and Learning from Hurricane Sandy: In August 2013, President Obama's Hurricane Sandy Rebuilding Task Force will deliver to the President a rebuilding strategy to be implemented in Sandy-affected regions and establishing precedents that can be followed

elsewhere. The Task Force and federal agencies are also piloting new ways to support resilience in the Sandy-affected region; the Task Force, for example, is hosting a regional "Rebuilding by Design" competition to generate innovative solutions to enhance resilience. In the transportation sector, the Department of Transportation's Federal Transit Administration (FTA) is dedicating $5.7 billion to four of the area's most impacted transit agencies, of which $1.3 billion will be allocated to locally prioritized projects to make transit systems more resilient to future disasters. FTA will also develop a competitive process for additional funding to identify and support larger, stand-alone resilience projects in the impacted region. To build coastal resilience, the Department of the Interior will launch a $100 million competitive grant program to foster partnerships and promote resilient natural systems while enhancing green spaces and wildlife habitat near urban populations. An additional $250 million will be allocated to support projects for coastal restoration and resilience across the region. Finally, with partners, the U.S. Army Corps of Engineers is conducting a $20 million study to identify strategies to reduce the vulnerability of Sandy-affected coastal communities to future large-scale flood and storm events, and the National Oceanic and Atmospheric Administration will strengthen long-term coastal observations and provide technical assistance to coastal communities.

II. Protecting our Economy and Natural Resources

Climate change is affecting nearly every aspect of our society, from agriculture and tourism to the health and safety of our citizens and natural resources. To help protect critical sectors, while also targeting hazards that cut across sectors and regions, the Administration will mount a set of sector- and hazard-specific efforts to protect our country's vital assets, to include:

Identifying Vulnerabilities of Key Sectors to Climate Change: The Department of Energy will soon release an assessment of climate-change impacts on the energy sector, including power-plant disruptions due to drought and the disruption of fuel supplies during severe storms, as well as potential opportunities to make our energy infrastructure more resilient to these risks. In 2013, the Department of Agriculture and Department of the Interior released several studies outlining the challenges a changing climate poses for America's agricultural enterprise, forests, water supply, wildlife, and public lands. This year and next, federal agencies will report on the impacts of climate change on other key sectors and strategies to address them, with priority efforts focusing on health, transportation, food supplies, oceans, and coastal communities.

Promoting Resilience in the Health Sector: The Department of Health and Human Services will launch an effort to create sustainable and resilient hospitals in the face of climate change. Through a public-private partnership with the healthcare industry, it will identify best practices and provide guidance on affordable measures to ensure that our medical system is resilient to climate impacts. It will also collaborate with partner agencies to share best practices among federal health facilities. And, building on lessons from pilot projects underway in 16 states, it will help train public-health professionals and community leaders to prepare their communities for the health consequences of climate change, including through effective communication of health risks and resilience measures.

Promoting Insurance Leadership for Climate Safety: Recognizing the critical role that the private sector plays in insuring assets and enabling rapid recovery after disasters, the Administration will convene representatives from the insurance industry and other stakeholders to explore best practices for private and public insurers to manage their own processes and

investments to account for climate change risks and incentivize policy holders to take steps to reduce their exposure to these risks.

Conserving Land and Water Resources: America's ecosystems are critical to our nation's economy and the lives and health of our citizens. These natural resources can also help ameliorate the impacts of climate change, if they are properly protected. The Administration has invested significantly in conserving relevant ecosystems, including working with Gulf State partners after the Deepwater Horizon spill to enhance barrier islands and marshes that protect communities from severe storms. The Administration is also implementing climate-adaptation strategies that promote resilience in fish and wildlife populations, forests and other plant communities, freshwater resources, and the ocean. Building on these efforts, the President is also directing federal agencies to identify and evaluate additional approaches to improve our natural defenses against extreme weather, protect biodiversity and conserve natural resources in the face of a changing climate, and manage our public lands and natural systems to store more carbon.

Maintaining Agricultural Sustainability: Building on the existing network of federal climate-science research and action centers, the Department of Agriculture is creating seven new Regional Climate Hubs to deliver tailored, science-based knowledge to farmers, ranchers, and forest landowners. These hubs will work with universities and other partners, including the Department of the Interior and the National Oceanic and Atmospheric Administration, to support climate resilience. Its Natural Resources Conservation Service and the Department of the Interior's Bureau of Reclamation are also providing grants and technical support to agricultural water users for more water-efficient practices in the face of drought and long-term climate change.

Managing Drought: Leveraging the work of the National Disaster Recovery Framework for drought, the Administration will launch a cross-agency National Drought Resilience Partnership as a "front door" for communities seeking help to prepare for future droughts and reduce drought impacts. By linking information (monitoring, forecasts, outlooks, and early warnings) with drought preparedness and longer-term resilience strategies in critical sectors, this effort will help communities manage drought-related risks.

Reducing Wildfire Risks: With tribes, states, and local governments as partners, the Administration has worked to make landscapes more resistant to wildfires, which are exacerbated by heat and drought conditions resulting from climate change. Federal agencies will expand and prioritize forest and rangeland restoration efforts in order to make natural areas and communities less vulnerable to catastrophic fire. The Department of the Interior and Department of Agriculture, for example, are launching a Western Watershed Enhancement Partnership – a pilot effort in five western states to reduce wildfire risk by removing extra brush and other flammable vegetation around critical areas such as water reservoirs.

Preparing for Future Floods: To ensure that projects funded with taxpayer dollars last as long as intended, federal agencies will update their flood-risk reduction standards for federally funded projects to reflect a consistent approach that accounts for sea-level rise and other factors affecting flood risks. This effort will incorporate the most recent science on expected rates of sea-level rise (which vary by region) and build on work done by the Hurricane Sandy Rebuilding Task Force, which announced in April 2013 that all federally funded Sandy-related rebuilding projects must meet a consistent flood risk reduction standard that takes into account increased risk from extreme weather events, sea-level rise, and other impacts of climate change.

III. Using Sound Science to Manage Climate Impacts

Scientific data and insights are essential to help government officials, communities, and businesses better understand and manage the risks associated with climate change. The Administration will continue to lead in advancing the science of climate measurement and adaptation and the development of tools for climate-relevant decision-making by focusing on increasing the availability, accessibility, and utility of relevant scientific tools and information. Specific actions will include:

Developing Actionable Climate Science: The President's Fiscal Year 2014 Budget provides more than $2.7 billion, largely through the 13-agency U.S. Global Change Research Program, to increase understanding of climate-change impacts, establish a public-private partnership to explore risk and catastrophe modeling, and develop the information and tools needed by decision-makers to respond to both long-term climate change impacts and near-term effects of extreme weather.

Assessing Climate-Change Impacts in the United States: In the spring of 2014, the Obama Administration will release the third U.S. National Climate Assessment, highlighting new advances in our understanding of climate-change impacts across all regions of the United States and on critical sectors of the economy, including transportation, energy, agriculture, and ecosystems and biodiversity. For the first time, the National Climate Assessment will focus not only on dissemination of scientific information but also on translating scientific insights into practical, useable knowledge that can help decision-makers anticipate and prepare for specific climate-change impacts.

Launching a Climate Data Initiative: Consistent with the President's May 2013 Executive Order on Open Data – and recognizing that freely available open government data can fuel entrepreneurship, innovation, scientific discovery, and public benefits – the Administration is launching a Climate Data Initiative to leverage extensive federal climate-relevant data to stimulate innovation and private-sector entrepreneurship in support of national climate-change preparedness.

Providing a Toolkit for Climate Resilience: Federal agencies will create a virtual climate-resilience toolkit that centralizes access to data-driven resilience tools, services, and best practices, including those developed through the Climate Data Initiative. The toolkit will provide easy access to existing resources as well as new tools, including: interactive sea-level rise maps and a sea-level-rise calculator to aid post-Sandy rebuilding in New York and New Jersey, new NOAA storm surge models and interactive maps from the National Oceanic and Atmospheric Administration that provide risk information by combining tidal data, projected sea levels and storm wave heights, a web-based tool that will allow developers to integrate NASA climate imagery into websites and mobile apps, access to the U.S. Geological Survey's "visualization tool" to assess the amount of carbon absorbed by landscapes, and a Stormwater Calculator and Climate Assessment Tool developed to help local governments assess stormwater-control measures under different precipitation and temperature scenarios.

LEAD INTERNATIONAL EFFORTS TO ADDRESS GLOBAL CLIMATE CHANGE

The Obama Administration is working to build on the actions that it is taking domestically to achieve significant global greenhouse gas emission reductions and enhance climate preparedness through major international initiatives focused on spurring concrete action, including bilateral initiatives with China, India, and other major emitting countries. These initiatives not only serve to support the efforts of the United States and others to achieve our goals for 2020, but also will help us move beyond those and bend the post-2020 global emissions trajectory further. As a key part of this effort, we are also working intensively to forge global responses to climate change through a number of important international negotiations, including the United Nations Framework Convention on Climate Change.

I. Working with Other Countries to Take Action to Address Climate Change

Enhancing Multilateral Engagement with Major Economies: In 2009, President Obama launched the Major Economies Forum on Energy and Climate, a high-level forum that brings together 17 countries that account for approximately 75 percent of global greenhouse gas emissions, in order to support the international climate negotiations and spur cooperative action to combat climate change. The Forum has been successful on both fronts – having contributed significantly to progress in the broader negotiations while also launching the Clean Energy Ministerial to catalyze the development and deployment of clean energy and efficiency solutions. We are proposing that the Forum build on these efforts by launching a major initiative this year focused on further accelerating efficiency gains in the buildings sector, which accounts for approximately one-third of global carbon pollutions from the energy sector.

Expanding Bilateral Cooperation with Major Emerging Economies:
From the outset, the Obama Administration has sought to intensify bilateral climate cooperation with key major emerging economies, through initiatives like the U.S.-China Clean Energy Research Center, the U.S.-India Partnership to Advance Clean Energy, and the Strategic Energy Dialogue with Brazil.

We will be building on these successes and finding new areas for cooperation in the second term, and we are already making progress: Just this month, President Obama and President Xi Jinping of China reached an historic agreement at their first summit to work to use the expertise and institutions of the Montreal Protocol to phase down the consumption and production of HFCs, a highly potent greenhouse gas. The impact of phasing out HFCs by 2050 would be equivalent to the elimination of two years' worth of greenhouse gas emissions from all sources.

Combatting Short-Lived Climate Pollutants: Pollutants such as methane, black carbon, and many HFCs are relatively short-lived in the atmosphere, but have more potent greenhouse effects than carbon dioxide. In February 2012, the United States launched the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollution, which has grown to include more than 30 country partners and other key partners such as the World Bank and the U.N. Environment Programme. Major efforts include reducing methane and black carbon from waste and landfills. We are also leading through the Global Methane Initiative, which works with 42 partner countries and an extensive network of over 1,100 private sector participants to reduce methane emissions.

Reducing Emissions from Deforestation and Forest Degradation: Greenhouse gas emissions from deforestation, agriculture, and other land use constitute approximately one-third of global emissions. In some developing countries, as much as 80 percent of these emissions come from the land sector. To meet this challenge, the Obama Administration is working with partner countries to put in place the systems and institutions necessary to significantly reduce global land-use-related emissions, creating new models for rural development that generate climate benefits, while conserving biodiversity, protecting watersheds, and improving livelihoods.

In 2012 alone, the U.S. Agency for International Development's bilateral and regional forestry programs contributed to reducing more than 140 million tons of carbon dioxide emissions, including through support for multilateral initiatives such as the Forest Investment Program and the Forest Carbon Partnership Facility. In Indonesia, the Millennium Challenge Corporation is funding a five-year "Green Prosperity" program that supports environmentally sustainable, low carbon economic development in select districts.

The Obama Administration is also working to address agriculture-driven deforestation through initiatives such as the Tropical Forest Alliance 2020, which brings together governments, the private sector, and civil society to reduce tropical deforestation related to key agricultural commodities, which we will build upon.

Expanding Clean Energy Use and Cut Energy Waste: Roughly 84 percent of current carbon dioxide emissions are energy-related and about 65 percent of all greenhouse gas emissions can be attributed to energy supply and energy use. The Obama Administration has promoted the expansion of renewable, clean, and efficient energy sources and technologies worldwide through:

- Financing and regulatory support for renewable and clean energy projects
- Actions to promote fuel switching from oil and coal to natural gas or renewables
- Support for the safe and secure use of nuclear power
- Cooperation on clean coal technologies
- Programs to improve and disseminate energy efficient technologies

In the past three years we have reached agreements with more than 20 countries around the world, including Mexico, South Africa, and Indonesia, to support low emission development strategies that help countries to identify the best ways to reduce greenhouse gas emissions while growing their economies. Among the many initiatives that we have launched are:

- The U.S. Africa Clean Energy Finance Initiative, which aligns grant-based assistance with project planning expertise from the U.S. Trade and Development Agency and financing and risk mitigation tools from the U.S. Overseas Private Investment Corporation to unlock up to $1 billion in clean energy financing.

- The U.S.-Asia Pacific Comprehensive Energy Partnership, which has identified $6 billion in U.S. export credit and government financing to promote clean energy development in the Asia-Pacific region.

Looking ahead, we will target these and other resources towards greater penetration of renewables in the global energy mix on both a small and large scale, including through our

participation in the Sustainable Energy for All Initiative and accelerating the commercialization of renewable mini-grids. These efforts include:

- **Natural Gas.** Burning natural gas is about one-half as carbon-intensive as coal, which can make it a critical "bridge fuel" for many countries as the world transitions to even cleaner sources of energy. Toward that end, the Obama Administration is partnering with states and private companies to exchange lessons learned with our international partners on responsible development of natural gas resources. We have launched the Unconventional Gas Technical Engagement Program to share best practices on issues such as water management, methane emissions, air quality, permitting, contracting, and pricing to help increase global gas supplies and facilitate development of the associated infrastructure that brings them to market. Going forward, we will promote fuel-switching from coal to gas for electricity production and encourage the development of a global market for gas. Since heavy-duty vehicles are expected to account for 40 percent of increased oil use through 2030, we will encourage the adoption of heavy duty natural gas vehicles as well.

- **Nuclear Power.** The United States will continue to promote the safe and secure use of nuclear power worldwide through a variety of bilateral and multilateral engagements. For example, the U.S. Nuclear Regulatory Commission advises international partners on safety and regulatory best practices, and the Department of Energy works with international partners on research and development, nuclear waste and storage, training, regulations, quality control, and comprehensive fuel leasing options. Going forward, we will expand these efforts to promote nuclear energy generation consistent with maximizing safety and nonproliferation goals.

- **Clean Coal.** The United States works with China, India, and other countries that currently rely heavily on coal for power generation to advance the development and deployment of clean coal technologies. In addition, the U.S. leads the Carbon Sequestration Leadership Forum, which engages 23 other countries and economies on carbon capture and sequestration technologies. Going forward, we will continue to use these bilateral and multilateral efforts to promote clean coal technologies.

- **Energy Efficiency.** The Obama Administration has aggressively promoted energy efficiency through the Clean Energy Ministerial and key bilateral programs. The cost-effective opportunities are enormous: The Ministerial' s Super-Efficient Equipment and Appliance Deployment Initiative and its Global Superior Energy Performance Partnership are helping to accelerate the global adoption of standards and practices that would cut energy waste equivalent to more than 650 mid-size power plants by 2030. We will work to expand these efforts focusing on several critical areas, including: improving building efficiency, reducing energy consumption at water and wastewater treatment facilities, and expanding global appliance standards.

Negotiating Global Free Trade in Environmental Goods and Services: The U.S. will work with trading partners to launch negotiations at the World Trade Organization towards global free trade in environmental goods, including clean energy technologies such as solar, wind, hydro and geothermal. The U.S. will build on the consensus it recently forged among the 21 Asia-Pacific Economic Cooperation (APEC) economies in this area. In 2011, APEC economies agreed to reduce tariffs to 5 percent or less by 2015 on a negotiated list of 54 environmental goods. The

APEC list will serve as a foundation for a global agreement in the WTO, with participating countries expanding the scope by adding products of interest. Over the next year, we will work towards securing participation of countries which account for 90 percent of global trade in environmental goods, representing roughly $481 billion in annual environmental goods trade. We will also work in the Trade in Services Agreement negotiations towards achieving free trade in environmental services.

Phasing Out Subsidies that Encourage Wasteful Consumption of Fossil Fuels: The International Energy Agency estimates that the phase-out of fossil fuel subsidies – which amount to more than $500 billion annually – would lead to a 10 percent reduction in greenhouse gas emissions below business as usual by 2050. At the 2009 G-20 meeting in Pittsburgh, the United States successfully advocated for a commitment to phase out these subsidies, and we have since won similar commitments in other fora such as APEC. President Obama is calling for the elimination of U.S. fossil fuel tax subsidies in his Fiscal Year (FY) 2014 budget, and we will continue to collaborate with partners around the world toward this goal.

Leading Global Sector Public Financing Towards Cleaner Energy: Under this Administration, the United States has successfully mobilized billions of dollars for clean energy investments in developing countries, helping to accelerate their transition to a green, low-carbon economy. Building on these successes, the President calls for an end to U.S. government support for public financing of new coal plants overseas, except for (a) the most efficient coal technology available in the world's poorest countries in cases where no other economically feasible alternative exists, or (b) facilities deploying carbon capture and sequestration technologies. As part of this new commitment, we will work actively to secure the agreement of other countries and the multilateral development banks to adopt similar policies as soon as possible.

Strengthening Global Resilience to Climate Change: Failing to prepare adequately for the impacts of climate change that can no longer be avoided will put millions of people at risk, jeopardizing important development gains, and increasing the security risks that stem from climate change. That is why the Obama Administration has made historic investments in bolstering the capacity of countries to respond to climate-change risks. Going forward, we will continue to:

- Strengthen government and local community planning and response capacities, such as by increasing water storage and water use efficiency to cope with the increased variability in water supply

- Develop innovative financial risk management tools such as index insurance to help smallholder farmers and pastoralists manage risk associated with changing rainfall patterns and drought

- Distribute drought-resistant seeds and promote management practices that increase farmers' ability to cope with climate impacts.

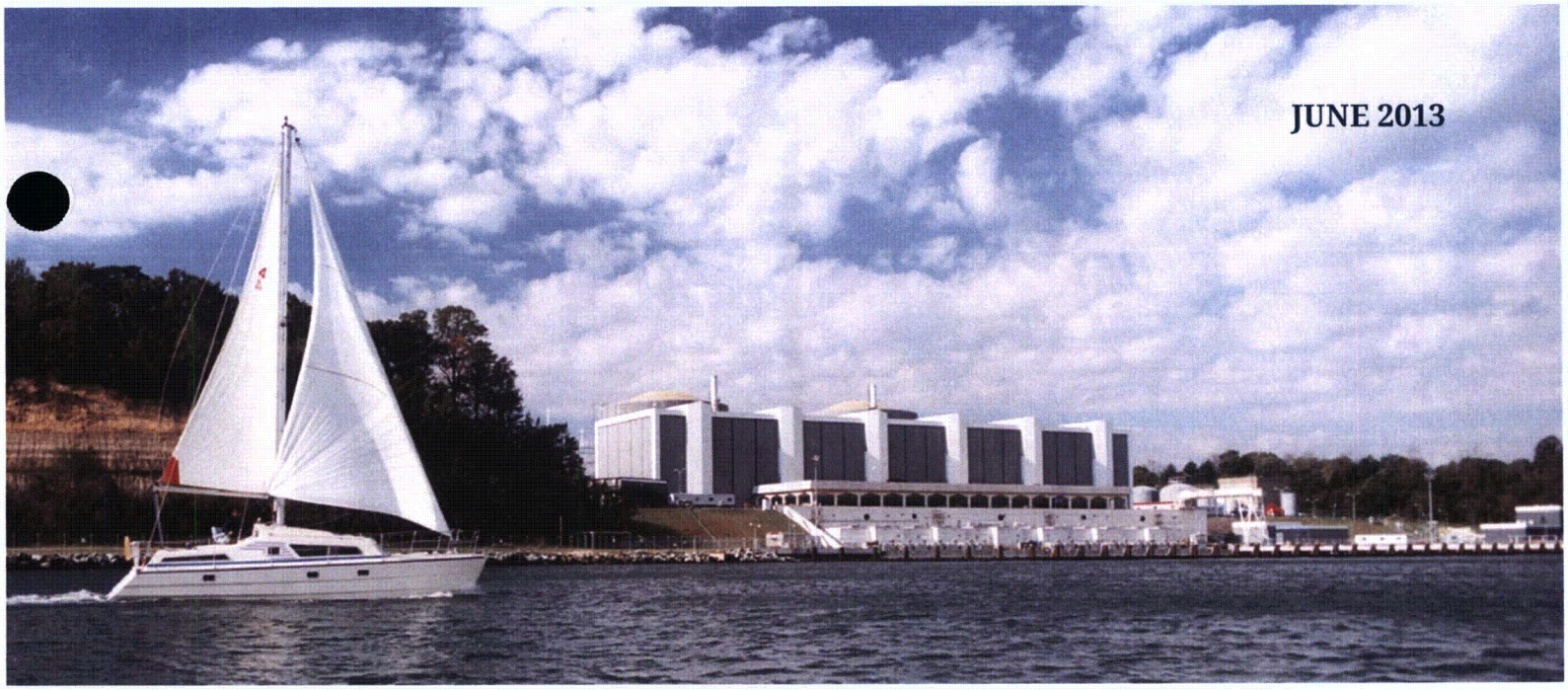
Mobilizing Climate Finance: International climate finance is an important tool in our efforts to promote low-emissions, climate-resilient development. We have fulfilled our joint developed country commitment from the Copenhagen Accord to provide approximately $30 billion of climate assistance to developing countries over FY 2010-FY 2012. The United States contributed approximately $7.5 billion to this effort over the three year period. Going forward, we will seek

to build on this progress as well as focus our efforts on combining our public resources with smart policies to mobilize much larger flows of private investment in low-emissions and climate resilient infrastructure.

II. Leading Efforts to Address Climate Change through International Negotiations

The United States has made historic progress in the international climate negotiations during the past four years. At the Copenhagen Conference of the United Nations Framework Convention on Climate Change (UNFCCC) in 2009, President Obama and other world leaders agreed for the first time that all major countries, whether developed or developing, would implement targets or actions to limit greenhouse emissions, and do so under a new regime of international transparency. And in 2011, at the year-end climate meeting in Durban, we achieved another breakthrough: Countries agreed to negotiate a new agreement by the end of 2015 that would have equal legal force and be applicable to all countries in the period after 2020. This was an important step beyond the previous legal agreement, the Kyoto Protocol, whose core obligations applied to developed countries, not to China, India, Brazil or other emerging countries. The 2015 climate conference is slated to play a critical role in defining a post-2020 trajectory. We will be seeking an agreement that is ambitious, inclusive and flexible. It needs to be ambitious to meet the scale of the challenge facing us. It needs to be inclusive because there is no way to meet that challenge unless all countries step up and play their part. And it needs to be flexible because there are many differently situated parties with their own needs and imperatives, and those differences will have to be accommodated in smart, practical ways.

At the same time as we work toward this outcome in the UNFCCC context, we are making progress in a variety of other important negotiations as well. At the Montreal Protocol, we are leading efforts in support of an amendment that would phase down HFCs; at the International Maritime Organization, we have agreed to and are now implementing the first-ever sector-wide, internationally applicable energy efficiency standards; and at the International Civil Aviation Organization, we have ambitious aspirational emissions and energy efficiency targets and are working towards agreement to develop a comprehensive global approach.



JUNE 2013

Restoring U.S. Leadership in Nuclear Energy

A National Security Imperative

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

The CSIS Commission on Nuclear Energy Policy in the United States

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A National Security Imperative

THE CSIS COMMISSION ON NUCLEAR ENERGY POLICY IN THE UNITED STATES

A Report of the CSIS Nuclear Energy Program

June 2013

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ABOUT THE CSIS NUCLEAR ENERGY PROGRAM

The Nuclear Energy Program at CSIS collaborates with industry, government, and the non-governmental sector to address the challenges facing the peaceful use of nuclear energy, including the challenges to the existing U.S. fleet. The case for U.S. leadership in nuclear energy, domestically and globally, is based on various dimensions of national security benefits to the U.S. While there are several critical areas of focus going forward, a principal area of immediate focus in the program will be the development and deployment of Small Modular Reactors (SMRs).

The United States may face a substantial contraction of commercial nuclear energy in the coming years. Very low prices for natural gas have fundamentally transformed the energy economy, with many positive benefits, but in so doing also contributed to a reduction in the competitiveness of commercial nuclear power. In addition, state and federal mandates and direct and indirect subsidies for renewable energy—particularly wind—create market distortions in the electricity sector that contribute to undermining the economic viability of nuclear power. Together, these forces are causing nuclear energy facilities to become increasingly uneconomic, particularly in competitive state electricity markets. Indeed, as many as a quarter of commercial nuclear energy facilities in America are cash-flow negative, or may be soon, or could be facing difficult investment decisions which may lead to early shutdowns.

Such a contraction would have a significant impact beyond the commercial nuclear energy sector, affecting university physics and engineering programs, materials, science laboratories, manufacturers, labor programs for training nuclear welders, and much more. It would undoubtedly affect the defense establishment and our nuclear Navy's capabilities, as well as the United States' ability to shape global standards for safety, security, operations, emergency response and nonproliferation.

Ongoing Work:

- Promote policies that ensure regulatory prioritization and increase regulatory certainty for the commercial nuclear energy sector.
- Educate policymakers on the market distortions created by certain targeted mandates and subsidies (direct and indirect) that put additional pressure on the economic viability of nuclear power, thus undermining U.S. national interests.
- Model the impact of a significant reduction in the number of operating nuclear power plants on the U.S. economy and defense establishment, including forecasting scenarios depicting a significant sectoral collapse. Conversely, model the impact of a healthy sectoral expansion.
- Advance the development and deployment of small modular reactors (SMRs) in a manner to support U.S. interests. Include consideration for deployment at military bases and government facilities, helping to insulate those facilities from cyber attack, while providing clean and reliable electricity.
- Encourage policies that result in the expansion of export markets for U.S. companies to help preserve domestic manufacturing capacity for nuclear technologies.

About the CSIS Commission on Nuclear Energy Policy in the United States

The CSIS Commission on Nuclear Energy in the United States is made up of senior public and private sector officials from across the political spectrum who agree that nuclear energy is an important part of this country's energy mix and that the United States is losing ground as other countries proceed with planned expansions of their nuclear sectors.

Concerns about the national security implications of a diminished U.S. presence in the global nuclear energy market are real. The Commission has provided insights on the benefits and challenges associated with nuclear energy, laying a foundation for public policy in this area. A variety of areas have been considered including environmental considerations, financial structuring, safety, regulatory structures, nonproliferation, trade, domestic economic impact, infrastructure contribution, national security, and waste.

Commission Structure and Events

- The Commission convened at CSIS on September 14th, 2011 to review the project's goals and agree on areas of work for a draft report.
- High-level subgroups made up of commissioners and outside advisors with expertise in a variety of areas provided input for critical work areas including financial structuring, implications of the Fukushima disaster, supply chain and labor concerns, opportunities for global collaboration, and national security implications.
- Throughout 2012, the CSIS U.S. Nuclear Energy Project staff engaged experts in various areas of industry and government to gain insight on the challenges facing nuclear energy and recommendations for next steps.
- The Commission's goals included providing recommendations that are substantive and actionable; this final report is intended to be a comprehensive, bipartisan, and credible treatment of this critical topic.

THE CSIS COMMISSION ON NUCLEAR ENERGY POLICY IN THE UNITED STATES

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* Commissioner Ayers served until his untimely death in April 2012. He was a great friend and adviser and we dedicate this report to his memory.

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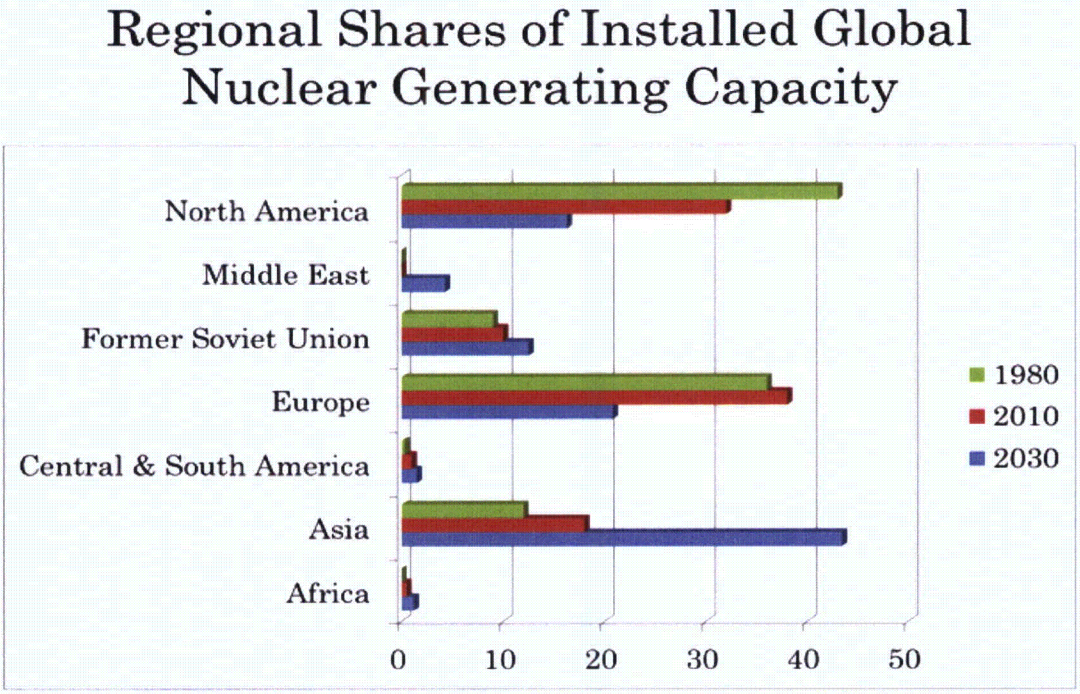
EXECUTIVE SUMMARY

RESTORING U.S. LEADERSHIP IN NUCLEAR ENERGY: A NATIONAL SECURITY IMPERATIVE

America's nuclear energy industry is in decline. Low natural gas prices, financing hurdles, failure to find a permanent repository for high-level nuclear waste, reactions to the Fukushima accident in Japan, and other factors are hastening the day when existing U.S. reactors become uneconomic, while making it increasingly difficult to build new ones. Two generations after the United States took this wholly new and highly sophisticated technology from laboratory experiment to successful commercialization, our nation is in danger of losing an industry of unique strategic importance and unique promise for addressing the environmental and energy security demands of the future.

The decline of the U.S. nuclear energy industry could be much more rapid than policymakers and stakeholders anticipate. With 102 operating reactors and the world's largest base of installed nuclear capacity, it has been widely assumed that the United States—even without building many new plants—would continue to have a large presence in this industry for decades to come. Instead, current market conditions are such that growing numbers of units face unprecedented financial pressures and could be retired early. Early retirements, coupled with scheduled license expirations and dim prospects for new construction, point to diminishing domestic opportunities for U.S. nuclear energy firms.

The outlook is much different in China, India, Russia, and other countries, where governments are looking to significantly expand their nuclear energy commitments. Dozens of new entrants plan



Sources: U.S. Energy Information Administration - http://www.eia.gov/todayinenergy/detail.cfm?id=6310 (historical data); McKinsey & Co (2030 forecast)

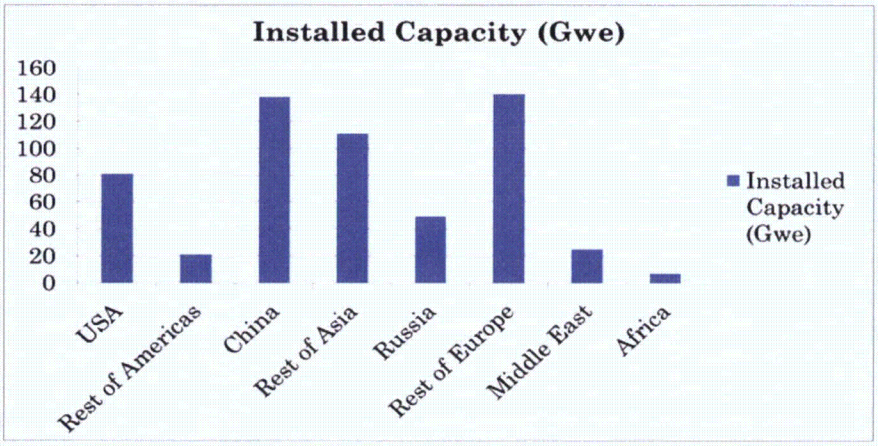
on adding nuclear technology to their generating mix, furthering the spread of nuclear materials and know-how around the globe. It is in our nation's best interest that U.S. companies meet a significant share of this demand for nuclear technology—not simply because of trade and employment benefits, but because exports of U.S.-origin technology and materials are accompanied by conditions that protect our nonproliferation interests. Yet U.S. firms are currently at a competitive disadvantage in global markets due to restrictive and otherwise unsupportive export policies. U.S. efforts to facilitate peaceful uses of nuclear technology helped build a global nuclear energy infrastructure—but that infrastructure could soon be dominated by countries with less proven nonproliferation records. Without a strong commercial presence in new nuclear markets, America's ability to influence nonproliferation policies and nuclear safety behaviors worldwide is bound to diminish.

In this context, federal action to reverse the U.S. nuclear industry's impending decline is a national security imperative. The United States cannot afford to become irrelevant in a new nuclear age. This brief outlines why.

MAKING THE CONNECTION: HOW A STRONG CIVIL NUCLEAR INDUSTRY SUPPORTS U.S. NATIONAL SECURITY OBJECTIVES

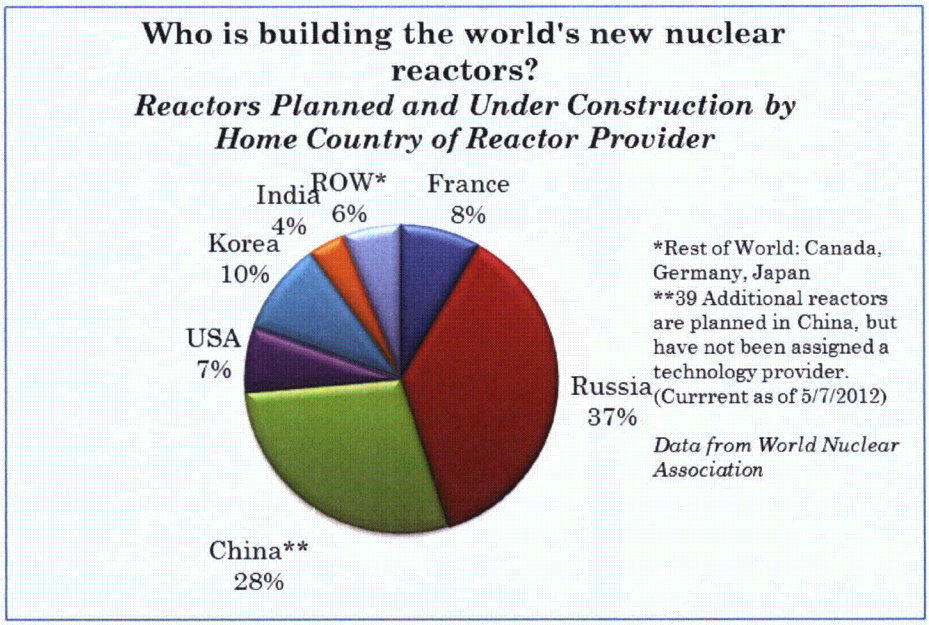
From the start of the nuclear era until the 1980s, the United States was the dominant global supplier of commercial nuclear energy technology. American leadership was instrumental in shaping the global nuclear nonproliferation regime and nuclear safety norms. A strong domestic nuclear program and supportive government policies helped sustain this dominant position. Today, the United States continues to exercise influence by virtue of its economic power and recognized expertise in facility operations, safety, and security. But our nation's ability to promote nonproliferation and other national security objectives through peaceful nuclear cooperation has diminished.

Projected Installed Global Nuclear Generating Capacity - 2030



Source: McKinsey & Co (2030 forecast)

An important source of U.S. leverage in the past was the ability to provide reliable nuclear technologies, fuel, and services to countries under strict nonproliferation controls and conditions. These controls and conditions go beyond provisions in the Treaty on the Non-Proliferation of Nuclear Weapons and include nine criteria that the United States applies to any agreement with a nonnuclear weapon state: for example, a guarantee that the recipient state will not enrich or reprocess transferred nuclear material without U.S. approval.



Today, much of the world's nuclear manufacturing and supply capability still relies on designs and technologies developed in the United States. But the firms involved are largely foreign-owned. Even in the market for conventional light-water reactors, where the United States led the world for decades, all but one of the U.S.-based designers and manufacturers have been acquired by non-U.S.-based competitors.

The countries that are currently strengthening their nuclear capabilities and global market position (i.e., France, Japan, South Korea, and Russia, with China close behind) have different reasons for pursuing nuclear technology—some are primarily concerned about energy security or about preserving domestic fossil fuel resources, while others may be motivated by a mix of nationalistic and geopolitical considerations. But in all cases they see nuclear technology as offering long-term benefits that justify a significant near-term sovereign investment, even faced with the prospect that world natural gas prices may fall if the unconventional gas production technologies in use in the United States are successfully applied in other parts of the world.

The most aggressive of these new national nuclear programs is underway in China. By 2020, China could have 50 commercial reactors in operation, compared with only 3 in 2000. India could add 7 new plants—and Russia, 10—in the next five years. These trends are expected to accelerate out to 2030, by which time China, India, and Russia could account for nearly 40 percent of global nuclear generating capacity.

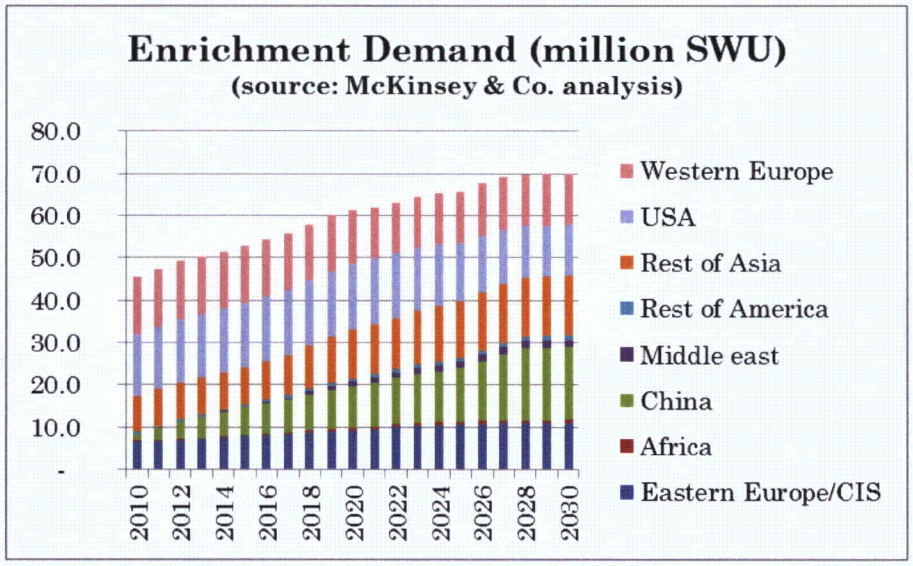
Meanwhile, many smaller nations—mostly in Asia and the Middle East—are planning to get into the nuclear energy business for the first time. In all, as many as 15 new nations could have nuclear generating capacity within the next two decades, added to the more than 30 countries that have it today or have had it in the past.

The national security concern is that much of this new interest in nuclear power is coming from countries and regions that may not share America's interests and priorities in the areas of nonproliferation and global security. And our leverage to influence their nuclear programs will be weak at best if U.S. companies cannot offer the technologies, services, and expertise these countries need to operate a successful nuclear program (including not only reactors, but other fuel-cycle facilities).

Expanded nuclear electricity generation outside the United States will drive a commensurate increase in the demand for enriched uranium. The facilities needed to supply this demand—

because they can be used to produce both nuclear fuel and nuclear weapons-usable material—are of particular national security concern.

During the 1960s, the U.S. operated the only uranium enrichment facility wholly dedicated to producing low-enriched uranium (LEU) for commercial purposes. Today, the single U.S.-based enrichment company, USEC, accounts for less than 20 percent of global LEU production capacity. USEC recently announced the shutdown of uranium enrichment at its only operating plant in Paducah, Kentucky, which was viewed as being outdated and too inefficient to be competitive with foreign suppliers.



In fact, much of the fuel used in U.S. reactors today is fabricated from imported enriched uranium obtained by USEC under a very successful agreement with the Russian government to supply down-blended highly enriched uranium, a contract that expires in 2013. Although USEC plans to replace the aging Paducah plant with a more advanced facility, prospects for following through on this plan are far from certain. Meanwhile, the European uranium enrichment company (Urenco) is expanding its market share worldwide with several new facilities planned or under construction in Europe and the United States. In addition, Russia is taking steps to modernize its enrichment services capability. All told, the U.S. share of global exports for enriched uranium and other sensitive nuclear materials declined from approximately 29 percent in 1994 to 10 percent in 2008.

A healthy domestic nuclear infrastructure also serves our national security interests by supporting the nuclear propulsion program of the U.S. Navy, which operates a fleet of 83 nuclear-powered submarines and aircraft carriers. While the Navy is careful to develop sources of supply that can weather short-term ups and downs in the commercial industry, a sustained decline in the commercial industry could have a direct and negative impact on the naval program.

Finally, the U.S. nuclear industry contributes to energy security at home. Today, nuclear power plants supply nearly 20 percent of U.S. electricity needs while also playing a central role in assuring grid reliability in several regions of the county and avoiding significant air pollution and greenhouse gas emissions. Yet with uncertainty about the prospects for new plant construction over the next decade and with nearly all existing plants scheduled to be shut down by 2050, the share of electricity generated by nuclear reactors in the United States will decline steadily to near zero by mid-century. By that time, the United States could be host to as little as 2 percent of global installed nuclear capacity—down from 25 percent today.

REBUILDING THE U.S. NUCLEAR ENERGY INDUSTRY—FORMIDABLE CHALLENGES

Nuclear power has been an important part of the U.S. energy mix for decades. Today's economics, however, do not support the construction of new nuclear power plants, in the United States, where a recent significant drop in natural gas prices is radically altering the competitive outlook for different generation options. It is no coincidence that new nuclear commitments are being made in countries where the government is the primary investor. Unlike private investors, governments can take a longer view and can factor non-economic considerations into their energy choices. They have the ability and an obligation to act in support of the broader national interest.

In the United States, where energy resource decisions are left largely to the market, the challenge is to forge bipartisan political support for policies that help align private incentives with the national interest. This is particularly difficult at a time when extreme constraints on public spending and deep distrust of government intervention and large energy companies alike make a comprehensive energy strategy unlikely. But if a vibrant commercial nuclear industry is critical for U.S. long-term energy and national security, the federal government must act to address the drivers of the industry's decline. That means both ensuring that U.S. export policies enable U.S. companies to compete successfully in international markets and overcoming hurdles that threaten to preclude new nuclear investments in the United States for the foreseeable future.

EXPORT MARKET CHALLENGES

America's declining role in global export markets for nuclear technology represents a major lost opportunity in terms of jobs, technological leadership, and our nation's balance of trade. It is also a critical national security issue, for all the reasons discussed above. Reversing this decline requires a critical look at current U.S. export policies and at options for helping American companies compete more effectively with foreign suppliers.

A necessary first step is to adopt a consistent and flexible approach to negotiating the "123 Agreements" that currently govern transfers of reactors, reactor components, or special nuclear material, source material, and byproduct material under license for commercial, medical, and industrial purposes to overseas customers (the term refers to Section 123 of the Atomic Energy Act). The United States has Section 123 Agreements in place with 21 individual countries, the European Atomic Energy Community (EURATOM) consortium (which includes 27 countries), Taiwan, and the International Atomic Energy Agency (IAEA). Seven of these agreements are scheduled to expire by 2015 (including those with major trading partners such as China, South Korea, and Taiwan); in addition, the United States does not have agreements in place with several nations that are developing new nuclear programs, including Saudi Arabia and Vietnam. Despite the clear need to renew or establish agreements with nations that are investing in nuclear energy, some members of Congress have advocated for the inclusion of additional restrictions that will make it more difficult to execute such agreements. While the Obama administration earlier announced that 123 Agreements would be negotiated on a case-by-case basis and that no blanket provisions would be pursued in future agreements, most important is putting priority on timely reviews of such agreements. Given the different views of the administration and key congressional leaders, the already-slow 123 Agreement process may grind to a halt.

While debate continues on whether future 123 Agreements contain provisions to restrict the development of enrichment and reprocessing technology within a sovereign nation, approval of a

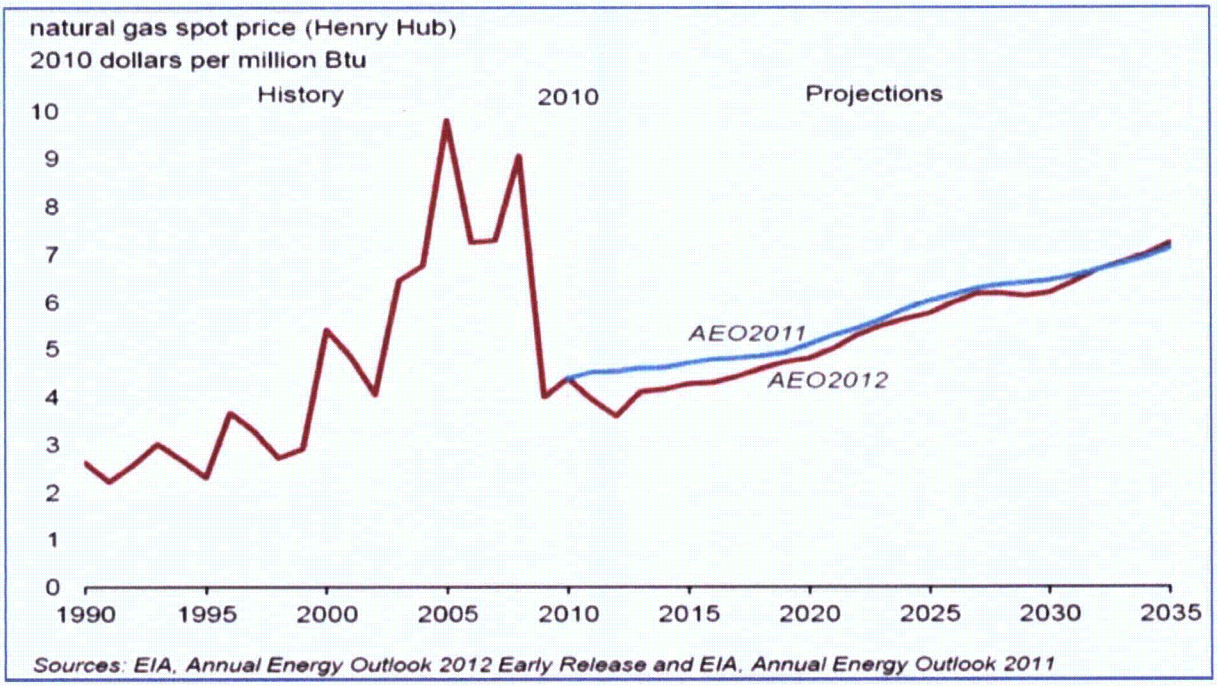
Section 123 Agreement only lays the foundation for U.S. trade in nuclear technology. Detailed export licensing requirements must still be satisfied, such as the 10 CFR Part 810 regulations that control the transfer of technology and other assistance to foreign nuclear energy programs. Recent administration proposals would make these requirements harder to satisfy. And even when agreements have been reached and export requirements have been satisfied, U.S. firms must compete with firms from other nations on the basis of technological competitiveness, cost, and other considerations. While U.S.-based firms still offer some of the most advanced technology available anywhere, they do not benefit, as many of their competitors do, from attractive, government-backed export incentives. Russian exporters—which currently account for more than one-third of the new reactors that are under construction or planned worldwide—at times offer turnkey services and fuel take-back programs, making deals with Russian firms attractive for countries with limited nuclear infrastructure. As a result of these and other factors, and in sharp contrast to our position of a few decades ago, the United States has become a net importer of nuclear components and materials.

Looking ahead to future markets, some 60 countries that do not currently have nuclear power plants have approached the IAEA to explore the possibility of acquiring one. The IAEA anticipates that about 15 of these aspiring nuclear nations will proceed to build one or more reactors over the next decade or two. In many of these nations (and in some nations that already have nuclear energy), a large nuclear plant may be poorly suited to local needs. Small modular reactors (SMRs) may offer a better fit for nations with smaller or slower-growing electrical demand. Cooperative public-private efforts are underway in the United States to explore the commercial potential of SMR technology, but the present pace of development may be insufficient to prevent other nations from capturing the lion's share of this potential new market.

DOMESTIC CHALLENGES

The challenges facing new nuclear plants in the United States come primarily in four areas: cost, waste management, regulation, and public acceptance.

High capital costs, together with long timeframes for licensing and construction and the increasing cost-competitiveness of alternative forms of generation, mean that new nuclear power plants are effectively out of the running compared to other generation options. Simply put, nuclear plants are large, long-term investments that often don't fit the needs of the small and diverse set of U.S. utilities that are focused primarily on meeting near-term business objectives. This is particularly true in markets in the United States and in some other nations where nuclear has to compete with low-cost gas and where utility-sector deregulation means no guarantee of cost recovery (see figure below; note that spot prices are roughly $4 per million BTU). Unfortunately, the incentives introduced under the Energy Policy Act of 2005—including loan guarantees and standby insurance—have met with limited success. While four new reactors are being built in Georgia and South Carolina—which is an important and positive development—the EPAct incentives have failed to produce more than a handful of new plant commitments in the United States. Future designs, such as small modular reactors, may reduce some of these competitive disadvantages, but a lack of field experience makes meaningful cost comparisons difficult at this time.



Access to financing is particularly challenging when the amount of capital required to build a new two-unit plant is upwards of $10 billion. Financing a civil nuclear facility, even with favorable economics, has long been a daunting undertaking for most private investors, particularly given the history of cost overruns with nuclear plant construction. New nuclear builds may therefore demand the involvement of large industrial companies, sovereign wealth, or other entities that have access to large amounts of capital and can take a long view of investment risks and returns.

Waste management has stood for decades as a barrier to the growth of nuclear energy in the United States. Several states have laws that ban construction of new nuclear plants until the waste issue is resolved. More broadly, the lack of a waste-disposal solution has damaged the credibility of, and undermined public confidence in, nuclear power as an energy source.

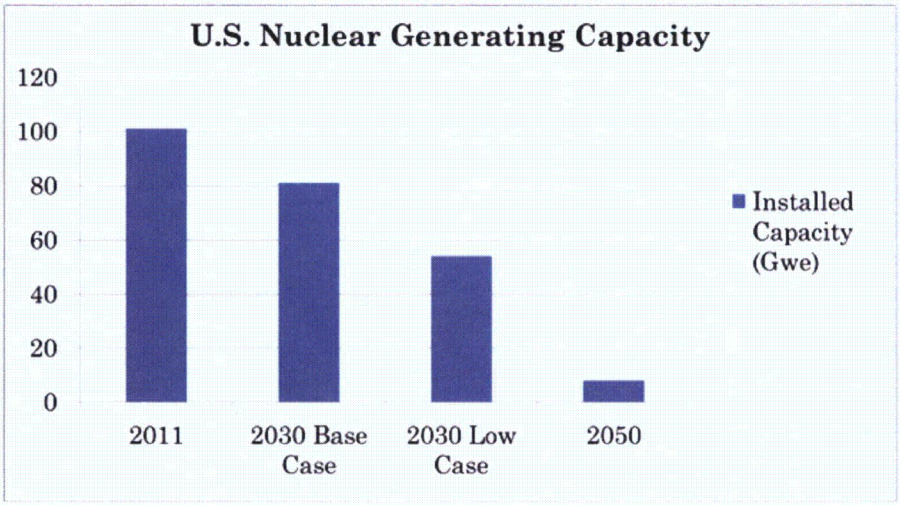
The recent report of the Blue Ribbon Commission on America's Nuclear Future found that "this nation's failure to come to grips with the nuclear waste issue has already proved damaging and costly and it will be more damaging and more costly the longer it continues: damaging to prospects for maintaining a potentially important energy supply option for the future, damaging to state–federal relations and public confidence in the federal government's competence, and damaging to America's standing in the world—not only as a source of nuclear technology and policy expertise but as a leader on global issues of nuclear safety, non-proliferation, and security."

If the United States can decide on a course of action to deal with its own spent fuel and other high-level nuclear waste, this could open the door to options such as fuel "take-away" arrangements between the United States and countries with small nuclear programs. Such agreements, which would allow a country to dispose of spent fuel in another country with established disposal capability rather than on its own soil, could have large safety and security benefits, especially if implemented in concert with nonproliferation goals. The United States has had a small but successful security initiative to repatriate spent foreign research reactor fuel for storage and disposal. If a similar program to accept spent fuel from foreign commercial reactors could be

established, this would greatly expand the options available to the United States in advancing its nonproliferation interests, particularly as new, small, and inexperienced nuclear entrants consider their fuel cycle options. Of course, such a program would likely be politically acceptable only in the context of discernible progress toward implementing a permanent disposal solution for U.S. spent fuel.

Increasing Financial Pressures Could Lead to Even More Rapid Reactor Shutdowns by 2030

(Source: McKinsey & Co. analysis)



The U.S. Nuclear Regulatory Commission (NRC) has set the global standard for excellence in nuclear energy regulation and has long served to bolster public confidence in nuclear operations. Yet there is a growing concern that the regulatory burden facing U.S. plant operators will be expanded without commensurate safety benefit, particularly in light of the understandable and appropriate desire to respond quickly to lessons learned from the Fukushima nuclear accident in Japan. It is essential that the NRC and the U.S. nuclear industry work constructively to enhance the safety and security of the U.S. nuclear fleet without placing undue burdens on reactor operators. The U.S. commercial industry has been unrelenting in its quest for excellence. The Institute of Nuclear Power Operations (INPO) has been a strong force for self-regulation and the result has been performance that sets the global standard. Added regulatory requirements when they produce real benefits are good for the industry; additional regulatory costs without appropriate benefits will weigh down otherwise well-performing nuclear facilities and their staff, and would contribute to financial pressures that could lead to even more rapid shutdowns of presently operating nuclear power plants.

Public acceptance of nuclear energy has fallen in the aftermath of the Fukushima accident. While most polls show a majority of Americans still support the use of nuclear energy, opposition to new plants in most parts of the country is still formidable. Sustained operational and regulatory excellence, competent and swift response to safety issues, and a path forward for the nuclear waste program can help turn the tide of public opinion.

RESTORING U.S. NUCLEAR LEADERSHIP—A TOOLKIT FOR POLICYMAKERS

Maintaining nuclear energy infrastructure at home and a leadership role in the nuclear arena abroad should be a national interest priority for the U.S. government. A robust domestic industry will deliver benefits for the American people beyond those recognized in the marketplace. It

therefore warrants support beyond what the market—left to private considerations of risk and reward alone—will provide.

Of course, there is no single policy step the government can take to restore the strength of the U.S. nuclear industry. And government cannot do it all—industry will still need to develop attractive technology offerings and deliver a quality product or service consistent with the cost and schedule requirements of their customers. The goal of government support for the U.S. nuclear energy industry should be to improve the economic picture for nuclear at home and reduce barriers to participating in nuclear commerce abroad in order to increase the overall likelihood that the United States will have a strong domestic nuclear industry. In this section, we offer a range of policy actions that can move us toward this goal.

Many critical issues surrounding nuclear energy have come into sharp focus through the meetings, workshops, interviews, and research undertaken by the U.S. Nuclear Energy Project (USNEP) between March 2011 and June 2012. While our full report provides deeper background on those issues, this summary addresses them at a high level. In some cases, our recommendations echo those of other noteworthy reviews and reports; in other cases, they are a direct outgrowth of the work of USNEP.

BOLSTERING U.S. COMPETITIVENESS IN EXPORT MARKETS

Improving the ability of U.S. firms to compete in the global nuclear marketplace is the highest-priority recommendation of the Commission. Our reasoning is straightforward. A large-scale, government-supported nuclear construction program in the United States would be cost-prohibitive. On the other hand, there are several other nations that have placed a higher priority on the nonmonetary advantages of nuclear energy and are therefore aggressively investing in new reactors. Rather than rest our hopes primarily on an expensive program of domestic industry supports, we believe that recommendations focused on making it easier for U.S. firms to compete have a greater likelihood of being implemented and a greater chance of achieving our goals.

Specifically, we recommend adoption of the following policies:

- 123 Agreements: The negotiation of future 123 Agreements based on individual, unique bilateral relationships—rather than insisting that nations cede their NPT rights to nuclear fuel cycle technologies—is the approach most likely to support U.S. nuclear exports. This policy should be the norm and should be recognized as such by the U.S. Congress, with the understanding that U.S. exporters playing a role in the global nuclear technology trade facilitates continued U.S. leadership in global nuclear nonproliferation goals.
- Part 810 Requirements: Part 810 prohibits U.S. companies from assisting foreign nuclear power programs unless such assistance is authorized by the secretary of energy, following an interagency review process specified by the Atomic Energy Act. These requirements can stand in the way of U.S. nuclear companies' ability to conduct routine business. The current Part 810 rules are already restrictive, but changes proposed by Department of Energy (DOE) staff in 2011 would only make matters worse. We understand that a new revision of the Section 810 rules is being prepared; this version should take into full account the concerns raised by U.S. nuclear firms. Timely completion of reviews should be a priority.
- Government Support for Exports and Export Financing: Despite offering some of the best technology in the world, U.S. providers of nuclear technology find themselves at a

competitive disadvantage due in part to the lack of consistent and coordinated government support for nuclear exports. U.S.-based companies are competing against state-owned or -directed nuclear suppliers overseas that enjoy consistent government support for nuclear technology exports and can offer government-backed financing agreements that are far more attractive than those currently available to facilitate U.S. exports. Given that nuclear exports provide the Unites States with important leverage in nonproliferation, nuclear safety, and other matters, the federal government should issue a clear policy statement in support of nuclear technology exports, should ensure that this policy is implemented consistently by the relevant federal agencies, and should streamline the cumbersome export approval process.

EXPANDED SUPPORT FOR SMR TECHNOLOGY DEVELOPMENT

To regain a competitive edge in international nuclear markets, U.S. firms will need to offer technology that other nations want to buy. Given that the government benefits by having strong U.S. nuclear firms, it is appropriate for technology investments to be supported both by industry and by the federal government.

A specific area where the United States is active and has an opportunity to take a commercial lead is in developing and deploying small modular reactor (SMR) technology, which holds promise for reducing capital expenditure requirements and construction timelines. In particular, the U.S. government could accelerate the development of SMR technology using military and DOE facilities. In recent years, the U.S. Department of Defense (DOD) has become increasingly interested in the potential of SMRs for military applications. This interest stems mainly from two critical vulnerabilities that DOD has identified: the dependence of U.S. military bases on the domestic electrical grid, and the challenge of providing assured energy supply to troops in forward operating locations.

The U.S. government is already investing tens of millions of dollars per year in the development of SMR designs. This effort should be continued and expanded, as envisioned under DOE's current SMR program plans. Going forward, these plans should allow for the parallel development of materials, fabrication, manufacturing, assembly, and operation of SMRs by several different vendors. The idea would be to meet NRC licensing requirements while maintaining flexibility to innovate and iterate throughout the development process.

Following the successful development of SMR technology, vendors should be encouraged to pursue global market opportunities while also advancing the highest U.S. standards for safety, security, reliability, and emergency response as applicable to this new technology. The same economic and financial structuring incentives available for light-water reactors should also be made available for SMRs. Commercialization should be accompanied by adherence to traditional regulatory requirements and NRC oversight as a way to build public confidence in the commercial deployment of this technology.

Looking even longer-term, an aggressive government-industry nuclear research, development, and demonstration (RD&D) program can help form the basis for advanced (Generation IV) nuclear reactor and fuel cycle technologies that may be deployed around the middle of the century. This may seem like a long time horizon, but nuclear energy technologies now take decades to move through the R&D phases to demonstration and into commercial use; the Generation III+ reactor designs being built today in the United States, China, and other nations are based on technologies that entered development in the 1980s. The United States should continue

to invest in similarly long-term R&D, including investments in the university and national laboratory research facility infrastructure needed to develop and demonstrate new nuclear technologies.

SOLVING THE NUCLEAR WASTE CHALLENGE

Demonstrating a credible path forward for nuclear waste management in the United States would both reduce public concerns about nuclear plant construction and satisfy laws in several states that prohibit new plant construction without a solution to the nuclear waste challenge. The dual challenges of spent nuclear fuel management and disposal are addressed at length in the final 2012 report of the Blue Ribbon Commission on America's Nuclear Future and the 2011 MIT Report on the Future of the Nuclear Fuel Cycle. We urge that the U.S. government act on recommendations in these reports as a critical step toward supporting the revival of the nuclear industry in the United States:

- Providing access to the funds nuclear utility ratepayers provide for the purpose of nuclear waste management.
- Establishing a new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
- Implementing a consent-based approach to siting future nuclear waste management facilities.
- Pursuing fuel-leasing options for countries that have or are pursuing small nuclear programs. These options should provide incentives to forego uranium enrichment and should incorporate spent-fuel take-back arrangements.
- Undertaking integrated system studies and experiments on innovative reactor and fuel cycle options, and selecting a limited set of options for more detailed analysis.

EXPANDED PARTICIPATION IN INTERNATIONAL NUCLEAR COOPERATION

The United States is widely respected internationally for its strong independent nuclear regulation and its successful industry self-governance model. The result has been demonstrated by top performance in safety, security, operations, and emergency response, which is recognized globally. The NRC is regularly engaged as the benchmark standard setter for regulators in other countries. The Institute of Nuclear Power Operations (INPO) is routinely approached for leadership and assistance in applying the same principles that govern U.S. industry nuclear operations to other operators around the globe. The World Association of Nuclear Operators (WANO), modeled after INPO, is evolving to influence safe operations globally. More recently, the International Framework for Nuclear Energy Cooperation (IFNEC) has evolved as an influential forum, with 62 participating nations, and a 5-nation steering committee (United States, United Kingdom, France, Japan, and China); it has been embraced by many countries expanding or seeking to enter the realm of nuclear operations as a key opportunity for gaining insight from the experiences of successful nuclear energy nations. IFNEC, in particular, with continued DOE leadership, is an opportune body for bringing forth and reinforcing the standards and principles for responsible and safe nuclear energy operations worldwide. Through these entities and others, the United States should broadly continue to leverage its regulatory and legal framework and its reputation for excellence in all aspects of nuclear energy development and operations to other nations, and especially to emerging nations seeking to establish nuclear energy as a new domestic source of electricity.

ECONOMIC SUPPORT AND FINANCIAL STRUCTURING FOR NEW U.S. REACTORS

A limited set of "first mover" financial incentives at both the federal and state levels can help jump-start the construction of new nuclear power plants in the United States. Below we present a wide array of options and opportunities for encouraging and facilitating investment in new construction. We recognize that the approaches presented below would all be costly and would be quite challenging to enact in this time of tight government budgets. We offer a range of options not with the expectation that all of them will be adopted, but with the conviction that implementing any of these options—at the federal level, within individual states, or both—will improve prospects for building several more new plants in the United States and thus help strengthen the U.S. nuclear industry.

FINANCING

We recommend action in two areas:

- *Loan Guarantees*
  The Loan Guarantee Program established by the Energy Policy Act of 2005 has been implemented in a manner that is inconsistent with the intent of the program and has not proved successful in spurring investment in new nuclear construction in the United States. It should be reviewed and revised in order to provide support for new light-water reactor (LWR) construction and SMR development.

- *Foreign Ownership*
  Encouraging broad opportunities for foreign ownership in new nuclear construction would ease the investment burden on relatively small market cap firms in the United States. Facilitating this will require changes to relevant codes and regulations so sovereign wealth funds, foreign investors, non-U.S.-owned companies, and pension funds are free to invest in U.S. nuclear plants. Foreign ownership should be allowed up to 90 percent of the equity value of the facility, contingent on a U.S.-based owner/operator recognized by the NRC retaining controlling interest. All matters related to the safety, security, and reliability of the facility, including the unalterable right to make capital calls on the owners of the facility in support of the safety, security, and reliability needs of the facility would remain with the U.S. owner/operator.

REVISIONS TO THE TAX CODE

The federal tax code provides mechanisms for the federal government to incent activity that is in the national interest and that the marketplace would not otherwise undertake. The Energy Policy Act of 2005 moved in this direction. Given the experience of the last several years, and the increased gap in the economic viability of new nuclear facilities, further expansion of these mechanisms would be beneficial in the following areas.

- Accelerated Depreciation (also known as "Bonus Depreciation") changes to relevant tax codes are needed to provide for depreciation at the time that investments are made. This kind of incentive provides benefits during the construction period, effectively offsetting the capital requirements for a new plant as it is being constructed.

- Tax Credits—changes to relevant tax codes to provide for a 30 percent investment tax credit upon project completion.[1]
- Property Tax Abatement—encourage state and local authorities to support an approach that excludes new facilities from property taxes for the first 10 years of operation, with a phase in of low tax requirements for the subsequent 5 years.

Monetization of external benefits

Mechanisms to provide monetary recognition of the societal benefits (such as low emissions and electricity supply diversification) of certain forms of energy supply would improve the prospects for new nuclear builds. Such mechanisms would have the effect of increasing the cost-competitiveness of nuclear-generated electricity. Given uncertainty regarding legislation to regulate carbon emissions, a more realistic means of monetizing the external benefits of nuclear-generated electricity may be through power purchase agreements with the U.S. government, including military bases.

INTERNAL GOVERNMENT POLICY COORDINATION

Successful implementation of these recommendations could be better assured if backed by senior-level policy coordination within government. Such coordination could take many forms, and we don't presume to know what arrangements will work best within a given administration or congressional body. Options include but are not limited to:

- A White House directed activity, providing interagency coordination and informed by the Quadrennial Energy Review process underway within DOE;
- A Cabinet member assigned responsibility for interagency coordination; and/or
- Congressional oversight of federal activities, either through a specific mandate to an existing committee(s) or through the establishment of a new oversight entity.

Consideration should also be given to forming a private-sector stakeholder advisory committee with representation from nuclear plant owners and operators, investors, labor groups, nuclear vendors and contractors, the financial sector, state officials, environmental advocates, and other organizations. This group would provide critical expertise and insight from outside the federal government in support of the common goal to maintain nuclear energy as a key component of electricity generation in the United States.

[1] As provided under 26 USC 45; see Database of State Incentives for Renewables and Efficiencies (DESIRE), "Renewable Electricity Production Tax Credit (PTC)," April 2013, http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F.

Chapter 1

NUCLEAR ENERGY IN THE UNITED STATES AND WORLDWIDE: CURRENT STATUS AND OUTLOOK

Nuclear power has been used to produce electricity since the early 1950s. Today there are more than 430 nuclear power reactors, with a total capacity of about 372 gigawatts electric (GWe), operating in 30 countries plus Taiwan.[1] An additional 70 units, totaling more than 60 GWe, are under construction.[2] During 2011, nuclear power produced more than 2.5 trillion kilowatt-hours (kWh) of electricity. Globally, the nuclear energy industry now has about 15,000 reactor-years of operating experience.[3]

The contribution of nuclear energy to total electricity generation varies considerably from country to country and in different parts of the world. In Western Europe, nuclear-generated electricity accounts for almost 27 percent of total electricity supply. In both North America and Eastern Europe, it is approximately 18 percent. In the Far East, nuclear energy accounts for 10 percent of electricity generation, whereas in Africa and Latin America it is 2.1 percent and 2.4 percent, respectively. In the Middle East and South Asia, it accounts for just 1 percent.[4]

As shown above, nuclear energy use is concentrated in technologically advanced countries. Over the past two years the overall contribution of nuclear generation to world electricity production has declined slightly, from 15 percent to less than 14 percent.[5] This decline is largely due to an

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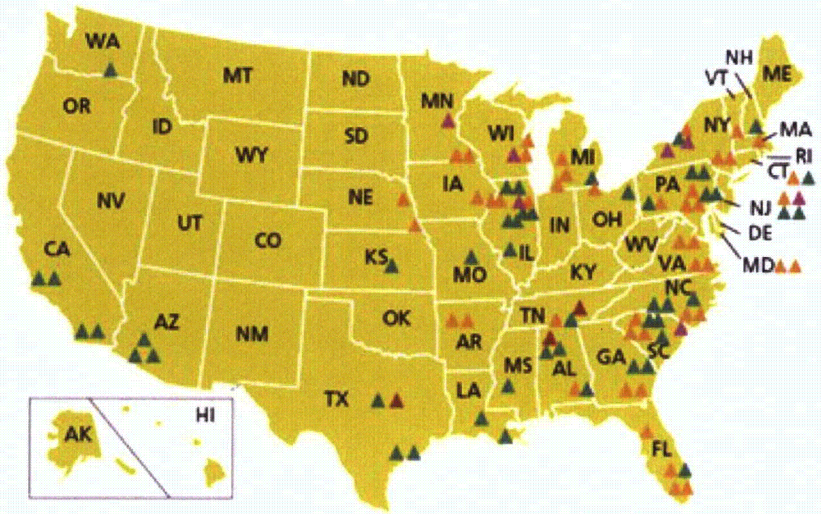
[1] International Atomic Energy Agency (IAEA), Power Reactor Information System (PRIS), "The Database on Nuclear Power Reactors," http://www.iaea.org/PRIS/home.aspx.
[2] Ibid.
[3] Ibid, p. 4.
[4] Ibid.
[5] "Global Commercial Nuclear Power Capacity Outlook for 2030," McKinsey & Company, February 2012.

increase in total electricity generation worldwide without a commensurate increase in the nuclear contribution.[6]

A number of countries with existing nuclear power programs have significantly expanded investment in future nuclear power plants. From 2008 to 2012, there were 49 construction starts around the world, extending a growth trend that started in 2003 (however, in 2011, the number of new starts fell to 2).[7] Notably, in 2008 and 2009, all of the 22 construction starts were pressurized water reactors (PWRs) in three countries: China, the Republic of Korea, and Russia.[8]

The United States currently has 102 commercial reactors in operation with a total generating capacity of 101 GWe. These reactors produce about 19 percent of U.S. electricity. Four new units (two at the Vogtle site in Georgia and two at the V. C. Summer site in South Carolina) are under construction. Construction of one partially completed reactor (at the Tennessee Valley Authority's Watts Bar site) resumed in 2007 with a target completion date of December 2015. Planning for about two dozen other new reactors has been underway; these plants are in various stages of the licensing process but none is expected to be in operation prior to 2020.

U.S. Commercial Nuclear Power Reactors—Years of Operation by the End of 2010



Years of Commercial Operation	Number of Reactors
△ 0–9	0
▲ 10–19	3
▲ 20–29	48
▲ 30–39	46
▲ 40 plus	7

Note: Ages have been rounded up to the end of the year.

Source: U.S. Nuclear Regulatory Commission

[6] Ibid., p. 5.
[7] Fiona Harvey et al., "Dramatic fall in new nuclear power stations after Fukushima," *The Guardian*, March 8, 2012, http://www.guardian.co.uk/environment/2012/mar/08/fall-nuclear-power-stations-fukushima.
[8] IAEA, Power Reactor Information System, http://www.iaea.org/PRIS/home.aspx.

The U.S. military is also a major user of nuclear-generated energy: about 40 percent of the major combat vessels in the U.S. Navy are nuclear powered. The Navy operates a fleet of 83 nuclear-powered submarines and aircraft carriers, which together employ a total of 103 nuclear reactors (aircraft carriers have at least 2 and as many as 8 reactors per vessel).[9] In 2008, the Navy began work on the Gerald R. Ford class of nuclear-powered aircraft carriers—the first of these carriers is slated to be delivered in 2015 and will replace the USS Enterprise (pictured at right), which was deployed in 1961.[10]

THE OUTLOOK FOR COMMERCIAL NUCLEAR ENERGY IN THE UNITED STATES

The outlook for commercial nuclear energy in the United States and abroad has changed considerably over just the past five years. This section provides a brief overview of some of the reasons for this change; a more detailed discussion of the specific challenges that nuclear energy confronts in the United States can be found in Chapter 3 of this report.

In terms of the domestic market for nuclear energy, by far the most important recent development has been a sharp decline in natural gas prices.[11] As a result, the cost of gas-fired electricity—which is driven largely by natural gas price—has fallen by nearly half over the past four years.[12] This drop in price has contributed to a large increase in the amount of U.S. electricity generated from natural gas, from 18.5 percent in 2003, to 21.6 percent in 2007, and to 30 percent in 2012.[13]

At the same time, increased safety and security requirements have considerably increased fixed operating costs for existing nuclear power plants.[14] This trend is expected to continue as new requirements are being imposed in the aftermath of the Fukushima-Daiichi accident in Japan.[15]

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[9] U.S. Department of Energy, "FY 2013 Congressional Budget Request," Volume 1, p. 482, http://energy.gov/sites/prod/files/FY13Volume1.pdf.
[10] See naval-technology.com, "Gerald R. Ford Class (CVN 78/79)—U.S. Navy CVN 21 Future Carrier Programme, United States of America," http://www.naval-technology.com/projects/cvn-21/.
[11] U.S. Energy Information Agency, Natural Gas, http://www.eia.gov/dnav/ng/hist/n9190us3a.htm.
[12] See electricity production cost data at Nuclear Energy Institute, http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/graphicsandcharts/uselectricityproductioncostsandcomponents/.
[13] U.S. Energy Information Administration, Electric Power Monthly, Data for February 2013, see http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_1_1.
[14] MIT, "The Future of the Nuclear Fuel Cycle," 2011, http://mitei.mit.edu/system/files/The_Nuclear_Fuel_Cycle-all.pdf.
[15] Nuclear Regulatory Commission, "Implementing Lessons Learned from Fukushima," http://www.nrc.gov/reactors/operating/ops-experience/japan-info.html.

THE FUTURE OF CHEAP GAS?

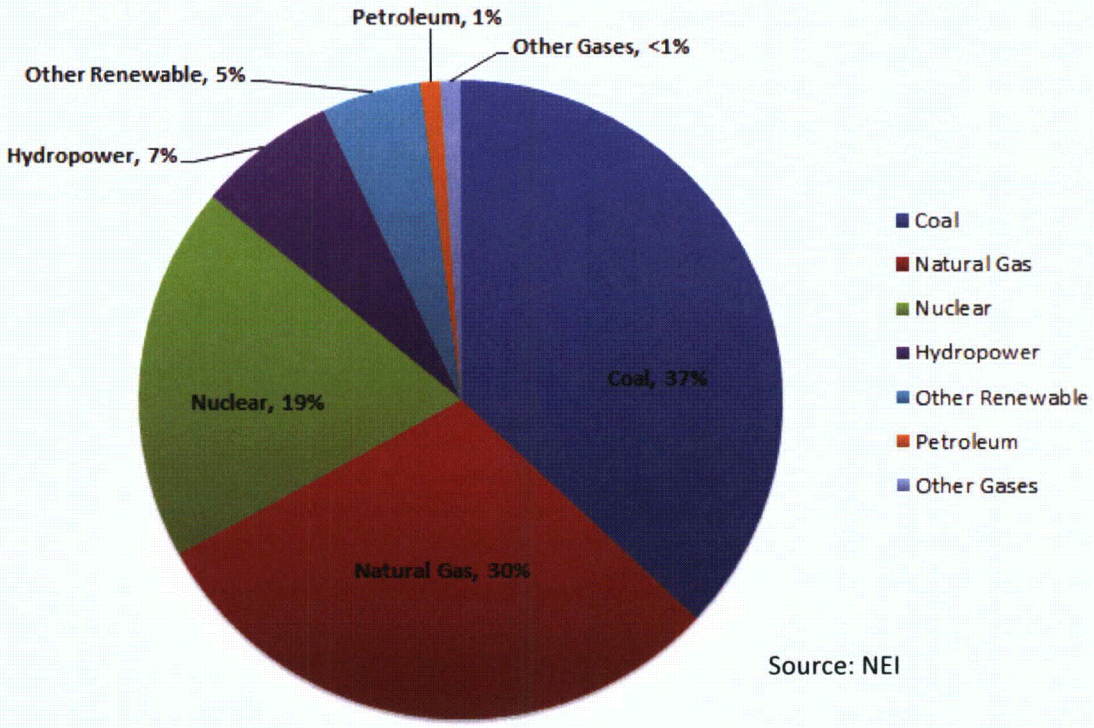
Many analysts predict continued upward movement in gas prices over the next several years. Why? The number of rigs drilling for natural gas in the United States has collapsed in the last 12 to 18 months – from about 900 rigs at work in late 2011 to about 400 today. Experts believe that sustaining current natural gas production takes about 600 rigs, so production may start to drift down with gas prices testing $5 per million BTU in 2014 and 2015. This is part of the normal cyclicality associated with a commodity business.

In addition, the United States may be seriously underestimating the prodigious volumes of natural gas consumed by a gas-fired combined-cycle plant running at full load. A one-thousand-megawatt gas plant burns more gas in a day than daily peak sendout for Boston Gas or Washington Natural Gas in Seattle. A 1,000-megawatt gas plant running at 90 percent capacity factor burns about 60 billion cubic feet a year—slightly less than New Hampshire's entire natural gas consumption in 2011 and more gas than 22 states burned for electric power production in 2011.

This combination of factors means that the economic viability of some smaller nuclear power plants in competitive electricity markets is in serious doubt. If electricity prices remain low and regulatory burdens continue to rise, it is quite possible that the operators of these reactors will decide to shut them down early rather than invest in major equipment change-outs or in the other capital-intensive plant upgrades and maintenance that will be required to operate the reactors to the end of their licensed operating lives. In May 2013, for example, Dominion retired its 556-megawatt Kewaunee nuclear power station approximately 20 years before the expiration of its license. Located outside of Green Bay, Kewaunee is the first early retirement of a nuclear plant explicitly due to competition from abundant, cheap natural gas and Powder River Basin coal, as well as large volumes of government-backed wind power. Kewaunee is the second plant to be shut down for economic reasons in 2013; in February, it was announced that the Crystal River nuclear plant was being retired when it was determined that repairs to the containment could not be made economically.

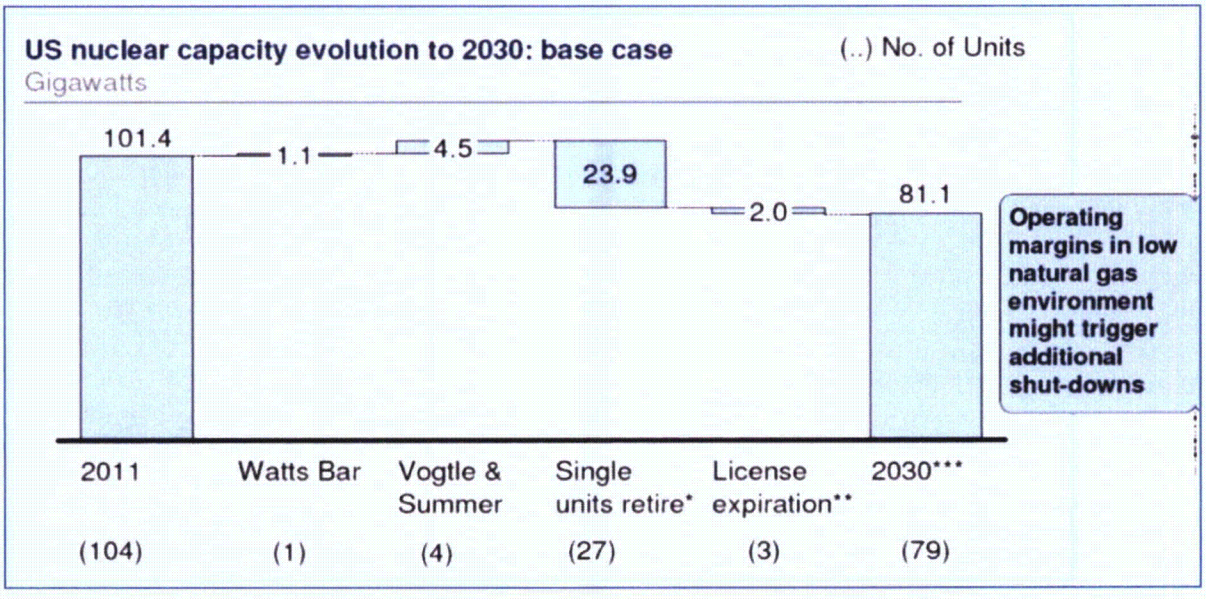
Low gas prices, increased public apprehension, and additional NRC requirements resulting from the Fukushima nuclear accident in Japan have had an even more dampening effect on prospects for building new plants in the United States. This is particularly true in competitive electricity markets, but it is also the case in regulated ones. Meanwhile, a federal loan guarantee program that was expected to help reduce nuclear power plant financing costs has thus far been met with limited success.

2012 U.S. Electricity Generation by Energy Source



Source: NEI

The economics for new plants in the United States are sufficiently challenging that it has proven quite difficult for some regulated owner/operators to take on the liabilities of seeing a new plant through the construction phase. While several state public utility commissions have provided or may provide the kind of rate treatment that can allow nuclear construction to proceed—as regulators are currently doing in Georgia, South Carolina, and a few other states—they are aware



that by doing so they are shifting risks and liabilities to the ratepayer.[16] Governors and legislatures, even in some states that are currently supportive of nuclear energy, may not be able to sustain that support, particularly if new plants experience the types of cost overruns and schedule delays that plagued reactors built in the United States in the 1970s and 1980s. Georgia Power has already announced a schedule delay at Vogtle due to delays in obtaining necessary regulatory approvals from the Nuclear Regulatory Commission.

If no new plants follow the Vogtle and Summer units, the picture for U.S. nuclear power production in 2030 could be very different than current government projections indicate. According to the reference case forecast by the U.S. Energy Information Administration, the United States will have about 110 GWe of nuclear generating capacity in 2030. By contrast, we project that nuclear capacity could drop to about 81 GWe by that date and to near zero by 2050.

THE OUTLOOK FOR COMMERCIAL NUCLEAR ENERGY OUTSIDE THE UNITED STATES

Looking abroad, a major shift also appears imminent in the global outlook for nuclear power. Until recently, Japan had the third-largest civil nuclear fleet—with nuclear power accounting for nearly 30 percent of overall generating capacity. The country's nuclear power program, however, suffered a major setback with the Fukushima accident, which resulted in a decision to shut down all nuclear plants in the country. Two reactors were later restarted as an emergency measure to avoid power shortages, but it remains an open question whether the remaining reactors will ever be restarted. Even with a return to service, 12 existing reactors will cease operation by 2020, absent life extensions, followed by an additional 18 reactors by 2030. Moreover, Prime Minister Shinzo Abe's pledge to restart reactors that meet strict new safety guidelines has been met with substantial resistance from local authorities and the public, which has lost confidence in the industry.

Certainly, the prospect for new builds in Japan is in serious doubt. Prior to the accident, Tokyo had planned to increase the nuclear contribution of overall power generation to 50 percent by 2030. Nine new nuclear reactors were to be brought on line by 2020 and five additional reactors by 2030. Already, the two reactors that were under construction at the time of the earthquake have been scrapped, and plans for other new plants have been put on hold.

In Western Europe, Germany, Belgium, Spain, and Switzerland have all decided to phase nuclear power out of their respective national energy portfolios over the next couple of decades. Italy, which had contemplated the introduction of commercial nuclear power plants, has since decided against it. However, other European nations—including Finland, Poland, the Czech Republic, and the United Kingdom—continue to press forward with new nuclear power development. France, which has the world's second-largest fleet of reactors, remains the region's staunchest supporter, though President François Hollande campaigned in favor of reducing France's dependence on nuclear power from 75 to 50 percent by 2025. Nonetheless, despite plans to shut down the

[16] Sony Ben-Moshe et al., "Financing the Nuclear Renaissance: The Benefits and Potential Pitfalls of Federal & State Government Subsidies and the Future of Nuclear Power in California," *Energy Law Journal*, Vol. 30:497, 2009, p. 497.

country's oldest reactor at Fessenheim within five years, Hollande's government remains committed to completing the new reactor at Flamanville.[17]

Outside Western Europe and Japan, interest in expanding nuclear capacity as a way to help meet growing electricity demand persists despite the accident. Thus, other nations—particularly China, India, Russia, and South Korea—are expected to continue pursuing robust nuclear expansion plans. New nuclear energy projects also remain on the table for policymakers in Vietnam, Turkey, Lithuania, and Jordan, to name a few.

The next several subsections provide further details on the nuclear development plans of China, India, Russia, and South Korea, since these nations are expected to become the industry's most important growth markets for the next few decades. We return to the policy implications of this global shift in nuclear investment and influence later in this chapter.

Japan, Germany, Switzerland and Italy have taken drastic steps after the Fukushima accident

		Pre Fukushima	Post Fukushima
Shut down	Japan	12 reactors with ~10 GW capacity were shutdown for periodic inspection	▪ 2 reactors shutdown at govt.'s request (3GWe) ▪ 6 reactors in cold shutdown (6GWe) ▪ 4 reactors shutdown to be decommissioned (3GWe)
	Germany	1 reactor in long term shutdown for upgrades	▪ Immediate shut down of 8 reactors ▪ Phase out by 2022 instead of 2030 for remaining 9 reactors
	Switzerland	N/A	▪ Complete phase out by 2034 without replacement[1]
	Italy	All reactors were shut down by 1990	▪ N/A
New build plans	Japan	14 planned/proposed reactors	▪ Cancellation of 14 planned/proposed reactors ▪ 2 reactors under construction
	Germany	No plan for nuclear new build	▪ No plan for nuclear new build
	Switzerland	Add 2 new reactors of 1.6 GWe	▪ Plan dropped
	Italy	Referendum set on Jun 2011 for new nuclear plants	▪ No new build for at least 5 years[2] and likely much longer

1 Based on 50-year operating lifetimes, nuclear power generation in the country would cease in 2034
2 Length of time for which a referendum result is binding in the country

SOURCE: WNA, IAEA, Team Analysis

[17] Tara Patel, "EDF Wins Reprieve as Hollande Cools on Greens Nuclear Pact," Bloomberg, April 25, 2012, http://www.bloomberg.com/news/2012-04-25/edf-wins-reprieve-as-hollande-cools-on-greens-nuclear-pact-1-.html.

THE FUKUSHIMA DAI-ICHI NUCLEAR ACCIDENT

The severe accident that occurred at Japan's Fukushima Dai-ichi nuclear power station in March 2011 prompted widespread concern about the safety of nuclear energy and cast serious doubts over prospects for expanding the role of nuclear energy in Japan and elsewhere.

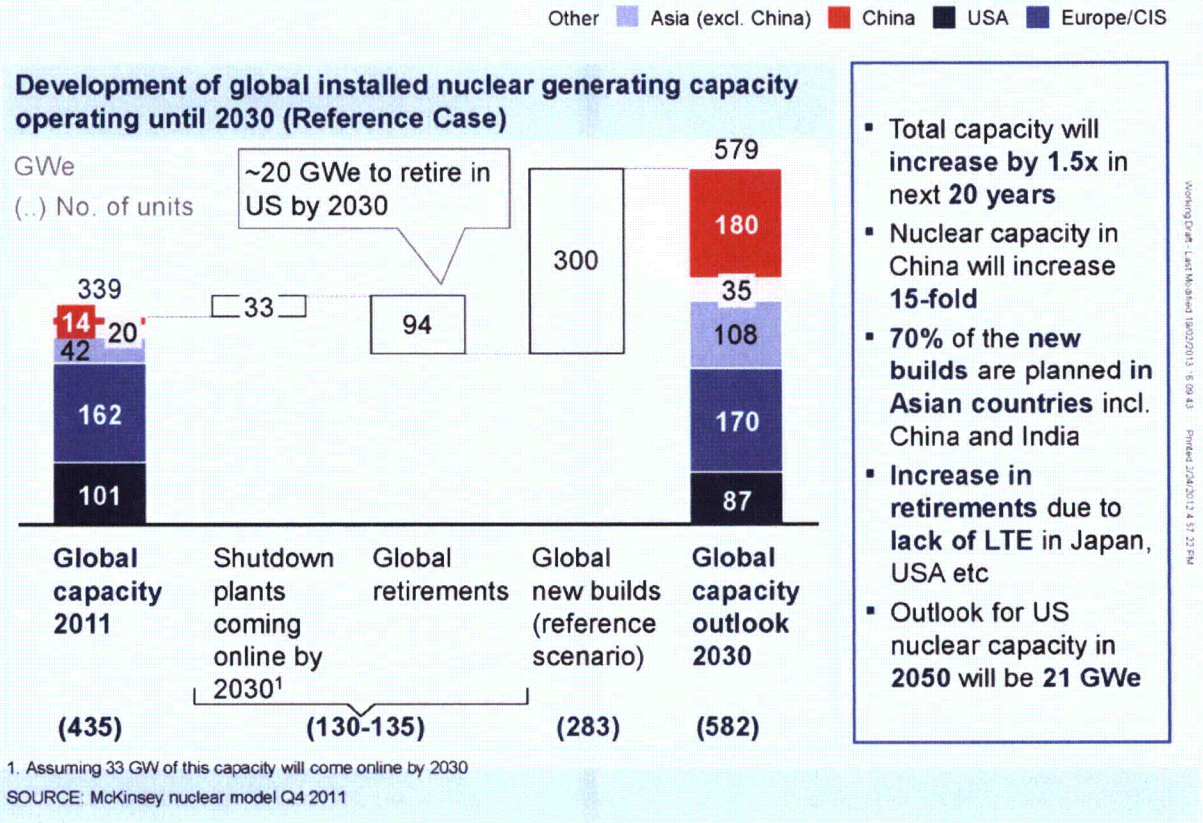
On March 11, 2011, an earthquake measuring 9.0 on the Richter scale occurred 112 miles off the eastern coast of Japan. The earthquake was the third largest ever recorded worldwide. In the immediate aftermath of the quake, all three of the operating units at Fukushima Dai-ichi automatically shut down via seismic reactor protection system trips. While the earthquake caused a loss of all external power to the site, the emergency diesel generator automatically started as designed, and provided AC power to emergency systems.

Within an hour after the earthquake, however, a series of tsunamis—including one with an estimated height of 46 to 49 feet—arrived at the site. This tsunami exceeded the design basis tsunami height of 18.7 feet, and rendered many of the emergency diesel generators inoperable.

The loss of emergency power to run cooling systems in turn led to a build-up of decay heat in the three loaded reactors and in the spent fuel being held in storage pools on site. Additionally, hydrogen generated from the damaged fuel accumulated in the reactor buildings and resulted in explosions in Units 1, 3, and 4. As a result, both primary and secondary containment structures for the reactors were damaged and radioactive material was released. About a month after the earthquake, the Fukushima accident was given the highest rating for seriousness on the International Nuclear and Radiological Event scale—it was rated 7 on a scale that runs from 1 ("anomaly") to 7 (major accident).

In July 2012, two separate reports on the Fukushima disaster by the Japanese parliament and by a government-formed panel of investigators strongly faulted both the plant's operator, Tokyo Electric Power Company, and Japan's nuclear regulatory agency for failing to ensure that proper safeguards and emergency preparations were in place before the tsunami occurred, and for an inadequate response as the crisis unfolded. The government created a new regulatory body, the Nuclear Regulation Agency (NRA), under the Ministry of the Environment in September 2012. The agency is reviewing current regulations and adding new safety measures in the hopes of increasing public confidence in the industry. The new safety rules are scheduled to be completed by the end of summer 2013. The Japanese people elected a cautiously pro-nuclear government in December 2012. The current prime minister, Shinzo Abe, will seek to restart the nation's reactors after new NRA safety criteria are established and met by the operators.

China dwarfs the US regarding installed capacity in 2030



CHINA

China—with current capacity only standing at about 13 GWe—is blazing ahead with the world's most aggressive civil nuclear expansion. With 17 reactors currently in operation, 28 units are being built, including 4 U.S.-designed AP1000 reactors at Sanmen and Haiyang. In response to Fukushima, Beijing postponed new approvals until reviews were held on the safety of existing plants and those under construction. By the summer of 2012, new safety standards for all nuclear facilities had been approved, giving the green light to plans to add more than 70 GWe of new capacity by the end of this decade.

The reactors that have been or are now being built rely on technology developed in many nations, including the United States, Russia, France, Japan, Canada, and others. A common theme across the wide variety of construction contracts signed by Chinese electricity providers has been the inclusion of aggressive requirements related to technology transfer. For example, Westinghouse has agreed to transfer technology to China's State Nuclear Power Technology Corporation (SNPTC) over the first four AP1000 units so that SNPTC can build subsequent units of this type on its own. In this way, China intends to transition from its current status as a nuclear technology importer to that of nuclear technology exporter over the next two decades.

Our analysis projects that China's demand for uranium and uranium enrichment services will grow nearly tenfold by 2030 (see figure below). Consequently, Beijing is pursuing an ambitious

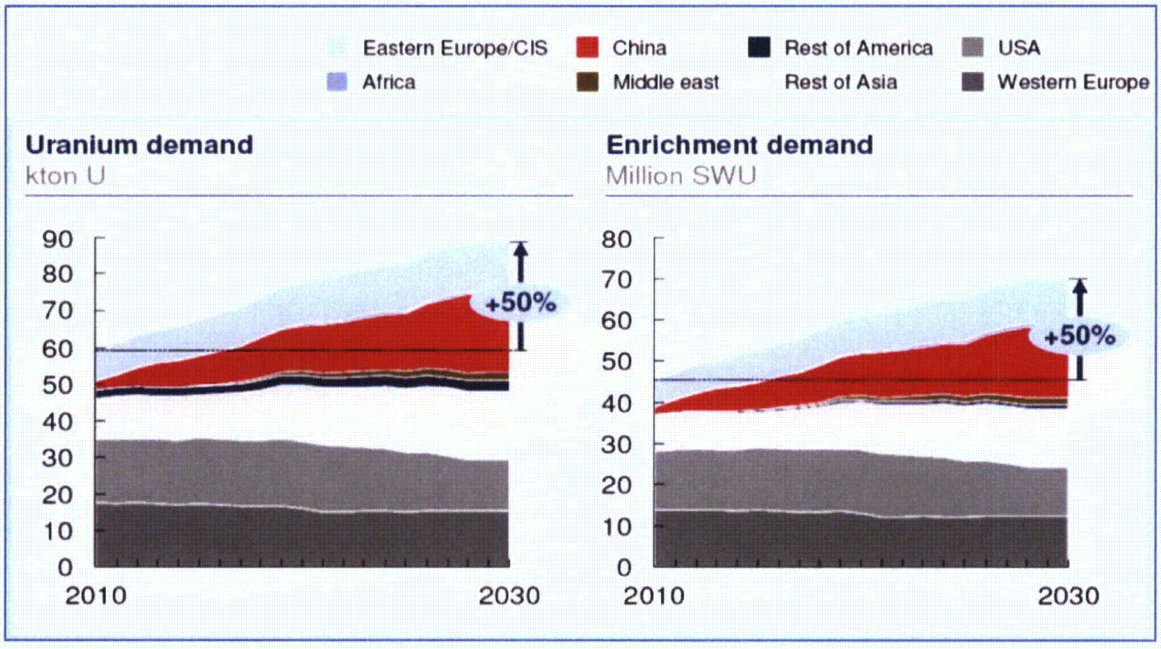
plan to lock up foreign uranium supplies—as it has done with other strategic minerals and resources. China will also increase its own production of uranium in Inner Mongolia and Xinjiang.

INDIA

India has an expanding and—until recently—largely indigenous nuclear power program, operating 20 nuclear reactors, which represent 4.4 GWe of generation capacity and supply about 4 percent of India's electricity.[18] India is building another seven reactors that will more than double its nuclear-electric production capacity.[19] It currently expects to have 20,000 MWe of nuclear capacity on line by 2020 and 63,000 MWe by 2032. India aims to supply 25 percent of its electricity from nuclear power by 2050.[20]

Because India is not a signatory to the Nuclear Non-Proliferation Treaty, it was largely excluded from global commercial nuclear markets over the past several decades until 2008. This hindered its development of civil nuclear energy, and as a result, India has for the most part developed its nuclear program without reactor fuel or technical assistance from other countries. Partly in response to its isolation from outside technical assistance and nuclear material supply, India has made independence in the nuclear fuel cycle and use of its abundant thorium reserves a major priority.[21]

Technical difficulties resulting from the isolation of its nuclear program contributed to India's power reactors having some of the world's lowest capacity factors up until the mid-1990s. But



Source: McKinsey & Co. Analysis

[18] World Nuclear Association, "Nuclear Power in India," April 2013, http://www.world-nuclear.org/info/inf53.html.
[19] International Atomic Energy Agency, Power Reactor Information System, http://www.iaea.org/PRIS/home.aspx.
[20] Ibid.
[21] Ibid.

capacity factors rose to 60 percent in 1995 and 85 percent in 2001–2002. More recently, from 2008 to 2010, capacity factors dropped again due to a shortage of nuclear fuel.[22]

In September 2008, an agreement with the Nuclear Suppliers' Group—and a follow-on 2009 safeguards agreement with the International Atomic Energy Agency (IAEA)[23]—liberalized nuclear trade with India, expanding the country's access to reactor technology and fuel from suppliers in other countries. India has since signed civil nuclear cooperation agreements with the United States, Russia, France, the United Kingdom, South Korea, and Canada, as well as with Argentina, Kazakhstan, Mongolia, and Namibia.[24] The development of foreign supply relationships has helped remedy India's shortage in uranium fuel and has also given the country greater access to intellectual property.

New Delhi plans to position its industry as a major player in the global supply chain, as well as use its expertise in fast reactors and the thorium fuel cycle to become a world leader in nuclear technology.[25] However, achievement of these goals will be impeded by domestic law such as the Nuclear Liability Act, which diverges from international practice in enabling broad legal recourse against suppliers. Private-sector companies, including Indian companies, are at particular risk in the unlimited-liability scenario created by the Act.

RUSSIA

In 2012, nuclear energy was used to generate 166.6 billion kWh in Russia—about 18 percent of the country's overall electricity supply. Nuclear electricity output has grown considerably over the past decade due to improved plant performance, with capacity factors rising from 56 percent in 1998 to 80 percent in 2012.[26]

Russia has an installed nuclear capacity of 23.2 GWe, with 32 operational reactors at 10 locations.[27] The Russian government has stated that it intends to increase nuclear and hydropower generation in the future to allow for greater export of natural gas; current plans call for a doubling of nuclear output—such that nuclear accounts for up to 25 percent of total generation—by 2030.[28] At that point, Russia's installed nuclear capacity would total about 50 GWe.[29]

All of the new nuclear power plants being constructed in Russia are based on indigenous technology. Russia has long been a leader in developing nuclear technology, and Russian-designed reactors can be found in many nations that were once part of the Soviet Union, as well as in several Asian countries. Russia continues to aggressively seek export markets for its reactor designs and nuclear fuel cycle services. This includes plans to build seven or eight floating

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[22] Ibid.
[23] Business Standard, "India signs safeguards agreement with IAEA," May 2013, http://business-standard.com/india/news/india-signs-safeguards-agreementiaea/347861/.
[24] See "India, South Korea ink civil nuclear deal," *Time of India*, July 25, 2011, http://articles.timesofindia.indiatimes.com/2011-07-25/india/29811954_1_nuclear-cooperation-agreement-nuclear-energy-bilateral-agreement; and "Indian and UK sign nuclear cooperation accord," World Nuclear News, February 12, 2010, http://www.world-nuclear-news.org/NP-India_and_UK_sign_cooperation_accord-1202105.html.
[25] World Nuclear Association, "Nuclear Power in India." http://www.world-nuclear.org/info/inf53.html.
[26] International Atomic Energy Agency, Power Reactor Information System, http://www.iaea.org/PRIS/home.aspx.
[27] U.S. Energy Information Administration, "Russia," http://www.eia.gov/countries/cab.cfm?fips=RS.
[28] World Nuclear Association, "Nuclear Power in Russia." http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/Russia--Nuclear-Power/#.UZEvNpWsEzU.
[29] "Global Commercial Nuclear Power Capacity Outlook for 2030," McKinsey & Company, February 2012

nuclear power plants by 2015, based on Russia's extensive experience with designing and building nuclear-powered icebreakers.[30]

SOUTH KOREA

South Korea currently ranks sixth in the world in terms of total nuclear-generating capacity (nuclear energy accounts for approximately one-third of the country's overall electricity supply mix). South Korea recently added two new reactors to its grid, bringing its total reactor fleet to 23. Plans for further expansion of the country's nuclear capacity (to as much as 50 percent of overall generation) have not been affected by Fukushima; the government reaffirmed its nuclear strategy in mid-2011, and construction of several new units was launched in 2012. At this point, nine additional reactors are scheduled to be completed by 2021.

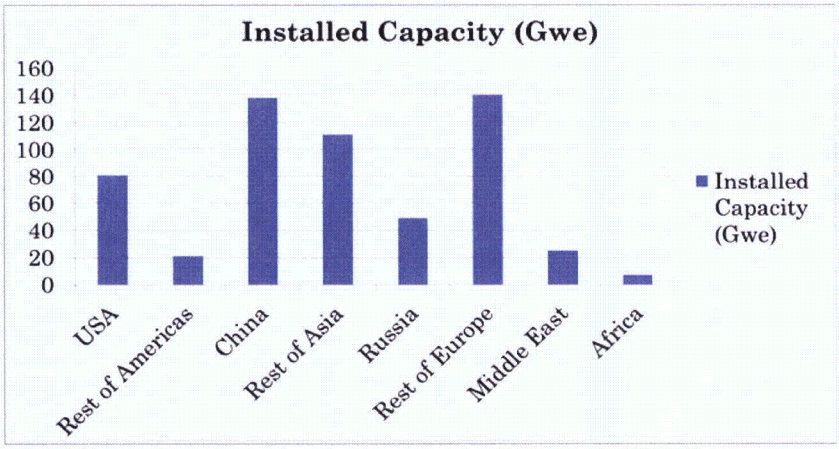
A peripheral player in the global nuclear marketplace until recently, South Korea is now a formidable competitor. The start of construction of two new domestic reactors in 2012 was hailed by the South Korean Ministry of Knowledge Economy as a "turning point" for the country's nuclear program because all domestic-made components were used "in the most important areas" of the plant. Developing a domestic capacity to both design nuclear plants and manufacture major components clearly helped South Korea's KEPCO secure the $20-billion United Arab Emirates (UAE) contract to build four 1,400-megawatt units at the end of 2009—an event that sent shockwaves throughout the global nuclear marketplace.

A CHANGING BALANCE OF POWER

The shifting outlook for nuclear power development globally could lead to a major change in the international "balance of power" in nuclear energy and technology. Whereas the United States currently has about 25 percent of the world's nuclear-generating capacity, by 2030 this number could drop nearly in half, to 14 percent.[31] China could displace the United States as the world's largest producer of nuclear energy by that date, and the four nations of China, India, South Korea, and Russia could account for nearly half of total global capacity.

[30] World Nuclear Association, "Nuclear Power in Russia." http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/Russia--Nuclear-Power/#.UZEvNpWsEzU.
[31] "Global Commercial Nuclear Power Capacity Outlook for 2030," McKinsey & Company, February 2012.

Projected Installed Global Nuclear Generating Capacity - 2030



Source: McKinsey & Co (2030 forecast)

Looking further ahead to 2050, the shift could be even more dramatic. Without a marked change in the economics of nuclear power in the United States, domestic nuclear-generating capacity could fall to less than 10 GWe. Assuming China, India, Russia, and South Korea, along with several new entrants, continue to construct and operate new plants, the United States could account for just a few percent of the world's installed commercial nuclear power capacity by mid-century.

In contrast to the outlook for U.S. commercial nuclear generation, the U.S. Navy has given no indication that it plans to scale back or end its reliance on nuclear power for submarines and aircraft carriers. In addition to the Gerald R. Ford class of aircraft carriers discussed earlier, the Navy is also building the next-generation attack submarine, the Virginia class. A total of nearly twenty Virginia-class submarines have been christened, are under construction, or are under contract;[32] each is expected to have an operating life of 30-plus years.

Later chapters of this report discuss the implications of these developments for U.S. economic, energy, and national security and the basis for our concern that a diminished presence in domestic and global markets means a diminished U.S. voice and influence in future international developments concerning nuclear fuel, processing, safety standards, and efforts to address weapons proliferation and security risks. Moreover, this decline in U.S. influence could be exacerbated by post-Fukushima developments in Japan's nuclear energy program, given the close relationships that exist between several major Japanese and American nuclear companies and the history of collaboration between both countries' governments on international nuclear policy matters.

This interdependence, in fact, has increased in recent years as U.S. and Japanese vendors have entered into a growing number of commercial partnerships. For example, Toshiba of Japan purchased Westinghouse in October 2006. The Toshiba Group supplied a significant percentage of the 430-plus units in operation globally. Also, the Japanese and American companies Hitachi and General Electric formed several joint ventures in 2007, including Hitachi-GE Nuclear Energy Limited for the Japanese market and GE-Hitachi Nuclear Energy for the U.S. market. Mitsubishi Nuclear Energy Systems, Inc., a wholly owned subsidiary of Mitsubishi Heavy Industries, is headquartered in Arlington, Virginia. Close engagement is not limited to the reactor and

[32] America's Navy, United States Navy Fact File, http://www.navy.mil/navydata/fact_display.asp?cid=4100&tid=100&ct=4.

equipment sector—in fact, various U.S. and Japanese companies are active along the supply chain. For example, USEC of the United States has historically been a maj Source: Moelis uranium to Japan. And Japan Steel Works and Ishikawajima-Harima Heavy Industries (IHI) of Japan have been key manufacturers of reactor vessels for U.S.-led projects globally.

A close alignment of business interests between the U.S. and Japanese nuclear industries is behind a series of efforts by the two governments to conclude nuclear cooperation agreements with potential market countries in recent years. A potential customer country must have bilateral cooperation agreements in place with both the U.S. and Japanese governments if a project by a Japan-U.S. consortium is to proceed in that market. For example, the United States has concluded what are commonly referred to as "123 Agreements" [33] with India (2008), Russia (2008), Turkey (2000),[34] and the United Arab Emirates (2009) in recent years. Additionally, the United States will negotiate, renegotiate, or extend approximately 10 nuclear cooperation agreements in the next three years.[35] Meanwhile, Japan has also concluded nuclear cooperation agreements with Jordan (2010), Russia (2009), South Korea (2010), and Vietnam (2011); all of these agreements were approved by the Japanese parliament in December 2011. Japan has also resumed negotiations on bilateral nuclear cooperation with India.[36]

OTHER NUCLEAR FUEL CYCLE FACILITIES AND CAPABILITIES

Much of the above discussion has focused on reactors and nuclear electricity generating capacity. Other aspects of the nuclear fuel cycle, however, also have important strategic, economic, and national security implications. Uranium enrichment (the "front end" of the nuclear fuel cycle) and spent fuel reprocessing (the "back end" of the nuclear fuel cycle) are of particular concern since both involve technologies and capabilities that could be diverted for weapons applications. A global expansion of nuclear generating capacity will drive increased demand for reactor fuel (enriched uranium, plutonium, or thorium); and it will generate increased quantities of spent fuel to be managed, either through direct disposal or through a combination of reprocessing (to extract some still useful components of the spent fuel) and long-term disposal.

To provide fuel for most types of commercial nuclear reactors, mined uranium has to be first purified and then "enriched" to increase the amount of fissionable uranium-235 it contains. Most light-water reactors in use or planned in the United States and worldwide today require fuel with a U-235 concentration anywhere from 3 to 5 percent. Nuclear weapons require more highly enriched uranium—typically with a U-235 content of 80–95 percent. The methods used to enrich uranium are well developed; those in use today rely on gaseous diffusion or centrifuge technology. Commercial deployment of laser enrichment technologies is possible later this decade.

As shown in the below chart, uranium ore is widely distributed across the globe, with large ore concentrations in nations such as Australia, Kazakhstan, and Canada and with large quantities

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[33] U.S. nuclear cooperation agreements are commonly referred to as the "123 Agreements" because Section 123 of the Atomic Energy Act mandates a nuclear cooperation agreement to meet nine nonproliferation criteria and directs the president to submit such agreement for congressional approval.

[34] The U.S.-Turkey bilateral agreement was concluded in 2000, with an initial effective period of 15 years, but the cooperation did not begin until 2008.

[35] Paul K. Kerr et al., "Nuclear Energy Cooperation with Foreign Countries: Issues for Congress," Congressional Research Service, July 11, 2011, p. 2.

[36] Anirban Bhaumik, "Indian hopes to restart nuclear talks with Japan soon," *Deccan Herald*, January 26, 2013, http://www.deccanherald.com/content/307958/india-hopes-restart-nuclear-talks.html.

Paducah Gaseous Diffusion Plant

(but in low concentrations) contained in seawater. By contrast, uranium enrichment facilities have been constructed in fewer than a dozen nations.

During the 1960s, the U.S. operated the first uranium enrichment facilities wholly dedicated to the production of low-enriched uranium (LEU) for commercial purposes.[37] Today, the single U.S.-based enrichment company, USEC, accounts for only about 20 percent of global production capacity for enriched uranium.[38]

Instead of being made from uranium enriched in the United States, much of the fuel used in U.S. reactors is fabricated from imported enriched uranium obtained by USEC under a successful agreement with the Russian government to supply down-blended highly enriched uranium—a contract that expires in 2013. Accordingly, USEC announced in 2011 that it had signed a multiyear contract with the Russian firm Techsnabexport for a 10-year supply of commercially produced Russian low-enriched uranium. USEC intends to deliver the uranium to USEC's customers under its portfolio of contracts.

Recently, USEC announced the end of uranium enrichment at its only operating plant in Paducah, Kentucky, which used 50-year-old gaseous diffusion enrichment technology and was too inefficient to compete against foreign suppliers.[39] Although USEC plans to replace the aging Paducah plant with a plant using advanced U.S. centrifuge enrichment technology, prospects for following through on this plan are far from certain.[40] USEC is currently pursuing development of its centrifuge capability under a research, demonstration, and development (RD&D) agreement with the DOE. The objective of the RD&D effort is to demonstrate the technology through construction and operation of a commercial plant configuration 120-centrifuge machine cascade.

In contrast to USEC's diminishing role, the European uranium enrichment company, Urenco, has deployed its centrifuge technology at three locations in Europe, at an operating facility in Hobbs, New Mexico, and (under a joint venture agreement) at a facility planned to be constructed by AREVA in Idaho Falls, Idaho. This will enable Urenco to increase its market share worldwide. In

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[37] M. D. Laughter, "Profile of World Uranium Enrichment Programs—2009", Global Nuclear Security Technology Division International Safeguards Group, April 2009, http://www.fas.org/nuke/guide/enrich.pdf.
[38] Ibid.; and World Nuclear Association, "Uranium Enrichment," 2013, http://www.world-nuclear.org/info/inf28.html.
[39] John K. Welch, CEO, USEC, "Remarks to Shareholders," April 26, 2012, http://www.usec.com/news/remarks-shareholders-1.
[40] For example, see Gregory Korte, "Politics stands in the way of nuclear plant's future," *USA Today*, April 27, 2012, http://www.usatoday.com/money/industries/energy/story/2012-04-13/usec-centrifuges-loan-guarantees/54560118/1.

addition, Russia is taking steps to modernize and expand its enrichment services capability, with plans to increase total enrichment capacity by about 50 percent by 2020.[41] China, which currently has two commercial-sized enrichment plants supplied by Russia to provide fuel for civilian reactors,[42] plans an even larger expansion of its enrichment capacity, from about 1,300 separative work units (SWU) today to between 6,000 and 8,000 SWU by 2030. All told, the U.S. share of global exports for enriched uranium and other sensitive nuclear materials declined from approximately 29 percent in 1994 to 10 percent in 2008.[43]

A second U.S. company, General Electric (GE), is attempting to enter the uranium enrichment market through the commercial application of an Australian laser enrichment technology known as SILEX, and on September 25, 2012, NRC staff issued a construction and operating license for the facility (for "separation of isotopes by laser excitation").[44] Laser enrichment holds the potential to be substantially more energy efficient than the gas centrifuge technology in use today. GE is planning to conduct the project in two phases, a test phase and a commercial-scale enrichment plant phase. The NRC issued a construction and operating license for the commercial-scale plant phase on September 25, 2012.[45] In 2008, GE announced the selection of Wilmington, North Carolina, as the site for the construction of the commercial facility.[46] In response to a DOE request for expressions of interest in potential uses for the Paducah gaseous diffusion plant site, GE also indicated a potential interest in that site as a possible location for a laser enrichment facility.[47], [48] However, GE has not announced a construction commitment or timetable.

Increasingly, other countries are also ahead of the United States when it comes to developing and implementing solutions for the back end of the nuclear fuel cycle. The back end of the fuel cycle refers to what happens to spent nuclear fuel once it leaves the reactor. Spent fuel contains quantities of uranium and plutonium that could be reused as reactor fuel, as well as other radioactive by-products of the fission reactions that occurred in the reactor core. There are effectively two options for spent nuclear fuel. The first option is to simply dispose of the spent fuel—presumably in a deep geologic repository designed to isolate the radioactive materials in the fuel over the millennia-long timescales needed for those materials to decay to the point where they no longer present a threat to living organisms. The second option is to reprocess the spent fuel so as to separate the still-usable elements; those elements can then be fabricated into new reactor fuel while the remaining radioactive material is repackaged for permanent disposal. Importantly, both pathways require permanent disposal capability as well as interim storage

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[41] World Nuclear Association, "Russia's Nuclear Fuel Cycle," http://www.world-nuclear.org/info/inf45a_Russia_nuclear_fuel_cycle.html.
[42] Ibid.
[43] U.S. Government Accountability Office (GAO), "Governmentwide Strategy Could Help Increase Commercial Benefits from U.S. Nuclear Cooperation Agreements with Other Countries," GAO-11-36, November 2010, p. 12, http://www.gao.gov/new.items/d1136.pdf.
[44] Nuclear Regulatory Commission, "GE Laser Enrichment Facility Licensing," http://www.nrc.gov/materials/fuel-cycle-fac/laser.html.
[45] Ibid.
[46] General Electric, Press Release, "GE Hitachi Nuclear Energy Selects Wilmington, N.C. as Site for Potential Commercial Uranium Enrichment Facility," May 1, 2008, http://www.genewscenter.com/content/detail.aspx?releaseid=3471&newsareaid=2.
[47] FedBizOpps.gov, "Request for Expression of Interest in DOE Paducah Gaseous Diffusion Plant," https://www.fbo.gov/index?s=opportunity&mode=form&id=ff41cfd2dd03365797d225a2773629a2&tab=core&_cview=1.
[48] See "Global Laser Enrichment Formally Proposes Uranium Facility for Paducah," March 7, 2013, http://nsspi.tamu.edu/pauloscornerarticles/2013-03/global-laser-enrichment-formally-proposes-uranium-facility-for-paducah.

facilities to allow spent fuel to cool off for further handling after it has been removed from the reactor core.

Around the world, the great majority of commercial nuclear reactors are light-water reactors operating on the "once-through" fuel cycle—that is, the enriched uranium that fuels the reactor is used once and then stored pending final disposal. The assumption in the early days of the U.S. nuclear program was that spent fuel would be reprocessed, but the United States abandoned commercial reprocessing in the 1970s—initially out of concern about the potential for nuclear weapons proliferation and later also for economic reasons. Today, a handful of countries still engage in reprocessing (see table below); several more, including China, have announced plans to develop reprocessing capability for civil nuclear applications.[49]

From a national security and weapons proliferation standpoint, the technologies and facilities needed to reprocess spent nuclear fuel and fabricate recycled fuel—like the technologies and facilities needed to enrich uranium—present special concerns and risks. This is because they all involve the handling of materials and the development of expertise that could be diverted for weapons applications. Various international mechanisms and regimes have been established to attempt to constrain that possibility—notably the IAEA and the Treaty on the Non-Proliferation of Nuclear Weapons (NPT)—but those mechanisms and regimes offer at best imperfect safeguards, as current concerns over the nuclear programs of Iran and North Korea illustrate.

World commercial reprocessing capacity[58]

		(tonnes per year)
LWR fuel	France, La Hague	1700
	UK, Sellafield (THORP)	900
	Russia, Ozersk (Mayak)	400
	Japan (Rokkasho)	800*
	Total LWR (approx)	3800
Other nuclear fuels	UK, Sellafield (Magnox)	1500
	India (PHWR, 4 plants)	330
	Total other (approx)	1830
Total civil capacity		5630

Regardless of a nation's plans for reprocessing spent nuclear fuel, a final disposal facility will be required to manage long-lived radioactive wastes, though Finland and Sweden are in the process of doing so. No nation has yet succeeded in establishing a final disposal capacity for spent nuclear fuel or high-level radioactive wastes. In this context, the ability of the United States to demonstrate a viable path toward the licensing and construction of a deep geologic repository could help emerging nations decide to pursue a once-through fuel cycle rather than pursue reprocessing as part of an overall waste-management strategy. Yet the U.S. administration's decision to halt the Yucca Mountain project has eroded the U.S. position

[49] Associated Press, "China Ready to Reprocess Nuclear Fuel," *New York Times*, January 3, 2011, http://www.nytimes.com/2011/01/04/world/asia/04china.html?_r=1.

as the clear leader in geologic repository development. To be sure, the U.S. experience in preparing a license application for the Yucca Mountain site and in developing and operating the Waste Isolation Pilot Plant for deep geologic disposal of transuranic wastes keeps the United States quite relevant in waste-management discussions. But today, nations such as Sweden and Finland are ahead of the United States in spent-fuel disposal and exercise increasing influence over the waste-management directions taken by other nations.

Chapter 2

MAKING THE CASE: THE NATIONAL INTEREST AND U.S. NUCLEAR ENERGY LEADERSHIP

The health of the U.S. civil nuclear industry bears directly on our nation's ability to advance a number of crucial objectives, particularly with respect to nonproliferation, military strength, and energy security. At the same time, a robust nuclear industry helps advance several important domestic priorities, such as reducing greenhouse gas emissions while creating jobs and supplying affordable, reliable energy.

ADVANCING NONPROLIFERATION OBJECTIVES

From the 1950s through the 1980s, the United States dominated the international market for commercial nuclear technology. As the dominant supplier, the United States was able to exert great influence in shaping the global nuclear nonproliferation regime. A strong program of domestic nuclear plant operation and construction, combined with government policies to promote advanced technologies and support nuclear technology cooperation with, and exports to, other nations helped the United States sustain this leadership position for decades.[50]

A particularly important source of U.S. leverage in the past was the ability to provide nuclear technology, fuel, and services to other countries on a reliable and stable basis, while imposing strict nonproliferation conditions.[51] These U.S.-imposed controls and conditions go beyond the limitations in the Treaty on the Non-Proliferation of Nuclear Weapons (commonly known as the NPT) and include nine criteria that an agreement with a nonnuclear weapon state must meet. As described in a recent Congressional Research Service report titled "Nuclear Cooperation with Other Countries: A Primer," these criteria include "guarantees that:

- Safeguards on transferred nuclear material and equipment continue in perpetuity;
- Full-scope International Atomic Energy Agency (IAEA) safeguards are applied in non-nuclear weapon states;
- Nothing transferred is used for any nuclear explosive device or for any other military purpose;
- The United States has the right to demand the return of transferred nuclear materials and equipment, as well as any special nuclear material produced through their use, if the cooperating state detonates a nuclear explosive device or terminates or abrogates an IAEA safeguards agreement;
- There is no retransfer of material or classified data without U.S. consent;
- Physical security on nuclear material is maintained;
- There is no enrichment or reprocessing by the recipient state of transferred nuclear material or nuclear material produced with materials or facilities transferred pursuant to the agreement without prior approval;
- Storage for transferred plutonium and highly enriched uranium is approved in advance by the United States; and

[50] Ibid.
[51] Ibid.

- Any material or facility produced or constructed through use of special nuclear technology transferred under the cooperation agreement is subject to all of the above requirements."[52]

Today, due largely to the fact that no new nuclear power plant has been built in the United States for more than three decades, our nuclear industrial capabilities have eroded. As prospects for a new surge of nuclear investment in the United States have dimmed, a number of U.S. firms have been selling off their nuclear capabilities. Meanwhile, as discussed in the previous chapter, several other countries are pursuing ambitious nuclear power programs and are poised to become major international suppliers.[53] In particular, France, Japan, South Korea, and Russia, with China close behind, have developed significant bases of operational experience and are able to compete effectively with their U.S.-based counterparts. While administration officials correctly argue that "nuclear trade carries with it a critical nonproliferation advantage in the form of consent rights, along with other opportunities to influence the nuclear policies of our partners," such trade is not possible unless U.S. firms can offer something other nations want to buy.[54]

Current trends are especially concerning from a national security standpoint because much of the recent global upsurge of interest in nuclear power is occurring in parts of the world that are less responsive to U.S. policies and prerogatives. To exert a positive influence on the nuclear development and nonproliferation policies, especially of these countries, the United States needs to be in a position to act as an active supplier and partner in the evolution of these countries' programs.

CONTROLLING THE SPREAD OF ENRICHMENT AND REPROCESSING TECHNOLOGIES

Growth in nuclear electricity production outside the United States will drive a commensurate increase in the demand for enriched uranium (or for plutonium recovered from used fuel via some form of reprocessing). Inevitably, the facilities needed to supply this demand—because they can be used to produce both nuclear fuel and nuclear weapons-usable material—are of particular concern from a national security standpoint.

During the 1960s, the United States supplied a significant percentage of the market for uranium enrichment services outside the former Soviet Union, through government-owned uranium enrichment plants located in Ohio, Kentucky, and Tennessee (Oak Ridge). The United States was also a major supplier of uranium. At its peak in 1979, employment in the U.S. uranium industry was nearly 22,000 person-years.[55] Employment in 2011 was 1,191 person-years,[56] only about 5 percent of the employment level in this industry in the 1970s. Meanwhile, domestic uranium production has fallen, for reasons discussed in the previous chapter, to about 11 percent of the 1980 production level.[57]

In addition to determined efforts by Urenco (the European enrichment company) as well as China and Russia to expand their commercial enrichment capabilities (see discussion in previous

[52] Paul K. Kerr and Mary Beth Nikitin, "Nuclear Cooperation with Other Countries: A Primer," Congressional Research Service, June 19, 2012, p. 2, http://www.fas.org/sgp/crs/nuke/RS22937.pdf.
[53] Ibid., p. 1.
[54] Letter from Daniel B. Poneman and Ellen O. Tauscher to Senator John Kerry, Chairman, Committee of Foreign Relations, January 10, 2012.
[55] Ibid.
[56] U.S. Energy Information Administration, "Domestic Uranium Production Report–Annual," May 9, 2012, http://www.eia.gov/uranium/production/annual/.
[57] Ibid.

chapter), several additional countries, such as Argentina, Brazil, India, Iran, Japan, and Pakistan, have small enrichment capabilities. Enrichment plants in India and Pakistan lack safeguards and many believe that Iran's enrichment capabilities are intended to support a weapons program, despite the efforts of the International Atomic Energy Agency (IAEA) to apply nonproliferation safeguards. The North Koreans are known to have at least one enrichment plant and there are reasons to believe they might have more such facilities. Other countries, while not currently operating enrichment facilities, have made clear that they do not intend to forego their rights under the NPT to do so in the future.[58]

In a recent paper titled "Limiting Transfers of Enrichment and Reprocessing Technology: Issues, Constraints and Options," Fred McGoldrick, an expert in nuclear security and nonproliferation, describes several ways in which the diffusion of enrichment technologies can increase the risk of nuclear weapons proliferation[59]:

> "First, enrichment facilities can produce nuclear materials—highly enriched uranium (HEU)—that are directly usable in nuclear weapons. With such materials, a state could abrogate its nonproliferation commitments and produce a nuclear weapon within a short period of time. Given the legal ability of a party to the NPT to acquire enrichment (and reprocessing) facilities, produce weapon-usable materials and then withdraw from the Treaty after giving notice of its withdrawal three months in advance, a state would be free to develop nuclear weapons without, strictly speaking, violating the NPT.
>
> Second, it is difficult to detect, either through national technical means or international inspections or both, clandestine enrichment plants using such technologies as centrifuge or laser isotope separation.
>
> Third, having enrichment capability could increase the chance that nuclear weapons advocates could convince leaders of a state to develop nuclear weapons. Other states fearing such an outcome may be tempted to build "standby" capabilities of their own. (In this regard a strong distinction should be made with power reactors, for which there is little evidence that a decision to proceed with a nuclear energy program increases the probability of a state deciding also to pursue a nuclear weapons program.)
>
> Finally, highly enriched uranium produced at enrichment plants offers a tempting target for terrorists or other non-state actors."

The potential for the spread of reprocessing technology raises similar proliferation concerns. While the United States. does not reprocess commercial reactor fuel, several leading nuclear nations—including France, Russia, and Japan—do. China[60] and India[61] are both conducting reprocessing on a limited scale and could expand their use of reprocessing technology in the future.

Reprocessing in France and Russia (and past reprocessing in the United Kingdom) has led to the accumulation of large stocks of separated plutonium that is intended for reuse in reactors but that

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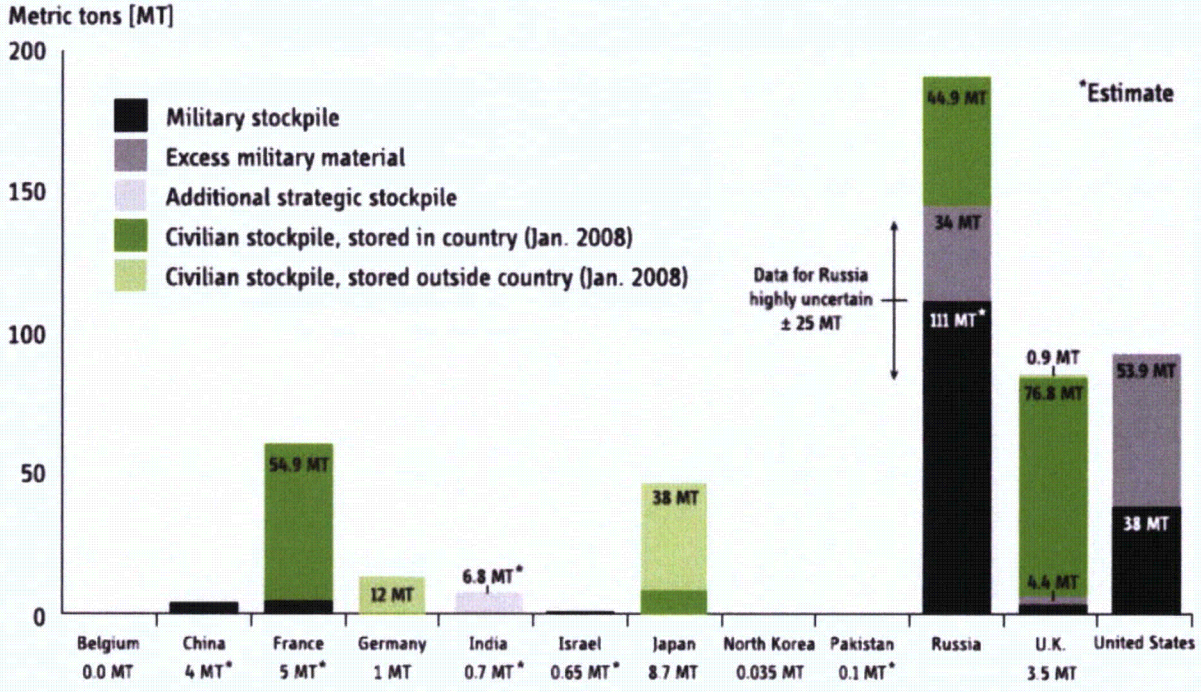
[58] Ibid., p. 10.
[59] ibid., p. 1.
[60] World Nuclear Association, "China's Nuclear Fuel Cycle," April 2013, http://www.world-nuclear.org/info/inf63b_china_nuclearfuelcycle.html.
[61] Fred McGoldrick, *Limiting Transfers of Enrichment and Reprocessing Technology: Issues, Constraints and Opinions,* Belfer Center for Science and International Affairs, Harvard Kennedy School, May 2011. http://belfercenter.ksg.harvard.edu/files/MTA-NSG-report-color.pdf.

has not been converted into fuel form.[62] There are many reasons why the supply of separated plutonium has outpaced demand, including technical challenges associated with the use of plutonium fuel in today's reactors and the slower-than-expected development of "advanced" reactors that can more readily use plutonium as fuel. But regardless of the reasons, experience has shown that nations that engage in large-scale reprocessing can wind up having to manage and secure large quantities of weapons-usable materials. While this isn't necessarily a cause for alarm in the nations that are presently managing these stockpiles, the obvious concern is that nations that are not presently nuclear weapons states could engage in reprocessing—as allowed under the NPT—and accumulate plutonium inventories that could be readily diverted to a nuclear weapons program.

National Stocks of Separated Plutonium



[62] International Panel on Fissile Materials, "Global Fissile Material Report 2009: A Path to Nuclear Disarmament," 2009, p. 15, http://fissilematerials.org/library/gfmr09.pdf.

Concerns regarding the potential misuse of enrichment and reprocessing capabilities have long been the basis for U.S. efforts to halt the spread of these technologies. One of the most significant developments in the history of efforts to achieve this objective came in the late 1970s, when the major nuclear suppliers agreed to form the Nuclear Suppliers Group (NSG). The NSG established guidelines governing exports of nuclear materials, equipment, and technology. In addition, members agreed to exercise restraint in the transfer of sensitive materials and technology, and specifically to establish special controls on the spread of enrichment and reprocessing technology.[63]

Unfortunately, past performance is no guarantee of future success. The fact remains that nonnuclear weapon states have a right to enrichment and reprocessing technology under the NPT.[64] If the United States were to develop and deploy a competitive uranium enrichment technology, international demand for this technology might put the United States in a stronger position to seek nonproliferation assurances from recipient nations that go beyond what is required by the NPT (and beyond what is required under NSG guidelines). Currently, however, America's role as a supplier of uranium enrichment services and technology looks set to decline, along with U.S. engagement in global markets for nuclear technology more generally. This will likely mean a loss of leverage in persuading aspiring nuclear nations to refrain from reprocessing.

SUPPORT FOR OUR NATIONAL DEFENSE CAPABILITIES

As discussed in Chapter 1, the U.S. civil nuclear industry has long supported, and been supported by, the U.S. Navy's nuclear propulsion program.

In fact, the commercial U.S. nuclear power industry is a direct descendant of the naval nuclear propulsion program. The U.S. Atomic Energy Commission (AEC) was established after World War II and subsequently took the lead in research and development to advance nuclear-powered energy generation. Momentum for this program built in 1949 when U.S. Navy Captain Hyman Rickover established a division in the AEC to develop a nuclear power plant for a submarine. This submarine reactor technology formed the basis for larger nuclear power reactor designs, and in the mid-1950s, the Duquesne Light Company of Pittsburgh, Pennsylvania, agreed to build and operate a conventional steam-driven power-generation system using nuclear reactor technology provided by the U.S. Navy. The resulting facility at Shippingport, Pennsylvania, is widely regarded as launching the first generation of commercial nuclear power plants in the United States.[65]

[63] Ibid., p. 1.
[64] Ibid., p. 19.
[65] The Babcock & Wilcox Company, *Steam: Its Generation and Use*, Edition 41.

Ultimately, the two main reactor technologies developed for naval use—pressurized water reactors and boiling water reactors—were commercialized by U.S. firms and later sold to other countries around the world.

To this day, the Navy and the commercial U.S. nuclear industry rely on many of the same providers of nuclear equipment and specialized manufacturing capability. While the Navy is careful to develop sources of supply that can weather short-term ups and downs, a sustained decline in the number of U.S. firms able to provide these products and services could leave the Navy with little choice but to rely more heavily on foreign suppliers, or even begin to invest in and develop its own dedicated supply chain resources.

Finally, a declining domestic commercial nuclear industry could affect the Navy's ability to enlist servicemen and women to serve in its nuclear propulsion program. The program's current recruitment materials assure new sailors that "Your knowledge of traditional and nuclear power will be an asset in high demand, whether with America's Navy or the civilian sector."[66] That pitch may be increasingly hard to make in the context of a contracting nuclear power industry with diminishing employment opportunities.

GLOBAL LEADERSHIP IN SAFETY AND SECURITY STANDARDS

The United States has been regulating applications of nuclear technology longer than any other nation. Starting in 1954, well before the NRC was created, nuclear regulation was the responsibility of the Atomic Energy Commission (AEC). The Atomic Energy Act of 1954, which launched the commercial nuclear power industry in the United States, gave the AEC two functions: to encourage the use of nuclear power while also regulating its safety.

Having a single agency responsible for both the promotion and regulation of nuclear power was understandably viewed as creating the potential for internal conflicts of interest.[67] This situation was rectified in 1974, when President Ford signed the Energy Reorganization Act. The Reorganization Act, among other things, established the Energy Research and Development Agency (ERDA, the forerunner to today's DOE) and replaced the AEC with the NRC. In this way, the two missions of nuclear technology promotion and nuclear technology regulation were separated and allocated to two distinct agencies.[68]

The 1979 accident at Three Mile Island (TMI) led to a wholesale reevaluation of both regulatory and industry approaches to assuring nuclear power plant safety. Shortly after the TMI accident, both the NRC and industry implemented major structural changes to address the problems identified by several groups that examined the event. The industry formed the Institute of Nuclear Power Operations (INPO) to promote the highest levels of safety and reliability in the nuclear power operations. Finally, the industry established the Nuclear Electric Insurance Limited to provide insurance coverage for nuclear plants using rates that were contingent on active participation in INPO and adherence to its standards.[69]

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[66] See America's Navy, "Serving a Core Function: Nuclear Technicians and Power Pant Operators—Nuclear Operations," http://www.navy.com/careers/nuclear-energy/nuclear-operations.html.
[67] Gary Vine, "Abridged History of Reactor and Fuel Cycle Technologies Development: A White Paper for the Reactor and Fuel Cycle Technology Subcommittee of the Blue Ribbon Commission," March 15, 2011, p. 17.
[68] U.S. Nuclear Regulatory Commission, "History," http://www.nrc.gov/about-nrc/history.html.
[69] Gary Vine, "Abridged History of Reactor and Fuel Cycle Technologies Development," p. 21.

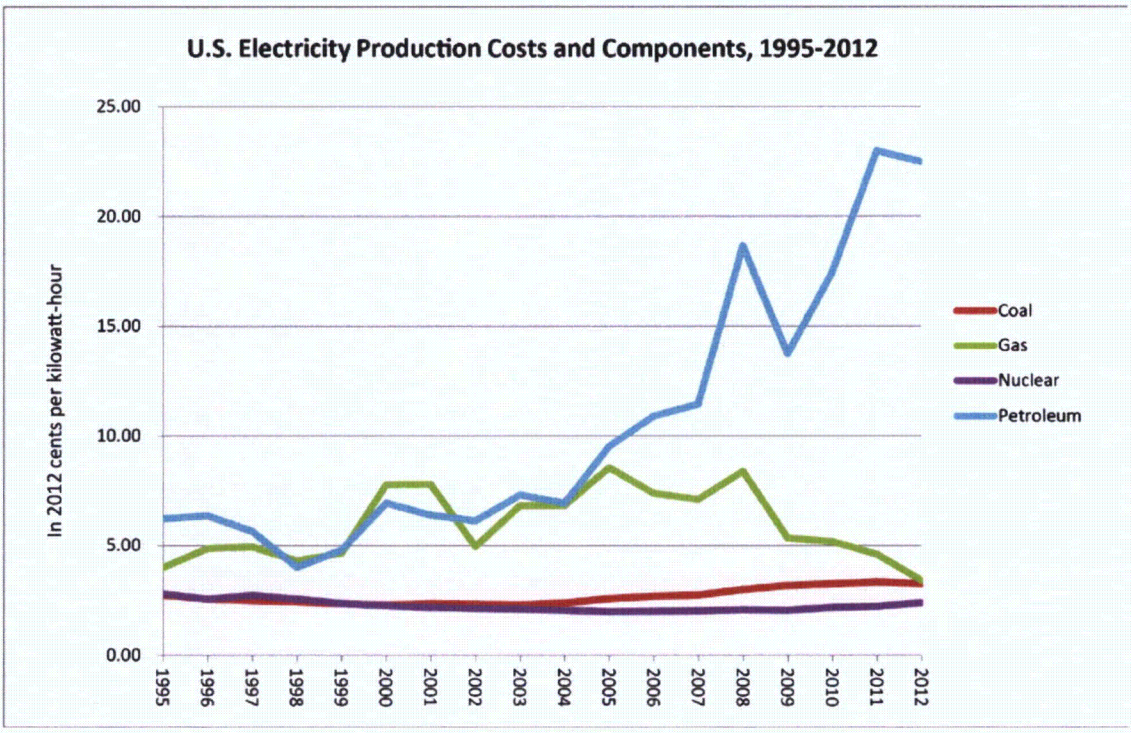
Throughout the 1970s and into the 1980s, the NRC reviewed license applications for, and oversaw the construction, startup, and operation of, more than 100 commercial nuclear power reactors in the United States. Beginning in the 1980s and extending to today, the NRC also reviewed new plant designs and plans to increase the power output of operating reactors. As a result, the NRC has more collective experience than any other nuclear regulatory agency in the world.

Thanks to robust NRC regulation and its own initiatives, particularly including the INPO, the commercial nuclear power industry in the United States has accumulated an impressive record of operational and safety performance. Operational and technological improvements have enabled plant operators to dramatically boost performance over the last several decades. For example, in 1980 the average capacity factor for the commercial U.S. nuclear plant fleet as a whole was just 56.3 percent. This figure rose to 66 percent in 1990 and continued rising over the past two decades, reaching 89 percent in 2011.[70]

For decades, and continuing through today, the U.S. system of regulations and operational standards has been viewed as the best in the world. An NRC license for a particular reactor design has been viewed as the "gold standard" and has opened opportunities to market that design around the world.[71] The desire to learn from U.S. regulatory and operational experiences is one of the factors that caused nations in the past to want to enter into agreements for nuclear cooperation with the United States, and it has given Washington an important edge in negotiating such agreements.

Cooperating with other countries on issues of nuclear safety, in turn, gives the United States an opportunity to shape behaviors in other areas, particularly with respect to plant security, materials safeguards, emergency response, and nonproliferation. Other leading supplier nations don't always adhere to the same strict controls the United States has adopted in these areas. Maintaining an edge in the regulatory arena, however, will be difficult if our nation's own commercial nuclear activities decline.

[70] Nuclear Energy Institute, "Resources and Stats," http://www.nei.org/resourcesandstats/graphicsandcharts/performancestatistics/.
[71] Dale E. Klein, Chairman, U.S. Nuclear Regulatory Commission, "Promoting Public Confidence in Nuclear Safety through High Standards," prepared remarks, October 8, 2008, p. 2, http://pbadupws.nrc.gov/docs/ML0828/ML082820479.pdf.



Source: EIA

As a large part of the overall U.S. electricity supply mix, nuclear energy provides substantial energy security and fuel diversity benefits.[72] These benefits—coupled with the low operating and maintenance costs of existing nuclear power plants [see figure above]—have helped U.S. utilities deliver reliable electricity at relatively low and stable prices over decades of sustained demand growth.

With the changes that have occurred in electricity markets over the past two decades—particularly the introduction of retail competition in about half the states—energy supply diversity and other long-term, nonmonetary considerations have been deemphasized as electricity providers have shifted their focus to short-term profitability. In regions where electricity supply is still regulated, such as the southeastern United States, these benefits are factored into decisionmaking by utilities and public utility commissions. As a result, nuclear is viewed much more favorably.

The emergence of inexpensive domestic natural gas supplies has made it more difficult for electricity decisionmakers—even those in the Southeast—to take a long view and assign value to the energy diversity and security benefits offered by nuclear power. The conventional wisdom is that natural gas prices will remain low throughout the decade; current price forecasts reflect that assumption. But it's important to recognize that these are just forecasts; nobody can say with certainty what impact more stringent environmental regulations, public concern about natural gas drilling (especially hydraulic fracturing or "fracking"), or other market factors (including the potential development of a major export market for U.S.-produced gas) will have on future gas

[72] Presentation by Gerry Cauley, president and CEO, North American Electric Reliability Corporation, January 2012.

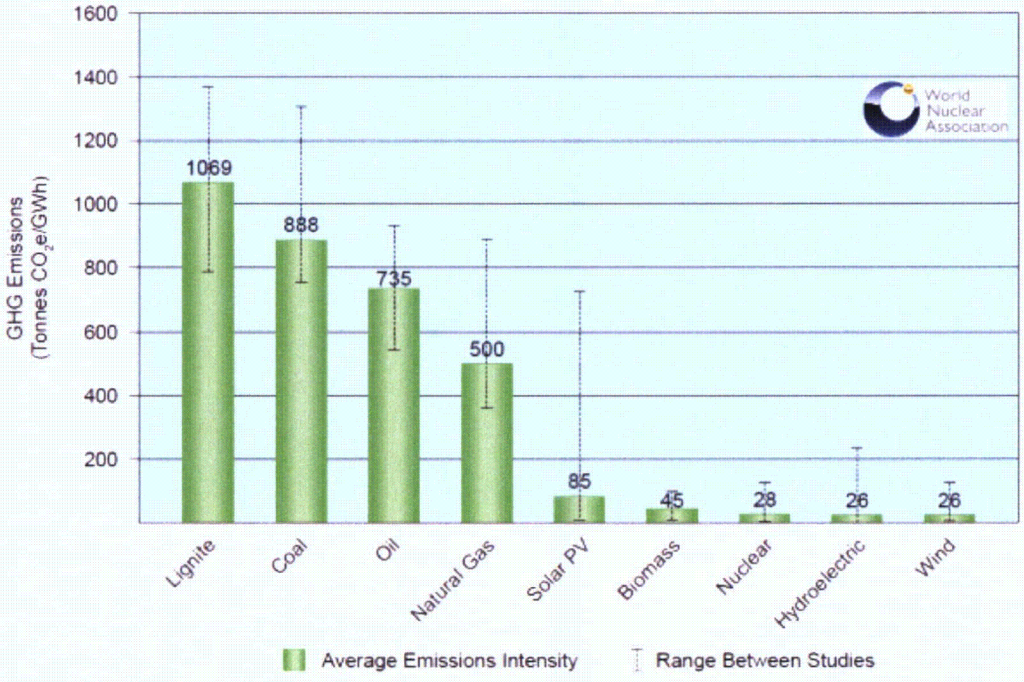
prices and on future gas price volatility. By contrast, electricity production costs at existing nuclear reactors have been remarkably stable over the last several decades, because these production costs are largely immune from changes in the price of uranium. Even when uranium prices climbed well above recent norms, as they did in the late 2000s, fuel costs still accounted for less than 15 percent of the price of nuclear-generated electricity.[73] In fact, once a nuclear plant is built, its operating costs can be forecast with a far higher degree of certainty than in the case of coal or natural gas-fired generators.

Finally, America's nuclear energy infrastructure contributes to U.S. security in one additional, less obvious, but clearly important way. In many parts of the country, nuclear plants anchor the electric grid and help to assure the continuous, reliable availability of affordable, high-quality electricity services on which our economy—and our defense systems—depend. As these plants retire, large quantities of new baseload capacity will be needed to assure continued grid stability.

ENVIRONMENTAL BENEFITS

Nuclear energy is currently the only commercially available, low-carbon generating resource that can provide reliable baseload power on a large scale. Any scenario for achieving substantial global carbon reductions in the future will require bringing large increments of low-carbon capacity on line, in the United States and worldwide. This could be much more difficult and potentially much more expensive without a sizable contribution from nuclear energy.

Political will to act on climate change has recently waned in the United States and elsewhere. But these conditions could change quickly if warming trends accelerate or if evidence emerges that the global climate system could be nearing a kind of tipping point beyond which damages become much more difficult or costly to manage.



[73] World Nuclear Association, "The Economics of Nuclear Power," March 2013, http://www.world-nuclear.org/info/inf02.html.

At present, nuclear energy accounts for about two-thirds of the low-carbon electricity supply in the United States and about 45 percent of the low-carbon electricity supply globally.[74] Over the next several decades, access to improved nuclear technologies could have enormous option value for reconciling the energy needs of modern societies with the scale and pace of carbon reductions needed to avert the most damaging consequences of human-induced warming. Indeed, access to U.S.-origin nuclear power technology could even be an important bargaining chip for U.S. negotiators if the United States someday finds itself in the position of bringing other countries along in an international effort to limit greenhouse gas emissions.

JOB CREATION AND OTHER ECONOMIC BENEFITS

Beyond its fuel diversity and energy security benefits, nuclear power provides significant regional and local benefits. Many nuclear plants have the support of their host communities because of the jobs they sustain, the tax revenues they generate, and the demand they create for high-quality components that require sophisticated manufacturing capability.

In particular, new nuclear plant construction supports large numbers of highly skilled and well-paid manufacturing jobs in the sectors that supply specialized plant components. According to one study of the job impacts associated with a large-scale program of new-plant construction, "this represents the most significant benefit to the wider economy, particularly when compared with the alternative of construction of fossil fuel plants. By retaining or repatriating these skilled functions, the United States will be at the leading edge of nuclear expertise within the global economy. This creates a potential source of future export earnings as the US provides expertise to select countries expanding their nuclear energy capacity."[75]

A 2012 study conducted by the Nuclear Energy Institute looked more closely at the economic and employment impacts of individual nuclear power plants.[76] That study concluded that the average nuclear power plant employs between 400 and 700 people to operate the plant (plus an undisclosed but significant number for plant security) and generates more than $25 billion in local economic value over the life of the plant.

On a per-megawatt basis, nuclear plants create far more local employment than nearly any other source of large-scale electricity generation.[77]

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[74] U.S. Energy Information Administration, "Short-Term Energy Outlook," May 7, 2013, http://205.254.135.7/forecasts/steo/report/electricity.cfm.
[75] Oxford Economics, "Economic, Employment and Environmental Benefits of Renewed U.S. Investment in Nuclear Energy: National and State Analysis," 2008, p. 4, http://www.oxfordeconomics.com/publication/open/222534.
[76] http://www.nei.org/CorporateSite/media/filefolder/NuclearEnergy's-Energy-s-Economic-Benefits--Current-and-Future: http://www.nei.org/resourcesandstats/Documentlibrary/New-Plants/whitepaper/jobs.pdf?ext=.pdf.
[77] Donald Harker and Peter Hans Hirschboeck, "Green Job Realities," *Public Utilities Fortnightly*, May 2010, http://www.fortnightly.com/fortnightly/2010/05/green-job-realities.

Chapter 3

CHALLENGES FOR THE U.S. NUCLEAR ENERGY INDUSTRY

This chapter explores the key challenges that must be addressed to secure a strong future for the U.S. nuclear energy industry. As such, it lays the groundwork for our recommendations, which follow in Chapter 4:

- Export Market Challenges
  - Difficulties in negotiating nuclear trade agreements
  - Overly burdensome export approval process
  - Insufficient export incentives
  - Technological competitiveness

- Domestic Challenges
  - Affordability of and financial structuring for new plants
  - Need to provide a convincing path forward on nuclear waste
  - Regulatory uncertainty and unpredictability
  - Wavering public and political support

EXPORT MARKET CHALLENGES

Given current patterns of nuclear energy development around the world, the most important opportunities for U.S. nuclear firms over the next several years are likely to be in export markets. However, the U.S. industry faces significant competitive challenges in these markets, despite its longstanding leadership in nuclear products and services. For example, the U.S. Department of Commerce estimates that the international market for nuclear equipment and services will total between $500 and $740 billion over the next 10 years.[78] But U.S. nuclear exports in recent years have remained relatively flat (see figure below). Several factors are at work. One is that U.S. suppliers do not benefit from the same level of government support in overseas markets as do their foreign competitors. Non-U.S. firms typically have the full backing of their national governments, while U.S. firms enjoy only fragmented support and are subject to particularly cumbersome export regulations.

DIFFICULTIES IN NEGOTIATING NUCLEAR TRADE AGREEMENTS

New government-imposed requirements have increased the complexity and difficulty of negotiating nuclear trade agreements with other countries. These changes have created an unintended but significant barrier to stronger U.S. participation in global export markets.

Such agreements, which typically outline the parameters of any future nuclear technology transfers between the United States and a potential recipient country, are a prerequisite for U.S. commercial nuclear exports. They are known in the industry as "123 Agreements" because they are governed by Section 123 of the Atomic Energy Act. The agreements cover "significant nuclear exports," a designation that encompasses power reactors, research reactors, source and special

[78] International Trade Administration, "Commerce Report: Small Modular Nuclear Reactors Can Help Meet Future Energy Demands, Create American Jobs," February 16, 2011,

U.S. Civil Nuclear Exports (in thousands of U.S. Dollars)

Product	2008	2009	2010	2011
Enriched Uranium	$1,391,791	$1,761,568	$1,266,016	$1,074,562
Nuclear Reactors	$33,253	$319	$420	$263
Isotropic Separation Machinery	$10,304	$14,258	$6,060	$7,720
Fuel Cartridges	$150,432	$183,760	$343,812	$314,085
Parts of Nuclear Reactors	$88,714	$87,462	$71,634	$96,737
TOTAL:	$1,674,494	$2,047,367	$1,687,942	$1,493,367

Source: USITC
Note: These figures do not include nuclear services or dual-use items.

nuclear materials (for use as reactor fuel), and major components of reactors, including pressure vessels, primary coolant pumps, fuel handling machines and control rod drives.[79]

The U.S. has Section 123 Agreements in place with 21 individual countries, the 27 countries under the EURATOM consortium, Taiwan, and the International Atomic Energy Agency.[80] Seven of these agreements are scheduled to expire by 2015 (including agreements with major trading partners such as China, South Korea, and Taiwan). In addition, the United States does not have agreements in place with several nations that are pursuing new nuclear programs, including Saudi Arabia and Vietnam.[81]

Negotiating and receiving congressional approval for 123 Agreements can take several years, and can be derailed by issues not directly relevant to the agreement. For example, President Bush and Russian president Putin agreed in July 2006 to negotiate an agreement for cooperation, and a signed agreement was submitted to Congress in May 2008.[82] But the agreement was withdrawn by

[79] U.S. Department of Commerce, International Trade Administration, "Civil Nuclear Exporters Guide," May 2009, http://ita.doc.gov/td/energy/Civil%20Nuclear%20Exporters%20Guide%20(FINAL).pdf.
[80] U.S. Government Accountability Office, "Governmentwide Strategy Could Help Increase Commercial Benefits from U.S. Nuclear Cooperation Agreements with Other Countries," GAO-11-36, November 2010, p. 1, http://www.gao.gov/new.items/d1136.pdf.
[81] Nuclear Energy Institute, "Public Policy: Nuclear Cooperation Agreements," March 2012, http://www.nei.org/publicpolicy/trade/diplomacy.
[82] Robert Einhorn et al., "The U.S.-Russia Civil Nuclear Agreement: A Framework for Cooperation," Center for Strategic and International Studies, May 2008.

President Bush in August 2008 after the start of the Russia-Georgia war.[83] President Obama resubmitted the agreement for approval in May 2010, and it went into force in January 2011.[84]

CHANGES ARE NEEDED TO THE BURDENSOME EXPORT APPROVAL PROCESS

U.S. nuclear exports are subject to a complex, cumbersome, and time-consuming web of export control regulations that are administered by several federal agencies. These include 10 CFR 810, administered by the Department of Energy (DOE), for exports of technology; 10 CFR 110, administered by the Nuclear Regulatory Commission (NRC), for exports of actual items; and 15 CFR 730-774, administered by the Department of Commerce (DOC), for exports of dual-use technology. Although these regulations play an important role in ensuring that nuclear technology, materials, and components are used exclusively for peaceful purposes, their implementation often confuses and frustrates exporters and customers alike and results in a competitive disadvantage to U.S. firms.

DOE's regulation of nuclear technology. Part 810 controls the provision of assistance to activities that directly or indirectly produce special nuclear material outside the United States. DOE also applies this regulation to "deemed exports," which is the transfer of technology to foreign individuals regardless of location. That means that visits by foreign experts to the United States or sharing information with foreign employees falls under this regulation. Part 810 is broadly interpreted by DOE to apply to technology transfers and technical assistance involving any part of the nuclear fuel cycle.[85] This is commonly applied to designs, sales information, technical specifications, as well as operating information and procedures.

In order for U.S. suppliers to export to certain "restricted" countries—which include India, China, and other important partners in nuclear trade—the Part 810 rule requires that they obtain a specific authorization approval from the secretary of energy. DOE currently requires one year to process the typical specific authorization. Certain cooperation and technology exports are "pre-approved" through a general authorization for some countries. For example, technology transfer related to light water reactors to Mexico is generally authorized.

A Part 810 specific authorization requires nonproliferation assurances from the recipient's government that the transferred technology will be used only for peaceful purposes and not be retransferred without prior U.S. consent. DOE often points to the foreign government as a source of delays in issuing these authorizations. But involvement of multiple U.S. departments and agencies in the review process contributes significantly to the inefficiency.

Equivalent licenses in other nuclear supplier countries are required by law to be processed within strict time limits. Processing times of equivalent licenses in Russia, Japan, and South Korea range from 15 to 90 days. As a result, the Part 810 rule does not just impede U.S. suppliers from holding timely commercial discussions with international customers, it imposes on U.S. suppliers a competitive disadvantage, particularly because many of those transfers are needed prior to an actual new reactor tender.

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[83] Matthew Rojansky and Peter Topychkanov, "The 123 Nuclear Cooperation Agreement: Energizing the U.S.-Russia Reset," *The Hill*, September 15, 2010, http://thehill.com/blogs/congress-blog/foreign-policy/118899-the-123-nuclear-cooperation-agreement-energizing-the-us-russia-reset.

[84] U.S. Department of State, Fact Sheet, "The Agreement between the Government of the United States of America and the Government of the Russian Federation... (U.S.-Russia 123 Agreement)," http://www.state.gov/r/pa/prs/ps/2011/01/154318.htm.

[85] U.S. Department of Commerce, International Trade Administration, "Civil Nuclear Exporters Guide," May 2009, http://ita.doc.gov/td/energy/Civil%20Nuclear%20Exporters%20Guide%20(FINAL).pdf

NRC's regulation of nuclear items. If a U.S. supplier wishes to export nuclear components, materials, or fuel, an NRC Part 110 license is required. Before a Part 110 license for these exports can be approved, a Section 123 agreement with the customer country needs to be in force. Typically requiring about a year to process, Part 110 licenses are required for the following types of hardware and physical material exports:

- Nuclear production and utilization facilities and especially designed or prepared equipment/components for such facilities
- Special nuclear material
- Source material
- Byproduct material
- Deuterium and heavy water
- Nuclear-grade graphite for nuclear end use[86]

Like the government-to-government assurances required for Part 810 authorizations, obtaining a Part 110 license requires that the recipient government pledge to use the acquired items in accordance with the applicable 123 Agreement.[87]

DOC's regulation of dual-use technology. Finally, the Bureau of Industry and Security (BIS) at the Department of Commerce has jurisdiction over certain nuclear-related "dual-use" items (items that can be used for both civilian and military purposes). Such items can include simulators, detectors, analytic equipment, and many other components.[88] Typically, these licenses are processed within 90 days.

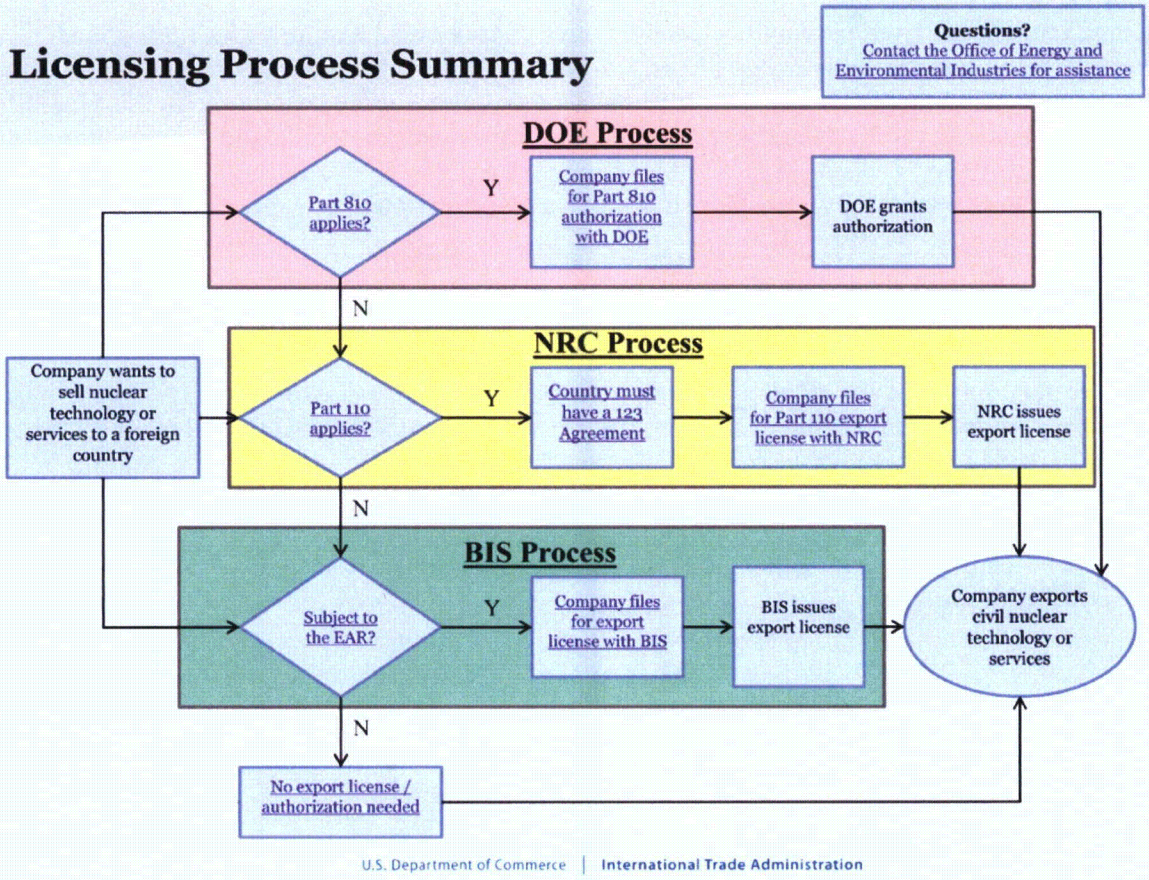
Varying impact on competitiveness. Although Part 810 and Part 110 licenses typically take a year or more to process, the impacts of these delays are significantly different because of the items controlled and when they are required. For example, if a consulting or engineering firm is planning to export technology under 10 CFR 810 to help establish a nuclear program abroad, government approval (license) is often required early in the project development process, and lead time is very limited. If a manufacturer is planning to export a major component under Part 110 for a nuclear project, a license is often required later in the project, providing greater lead time. In fact, the transfer of a component under Part 110 is often preceded years earlier by the transfer of related information under a Part 810 license. DOE also applies Part 810 to proprietary information used for marketing purposes. Such information must be shared early in the tender process, often with little lead time. Long delays in obtaining Part 810 licenses can therefore preclude U.S. suppliers from competition. For these commercial reasons, the processing of Part 810 licenses is significantly more urgent for exporters than the processing of Part 110 licenses.

The entire export approval process is mapped out in the figure below.[89]

Though existing U.S. trade requirements are more restrictive than those of other supplier countries, limited support exists in Congress to require additional provisions that could make it even harder to execute or renew nuclear-related trade agreements in the future. During the last Congress, the House Foreign Affairs Committee unanimously adopted HR 1280, which sought to impose on partner countries several new requirements that are not required by other suppliers, including a condition that the partner forswear enrichment and reprocessing technologies. The

[86] Ibid.
[87] Ibid.
[88] Ibid.
[89] Ibid.

bill, which did not receive a vote on the House floor, would have also revised current law by requiring Congress to actively affirm such agreements—via a joint congressional resolution—before taking effect. It remains to be seen whether similar legislation will be introduced in the current Congress.



Representative Ros-Lehtinen and other members of Congress want the United States to replicate in future 123 Agreements the same assurances accepted by the UAE as part of a 123 Agreement formalized in 2009. In that agreement, the UAE declared it would not engage in uranium enrichment or reprocessing (commonly referred to as ENR) on UAE soil. At the time, a State Department spokesman branded this pledge the "gold standard" for future U.S. nuclear agreements.[90]

However, administration officials have told Congress that nuclear agreements being negotiated with Vietnam and Jordan might not meet the same "no-ENR" standard. Instead, the administration plans to take a "case-by-case" approach to negotiating future agreements, according to a January 10, 2012, letter from the deputy secretary of energy, Daniel Poneman, and the undersecretary of state for arms control and international security, Ellen Tauscher, to the chairmen and ranking members of the House and Senate foreign affairs panels. In the letter, Poneman and Tauscher argue that "nuclear trade carries with it a critical nonproliferation

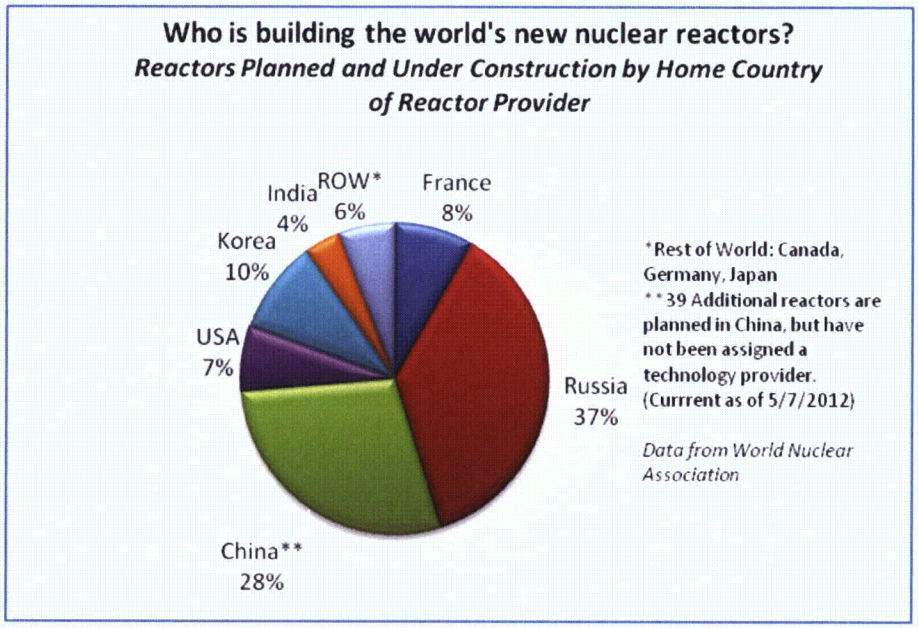
[90] Elaine M. Grossman, "U.S. Nuclear Trade Policy Concerns Mounting on Capitol Hill," *Global Security Newswire*, February 17, 2012, http://www.nti.org/gsn/article/us-nuclear-trade-policy-concerns-mounting-capitol-hill/.

advantage in the form of consent rights, along with other opportunities to influence the nuclear policies of our partners. To obtain this advantage, we need to negotiate agreements that our partners can accept and that open doors to U.S. industry." The letter also argues that 123 Agreements are just one of many ways in which the United States can address ENR proliferation concerns.

Inconsistent signals from U.S. political leaders have caused other nations to harbor serious concerns about the reliability of the United States as a nuclear technology provider. For example, news reports following the UAE's decision to purchase South Korean reactor technology hailed the decision as "the right strategic choice" for that country. Nuclear trade and cooperation agreements require a reliable, consistent, and long-term partner, and analysts outside the United States seem to share the view that there are risks in awarding nuclear energy contracts to U.S. firms.

INSUFFICIENT EXPORT INCENTIVES

While the administration's decision not to constrain future nuclear trade negotiations may alleviate one type of export hurdle, other challenges remain. U.S. firms must still compete with firms from other nations on the basis of technological competitiveness, cost, and other factors. While U.S.-based firms still offer some of the most advanced technology available, they do not benefit, as many of their competitors do, from attractive, government-backed export incentives.



For example, Russian companies—which are currently involved in more than a third of the new reactors currently under construction or planned for construction around the world (see figure above)—often offer turnkey services and fuel take-back programs. This makes them attractive suppliers for countries with limited nuclear infrastructure. And in the South Korea-UAE deal discussed earlier, South Korea's Export-Import Bank expects to lend about $10 billion to Korea

Electric Power Corporation and other contractors to build the four plants the UAE has contracted for.[91]

Of course, not all nuclear power plant construction contracts are even open to competition. Several contracts for reactors under construction in China were awarded to Chinese firms without competition; similarly, the French national utility company did not have to compete for the contract to build a new reactor at Flamanville in France.

The inability to offer generous export incentives, however, puts U.S. firms at a disadvantage for the subset of contracts that is competitively bid worldwide; thus the overall result has been a serious erosion of global market share for U.S. nuclear plant providers. Today, U.S. firms are supplying only 7 percent of the reactors planned or under construction around the world, while Chinese, Russian, Korean, and French firms dominate the global market.

Concern that U.S. nuclear firms are operating at a competitive disadvantage and that this could have longer-term national and global security implications is a central theme of the Poneman/Tauscher letter, which warns that "our competitors are not standing still." The letter goes on to note that "France and Russia in particular are very aggressive in pursuing nuclear business worldwide, and offer favorable terms. Neither imposes ENR conditions in their agreements. Each billion dollars of American nuclear exports supports 10,000 jobs, and provides the U.S. with access and influence over the direction of nuclear programs, ensuring they meet the highest standards for nonproliferation, security, and safety."

For reasons discussed in Chapter 2 of this report, we believe the U.S. has compelling economic and security reasons for maintaining a strong presence in international markets for nuclear energy. This will require continued investment to develop U.S. technology and expertise—particularly in new areas that may hold particular promise for export markets, like small modular reactors (SMRs). It will also require a thoughtful examination of current export policies to explore reforms and improvements that would allow U.S. firms to compete more effectively while still advancing high standards for safety, security, and nonproliferation around the world.

TECHNOLOGICAL COMPETITIVENESS

Today, U.S.-based firms offer several highly competitive nuclear reactor technologies. For example, the Westinghouse AP-1000 design has been embraced by U.S. and Chinese power companies, in part due to its advanced passive safety features (and in part due to its lower estimated cost per megawatt of installed capacity). AP-1000 agreements have been reached with the Czech Republic and Canada and are also under consideration for construction in India and potentially elsewhere.[92]

To maintain or regain a competitive edge in international nuclear markets, U.S. firms will need to continue to offer technology that other nations want to buy. The advanced reactor designs offered for sale today by U.S. firms (such as the AP-1000 and the General Electric/Hitachi-designed

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[91] Ayesha Daya, "South Korea Plans to Lend $10 Billion for U.A.E. Nuclear Plants," Bloomberg News, October 7, 2010, http://www.bloomberg.com/news/2010-10-06/south-korea-plans-to-lend-a-total-of-10-billion-for-u-a-e-nuclear-plants.html.

[92] See Westinghouse, News Release, "Westinghouse and Nuclear Power Company of India Limited Sign Memorandum of Understanding for Early Works Agreement," June 13, 2012, http://westinghousenuclear.mediaroom.com/index.php?s=43&item=326; and Westinghouse, News Release, "Westinghouse to Prepare Detailed Construction Plans and Cost Estimates for Potential AP1000 Units at Darlington," July 23, 2012, http://westinghousenuclear.mediaroom.com/index.php?s=43&item=332.

ESBWR) were developed over the course of a decade or more through public-private partnerships such as the DOE's Advanced Light Water Reactor program in the 1990s and the Nuclear Power 2010 program in the 2000s.[93] Given the importance of these successes in terms of broader U.S. trade and security interests, we believe it is appropriate for future technology investments to continue to be supported by both industry and the federal government.

Looking ahead to future markets, it is worth noting that some 60 countries that do not currently have nuclear power plants have approached the IAEA to explore the possibility of acquiring one. The IAEA anticipates that about 15 of these aspiring nuclear nations will proceed to build one or more reactors over the next decade or two.[94] In many of these nations (and in some nations that already have nuclear energy), a large nuclear plant may be poorly suited to local needs. Small modular reactors (SMRs) may offer a better fit for nations with smaller or slower-growing electrical demand. Cooperative public-private efforts are underway in the United States to explore the commercial potential of SMR technology, but the present pace of development may be insufficient to prevent other nations from capturing the lion's share of this potentially important new market.

Meanwhile, ensuring that an array of civilian nuclear technologies (including, but not limited to, SMRs) will be available to meet longer-term energy needs requires keeping the technology R&D pipeline full. Nations like China, India, and others have shown substantial interest in advanced (Generation IV) nuclear reactor and fuel cycle technologies that may be deployed around the middle of the century. This may seem like a long time horizon, but as demonstrated by the time it took to get the AP-1000 and ESBWR designs ready for commercial development, nuclear energy technologies take decades to move through the R&D phases to demonstration and into commercial use. The United States will need to make sustained investments in technology development if it is to maintain a leadership role in commercial nuclear energy.

CHALLENGES IN THE DOMESTIC MARKET

The challenges facing new nuclear plants in the United States come primarily in four areas: cost, waste management, regulation, and public acceptance.

COST

A principal barrier for the U.S. commercial nuclear energy industry is that the construction of new plants cannot, in most U.S. electricity markets today, be justified on the basis of economics alone.

This statement is borne out by the work of the Commission's Financial Structuring Sub-Group. The subgroup analyzed the economics for a single entity proposing to build five new plants total, with staggered construction and start dates. This approach was intended to capture efficiencies and capital cost savings resulting from experience and "learning by doing." Realistically, any entity in the business of building new nuclear power plants is unlikely to plan for just a single reactor; moreover the first new reactor would be expected to cost more and take longer than the fourth or fifth reactor. Other critical assumptions are summarized in the text box.

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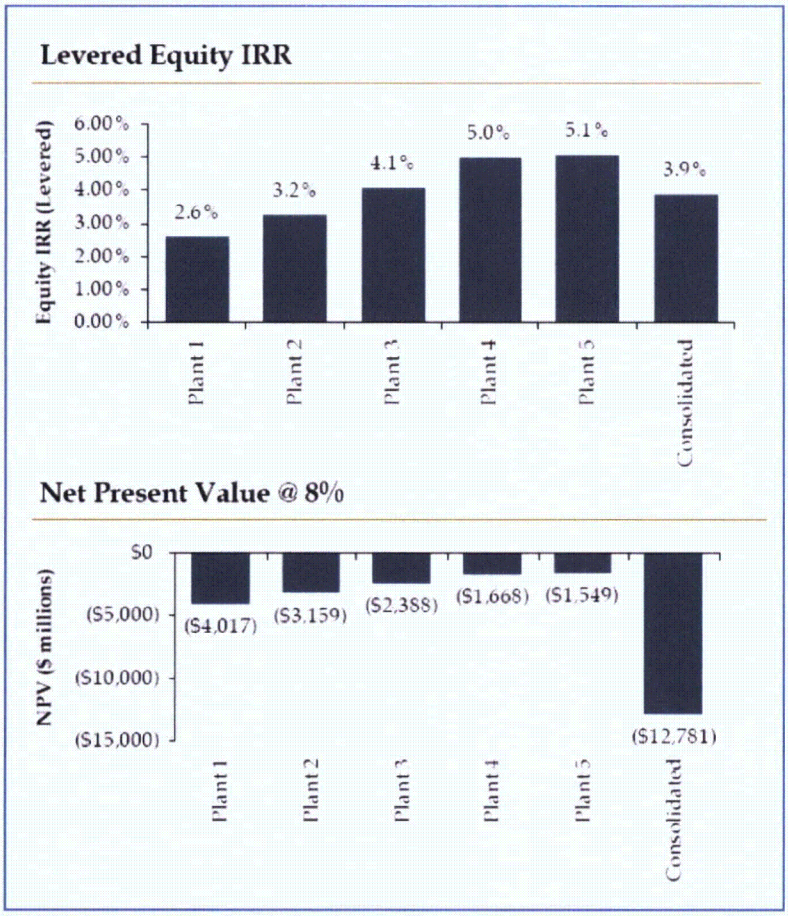
[93] Program information available at Office of Nuclear Energy, http://www.ne.doe.gov/np2010/overview.html.
[94] Blue Ribbon Commission on America's Nuclear Future (BRC), Final Report to the Secretary of Energy, January 2012, p. 110, http://cybercemetery.unt.edu/archive/brc/20120620220235/http://brc.gov/sites/default/files/documents/brc_finalreport_jan2012.pdf.

Key Assumptions in Economic Analysis

- General inflation rate: 2 percent
- Capital structure: 50/50 debt/equity
- Cost of debt: 7 percent (no loan guarantee)
- Overnight capital cost: $6,300/kW ($8.8 billion for first plant)
- Annual escalation on capital costs: 2 percent
- Construction time: 6 years for plants 1 and 2; 5 years for plants 3–5
- Capital cost savings after first plant: 10 percent for each successive plant to a max reduction of 30 percent
- Decommissioning fund: $500 million (2012 $); 8 percent investment return
- Plant capacity: 1,400 MW
- Life of plant: 40 years
- Capacity factor: 93 percent
- Operating statistics (2012 $): Fixed O&M at $10/MWh; fuel at $7.5/MWh; major maintenance at $50/kW-yr
- Power prices: based on Henry Hub natural gas futures through 2024; escalated at 3 percent thereafter
- Capacity prices: blended average of NE and PJM through 2015; escalated at 3 percent thereafter
- Tax rate: 38 percent
- Depreciation: 15-year modified accelerated cost recovery system (MACRS) at time of operation
- Property tax: 1 percent of total cost

It is important to note up front that the assumptions used here are for illustrative purposes only and are intended to represent a middle range of what might be experienced across the United States. The factors included in this list of assumptions may vary greatly from region to region. Thus, our assumptions may differ considerably from the actual conditions facing U.S. companies that have made or are considering making investments in nuclear power.

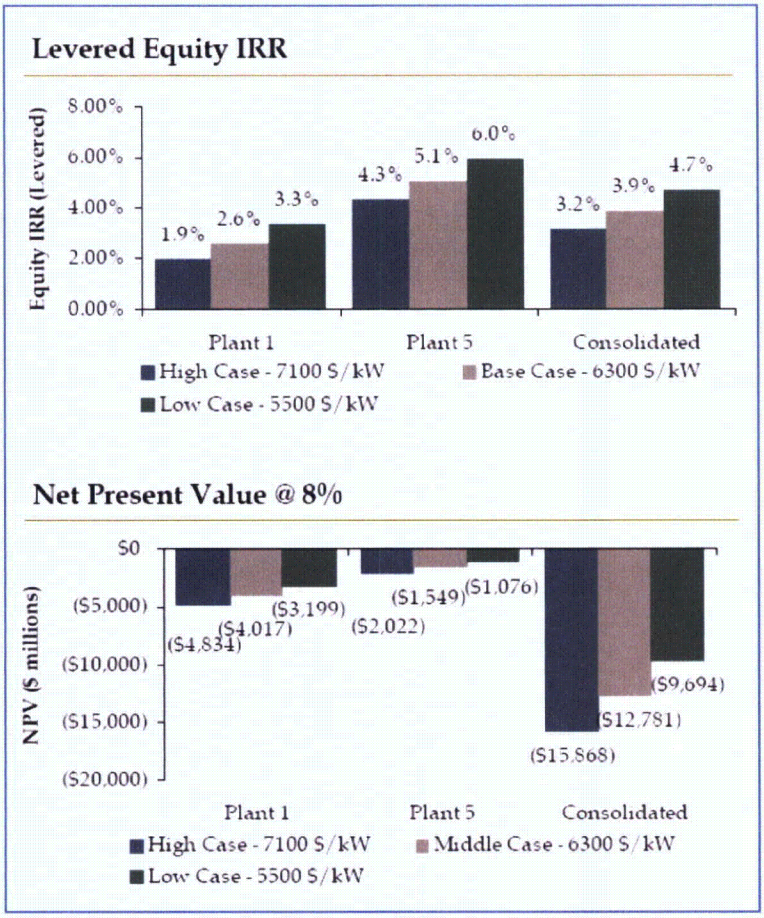
Projected IRR and NPV: Construction of Five New Nuclear Plants



Source: Moelis

For each of the five plants and for all five plants together in our example, we calculated the "levered equity" internal rate of return (IRR) on investment ("levered equity" means that the IRR figures shown include a reduction for debt service payments). The results of the analysis are presented in the figure above and show that, while the reactors in our scenario would produce increasingly positive returns, the returns individually and collectively fall short of the 12–15 percent IRR private investors are typically looking for. In other words, returns under the base case are unattractive and would likely not attract investment. While there is significant improvement through the "learning curve" such that the fifth plant is much more profitable than the first plant (the change in net present value between Plant 1 and Plant 5 is $2.5 billion and the IRR for Plant 5 is nearly double the IRR for Plant 1), the economics are such that even the fifth plant is unlikely to clear the bar for private investment.

Sensitivity Analysis—Low, Middle, and High Plant Construction Costs



Source: Moelis

In our analysis we assume that construction costs for new nuclear plants in the United States will be high. This is largely due to uncertainties resulting from the decades-long hiatus in nuclear plant construction in this country—a hiatus that has led to the "mummification" of build capabilities and experience. Of course, it is possible that capital costs for a new plant could come in significantly lower (or higher) than assumed in this analysis. To explore this possibility, the Financial Structuring Sub-Group conducted a sensitivity analysis to examine how changes in capital cost would change the attractiveness of new nuclear plant investment. Specifically, the subgroup looked at three overnight capital cost scenarios:

- High: $7,100/kW or $10.0 billion
- Base: $6,300/kW or $8.8 billion
- Low: $5,500/kW or $7.7 billion

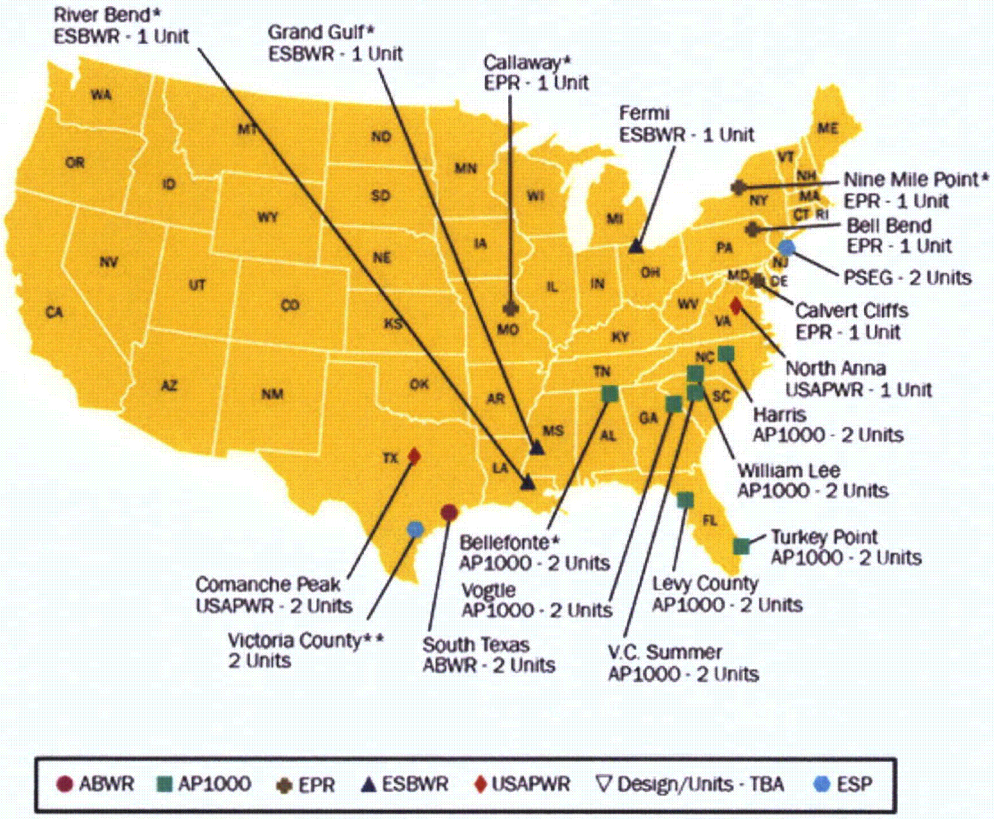
The results indicate that even at the low end of the capital cost range considered (i.e., $5,500 per kW), expected returns are still below the levels demanded by most private investors (see figure above).

The finding that new nuclear power plants face steep economic hurdles is not a new one. Concern that these hurdles would effectively preclude private investment in new nuclear plants prompted

the inclusion of various construction incentives in the Energy Policy Act of 2005—specifically, federal loan guarantees, production tax credits, and insurance provisions to guard against regulatory delays for new nuclear power plants.

Initially, these provisions—along with a DOE program to provide assistance for new plant licensing and the widespread expectation that Congress would pass some form of regulation to restrict greenhouse gas emissions—succeeded in spurring significant interest in new plants. More than a dozen utilities began licensing activities for new nuclear power plants (see figure below). This resurgence of interest, however, proved relatively short-lived. Today, despite the various incentives in the Energy Policy Act, only two projects seem likely to advance to completion before 2020: the two units being built by Southern Company at its Vogtle site and two units proposed by Scana Corporation for the V.C. Summer site.

New Nuclear Plant License Applications



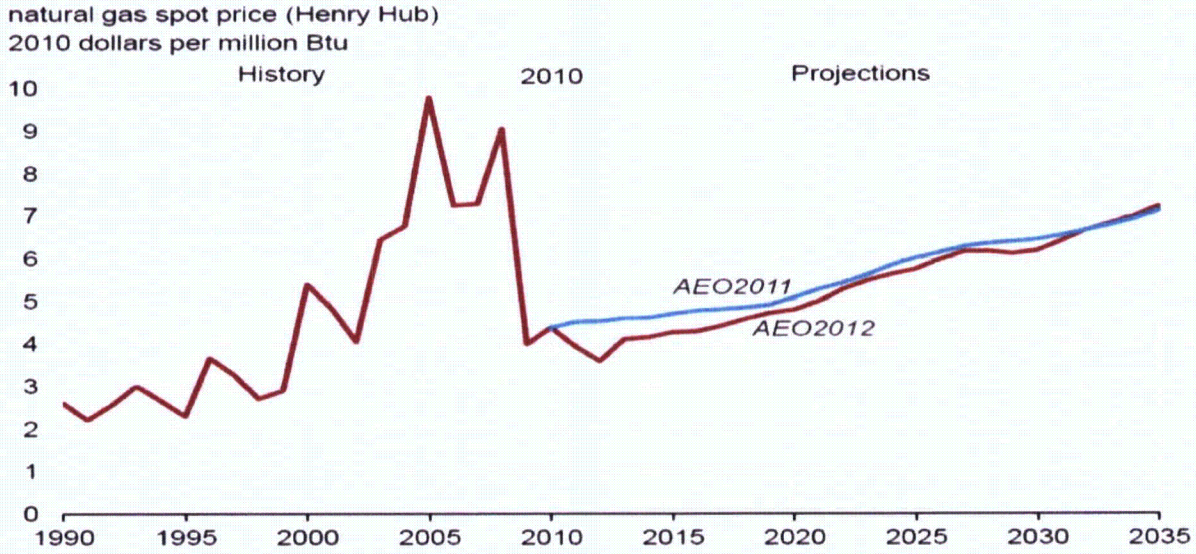
*Review Suspended by Applicant

** COL Application Amended by Applicant to ESP on 03/25/2010

There are several reasons why the momentum behind new plant construction has waned. To be sure, the inability of the federal government and utility applicants to agree on loan guarantee terms is high on the list (today, nearly seven years after the loan guarantee program was codified, not a single loan guarantee for a nuclear power plant has been finalized). The failure of the federal incentive programs notwithstanding, no factor has dampened enthusiasm for new nuclear as much as the radically altered supply and price outlook for natural gas.

Natural gas prices, which averaged as high as $8 per million BTU in 2008, now average about $4. EIA predicts prices will remain below $5 by 2018[95] [see figure below] despite increasing demand—particularly in the electricity sector, where the U.S. Energy Information Administration (EIA) shows that natural gas consumption grew by 21 percent in 2012.[96]

The expectation that natural gas prices will remain relatively low and stable, despite increasing demand, reflects an assumption that domestic natural gas production will continue to grow. In fact, EIA projections indicate that the United States will become a net exporter of liquefied natural gas starting in 2016, and will be an overall net exporter of natural gas by 2021.[97]



Sources: EIA, Annual Energy Outlook 2012 Early Release and EIA, Annual Energy Outlook 2011

In an environment where electricity prices are driven by the availability of low-cost and abundant natural gas, new nuclear cannot compete on the basis of economic factors alone, particularly so long as greenhouse gas emissions remain unrestricted (and unpriced). While the importance of the two new reactor projects underway in the United States should not be underestimated, it is now clear that the federal incentives included in the Energy Policy Act of 2005 will not be sufficient to spur a new wave of utility investment in nuclear technology. As growing numbers of existing plants retire, different and/or more generous forms of support will be needed to sustain a meaningful role for nuclear power in the U.S. electricity generating mix going forward.

As discussed in Chapter 1, a critical enabling factor for the two new plants that are moving forward at this time (Vogtle and Summer) is support from state regulators that helps reduce the stress on cash flow and earnings during the construction period. Specifically, public utility commissions in Georgia, South Carolina, and a handful of other states have provided the rate

[95] U.S. Energy Information Administration, "Annual Energy Outlook 2012 Early Release," January 23, 2012, http://www.eia.gov/todayinenergy/detail.cfm?id=4671#.
[96] U.S. Energy Information Administration, "Short-Term Energy Outlook," March 6, 2012, http://www.eia.gov/forecasts/steo/archives/mar12.pdf.
[97] U.S. Energy Information Administration, "Annual Energy Outlook 2012 Early Release."

treatment needed to support investment in new plants,[98] at least in part because the addition of new nuclear capacity is consistent with their integrated resource planning processes, which typically allow for the consideration of factors such as stability and diversity of long-term electricity supply. But in providing favorable rate treatment, utility commissions are shifting a portion of the risks and liabilities of nuclear plant investments to ratepayers.[99] Even where there is state-level support for these investments now, the political environment could change, particularly if the new reactors presently under construction experience the types of cost overruns and schedule delays that plagued nuclear plants constructed in the United States in the 1970s and 1980s.

For merchant owners/operators, the risks are even greater, and credit rating agencies and shareholders are even less likely to support a sustained campaign of investment in a new generation of nuclear plants. This is especially obvious when one considers the market capitalization of even the largest merchant owners/operators in comparison to the cost of a single nuclear reactor, let alone multiple units. As discussed in Chapter 1, even the largest of the privately held companies that supply most of the electricity in the United States has a market capitalization of less than $40 billion (and most have a market cap of less than $20 billion). Additionally, merchant markets do not provide a mechanism to fully value factors like reliability, clean air compliance value, fuel diversity, and price stability that may argue in favor of new nuclear investments; these markets are inherently focused on the short term. But in any case, whether a company is operating in regulated or competitive markets, the decision to invest up to $10 billion or more in a new nuclear power plant is one that won't be taken lightly. Under current market conditions, this decision is unlikely to be taken at all.

For new nuclear energy projects to go forward, the national interest and common good objectives and benefits discussed in Chapter 2 need to be recognized, and the federal government and states need to bring policy alternatives to the table. When new projects are "in the money," these national interest and common good benefits will be realized by the market without any direct financial cost to the government. But when the economics of new nuclear plants are "out of the money," private investors and shareholders will not proceed absent government incentives or subsidies that reflect these public interest considerations.

WASTE MANAGEMENT

Finding a long-term solution to the problem of spent nuclear fuel has long been viewed as a challenge that must be met if nuclear power is going to remain viable. At present, several states (California, Connecticut, Illinois, Kentucky, Maine, New Jersey, Oregon, West Virginia, and Wisconsin) prohibit new nuclear plant construction until certain waste management conditions are met.[100] There have been several attempts to repeal these laws in recent years, but none have been successful to date.[101]

More recently, challenges to the NRC's so-called "waste confidence" decisions have brought heightened attention to the nuclear waste issue. The first waste confidence decision was issued in

[98] Sony Ben-Moshe et al., "Financing the Nuclear Renaissance: The Benefits and Potential Pitfalls of Federal & State Government Subsidies and the Future of Nuclear Power in California," *Energy Law Journal*, Vol. 30:497, 2009, p. 497.
[99] Ibid.
[100] Blue Ribbon Commission on America's Nuclear Future (BRC), Final Report to the Secretary of Energy, January 2012, p. 25.
[101] Ibid.

1984; more recently, in 2010, the NRC issued a revised decision. In it, the NRC expressed confidence that spent nuclear fuel can be safely stored at U.S. nuclear power plants for at least 60 years beyond the licensed life of the plant; the NRC also expressed confidence that sufficient disposal capacity will be available when needed.[102]

Despite that confidence, the Obama administration's decision in January 2010 to withdraw the Yucca Mountain license application has clearly complicated the nuclear waste picture. Four states appealed the NRC's recent waste confidence statement in light of the decision to terminate the Yucca Mountain project, and in June 2012, the U.S. Court of Appeals directed the NRC to conduct a more thorough environmental analysis before issuing a revised decision on waste confidence.[103] The Commonwealth of Massachusetts is now using this court decision as a basis to challenge the NRC's decision to grant a 20-year extension of the operating license for the Pilgrim nuclear power plant.[104]

Following his decision to withdraw the license application for Yucca Mountain, President Obama directed the secretary of energy to form a Blue Ribbon Commission on America's Nuclear Future to recommend a new strategy for nuclear waste management in the United States. The report subsequently issued by the Blue Ribbon Commission (BRC) in January 2012 concluded: "this nation's failure to come to grips with the nuclear waste issue has already proved damaging and costly and it will be more damaging and more costly the longer it continues: damaging to prospects for maintaining a potentially important energy supply option for the future, damaging to state–federal relations and public confidence in the federal government's competence, and damaging to America's standing in the world—not only as a source of nuclear technology and policy expertise but as a leader on global issues of nuclear safety, non-proliferation, and security."[105]

The Commission's recommended strategy for resolving the nation's nuclear waste impasse included eight key elements:

1. A new, consent-based approach to siting future nuclear waste management facilities.
2. A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
3. Access to the funds nuclear utility ratepayers are providing for the purpose of nuclear waste management.
4. Prompt efforts to develop one or more geologic disposal facilities.
5. Prompt efforts to develop one or more consolidated storage facilities.
6. Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available.
7. Support for continued U.S. innovation in nuclear energy technology and for workforce development.

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[102] Ibid., p. 26.
[103] World Nuclear News, "Court rejects NRC used fuel ruling," June 11, 2012, http://www.world-nuclear-news.org/WR-Court_rejects_NRC_used_fuel_ruling-1106124.html.
[104] World Nuclear News, "NRC Reactor Licensing Decisions Challenged," June 20, 2012, http://www.world-nuclear-news.org/RS-NRC_reactor_licensing_decisions_challenged-2006124.html.
[105] Blue Ribbon Commission on America's Nuclear Future (BRC), Final Report to the Secretary of Energy, January 2012, p. vi.

8. Active U.S. leadership in international efforts to address safety, waste management, nonproliferation, and security concerns.[106]

In response to the BRC final report, the Department of Energy (DOE) published an implementation plan titled "Strategy for the Management and Disposal of Used Nuclear Fuel and High-level Radioactive Waste" in January 2013. The strategy proposed a management system composed of the following:

- A pilot, interim storage facility with limited capacity that will be focused on spent fuel from decommissioned plant sites to be opened by 2021;
- A larger, consolidated storage facility to be open by 2025; and
- A permanent geologic repository for the disposal of used nuclear fuel and high-level radioactive waste to be opened in 2048.

The strategy also calls for the establishment of a new, used-fuel management entity outside of DOE with assured access to long-term, stable funding. The strategy endorses a consent-based siting approach for both the consolidated storage facilities and a geologic repository. The strategy also presumes that the Yucca Mountain site will not be used. DOE outlined their current activities in used fuel space at the end of the document, including transportation infrastructure and planning and disposal-related research.

A key message in the DOE strategy is that the Department needs congressional direction before implementing the planned system of storage and disposal facilities.

Adoption of the BRC's recommendations would go a long way toward restoring confidence that the federal government is serious about meeting its waste management commitments and would lower one of the barriers to the construction of new nuclear power plants in the United States.

REGULATORY UNCERTAINTY AND UNPREDICTABILITY

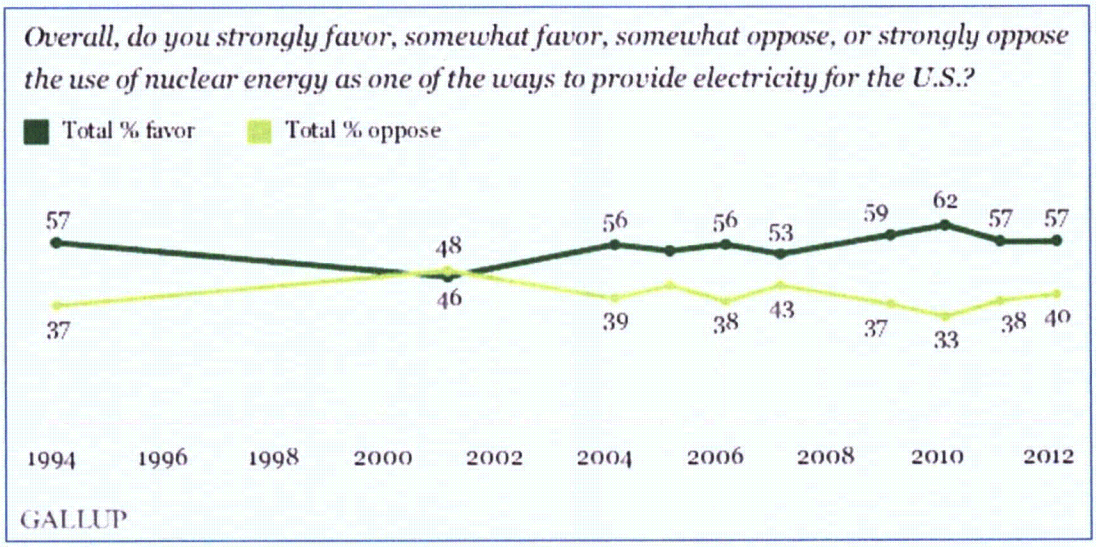
U.S. nuclear plant operators face a greater regulatory burden than operators in any other nation. While the regulatory system in the United States has provided a model for other nations and has been effective in ensuring safe operation of the U.S. reactor fleet, there is concern that regulations have continued to expand without adequate consideration of costs and benefits.

We believe it is essential that the NRC and the U.S. nuclear industry work constructively to maintain the safety and security of the U.S. nuclear fleet without placing undue burdens on reactor operators. As we noted in Chapter 1, the U.S. commercial industry has been unrelenting in its quest for excellence. The Institute of Nuclear Power Operations (INPO) has been a strong force for self-regulation and the result has been performance that sets the global standard. According to nuclear industry reports, however, capital expenditures for regulatory compliance have tripled over just the past five years. Added regulatory requirements when they produce real benefits are good for the industry; additional regulatory costs without appropriate benefits will weigh down otherwise well-performing nuclear facilities and their staff, and will contribute to financial pressures that could lead to even more rapid shutdowns of presently operating nuclear power plants.

[106] Ibid., p. vii.

PUBLIC AND POLITICAL SUPPORT

Favorability ratings continue an upward trend, buoyed by high public ratings for safety at America's reactors (7 out of 10 give them high safety marks). By February 2013, support had risen to 68 percent. The industry saw a temporary downturn in public support after the Fukushima accident, falling to a low of 46 percent in April 2011—just after the accident. Seventy-three percent of respondents now believe that nuclear plants operating in the United States are safe and secure, with 24 percent thinking they are not. Also, 65 percent believe that "nuclear power plants in this area are able to withstand the most extreme natural events that may occur here."[107]



At the federal level, nuclear power has generally enjoyed bipartisan political support; in recent years, successive administrations and Congress have backed continued funding for nuclear energy R&D along with a variety of incentives and subsidies aimed at kick-starting the domestic industry. As noted earlier, however, policies adopted as part of the Energy Policy Act of 2005 have yet to stimulate construction commitments beyond the units currently planned for the Vogtle and Summer sites. The federal loan guarantee program, in particular, has not worked as intended, while the other two incentive programs in the Act—the production tax credit and insurance to guard against regulatory delays—cannot be used until new plants are operating or at least under construction.

The primary problem involves the credit subsidy cost—the fee charged to project developers for the loan guarantee. Credit subsidy costs for the Department of Energy's loan guarantee program are calculated using a credit subsidy calculator developed by the Office of Management and Budget. Of the major inputs to the calculator, two of them—default probability and recovery rate in the event of default—have the greatest impact on results. The Executive Branch employs a recovery rate of 55 percent across the board for all energy technologies and projects being considered for Title XVII loan guarantees. This assumption inflates the credit subsidy cost well

[107] Nuclear Energy Institute, News Release, "New Poll Shows Americans' Support for Nuclear Energy, New Facilities Remains Solid," Bisconti Research, Inc. with GfK Roper survey, February 11, 2013, http://www.nei.org/newsandevents/newsreleases/New-Poll-Shows-Americans%E2%80%99-Support-for-Nuclear-Ener.

beyond the level required to compensate the federal government for the risk taken in providing the loan guarantee. At least one nuclear power project was quoted an unrealistically high credit subsidy cost, which ignored the project's strong credit metrics and the robust lender protections built into the transaction. The 55-percent recovery rate now used is well below the recovery rates historically observed for regulated utility debt and project finance debt. According to historical data, recovery rates for these types of debt typically range from approximately 85 percent to 100 percent.

It is vitally important that credit subsidy costs be calculated accurately. If current practices continue, the Executive Branch will continue to produce inflated credit subsidy costs. Project sponsors, in turn, will simply abandon otherwise creditworthy nuclear energy projects, and the nation will forego the carbon-free energy and thousands of well-paying jobs represented by these facilities.

Going forward, severe budget pressures and an overall climate of fiscal austerity, coupled with diminished public enthusiasm for nuclear energy in the aftermath of Fukushima, are likely to further constrain the federal government's capacity and willingness to provide financial incentives for new plant construction.

At the state level, there is greater variation in the degree of political and policy support for nuclear energy. As noted earlier, several states have adopted moratoriums on new plant construction until issues such as waste management are addressed. At the other end of the spectrum, at least a handful of states have adopted policies aimed at promoting investment in new reactors, in some cases by supplementing financial incentives provided by the federal government.

In states with rate-regulated utilities, the most commonly used policy lever to encourage nuclear construction involves favorable rate treatment that allows utilities to recover the capital costs of new plants. Typically, utilities are allowed to include construction costs in their rate-base. In this way, utilities are assured of being able to recover their costs, in some cases even before construction is complete and the plant has begun to operate. In states that do not permit utilities to recover costs during plant construction, the public utility commission typically approves costs on a non-appealable, year-to-year basis. Approved costs are included in the rate-base and can begin to be recovered upon commercial operation or abandonment. And both rate-regulated states and states that have restructured their electricity markets provide tax credits or exemptions for new nuclear construction. For example, Kansas exempts new nuclear facilities from state property taxes, while Texas permits school districts to enter into agreements with developers of new nuclear plants to limit the appraised value of the plants for purposes of assessing property taxes for school district maintenance and operations.[108]

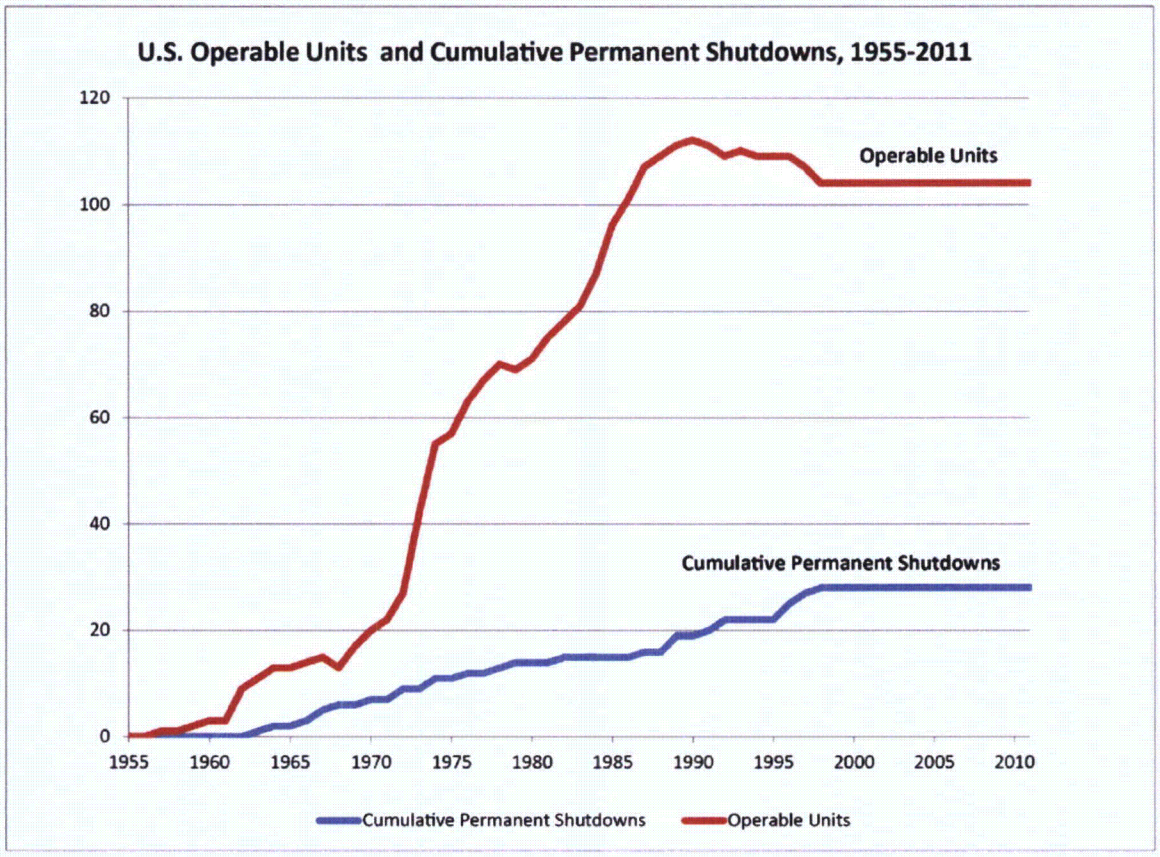
Many of these state-level incentives were put in place in the mid-to-late 2000s, when the prospects for new nuclear power plant construction looked quite positive. Today, in the aftermath of the Fukushima accident, there is less state-level support for the construction of new nuclear power plants. For example, efforts by the Minnesota House and Senate to lift a statewide ban on building new nuclear power plants stalled in 2011 following the Fukushima accident.[109] In Indiana, an

[108] Sony Ben-Moshe et al., "Financing the Nuclear Renaissance: The Benefits and Potential Pitfalls of Federal & State Government Subsidies and the Future of Nuclear Power in California," *Energy Law Journal*, Vol. 30:497, 2009.
[109] Tim Pugmire, "Plan to repeal Minn. ban on new nuclear power on hold," Minnesota Public Radio, March 14, 2011, http://minnesota.publicradio.org/display/web/2011/03/14/minnesota-nuclear-ban-repeal-on-hold.

initiative that would have provided incentives for companies to invest in clean energy, including nuclear power, passed the state senate but did not advance further because of events in Japan.[110]

ERODED SUPPLY CHAIN AND AGING WORKFORCE

From the earliest stages of development, the successful construction of new nuclear plants depends on a robust supply chain of nuclear equipment manufacturers. Because nuclear plants are made up of hundreds of specialized components and subcomponents, the industry requires a deep and diverse supplier base.



*Does not reflect the two recent shutdowns at Kewaunee and Crystal River

Source: EIA

From the early 1970s to the late 1980s, the United States was engaged in a vigorous program of new nuclear power plant construction.[111] As seen in the figure above, about 100 nuclear power reactors were completed in the United States during that period.

These plants were built according to U.S.-developed designs; they included major components (such as reactor pressure vessels, steam generators, and pumps) that were built in the United States, and they operated on uranium that was enriched at the U.S. government's enrichment

[110] John Russell, "Indiana's interest in nuclear power is dampened," Indystar.com, March 17, 2011, http://www.indystar.com/article/20110317/LOCAL/103170407/Indiana-s-interest-nuclear-power-dampened.
[111] American Council on Global Nuclear Competitiveness (ACGNC), "The U.S. Domestic Civil Nuclear Infrastructure and U.S. Nonproliferation Policy," May 2007, p. 15.

plants and fabricated into fuel assemblies at facilities operated by companies like General Electric, Westinghouse, and Exxon Nuclear.

Today, however, these U.S.-based capabilities have atrophied. According to a 2005 assessment[112] of the state of the infrastructure for building new nuclear power plants, "major equipment (reactor pressure vessels, steam generators and moisture separator reheaters) for the near-term deployment of [new] units would not be manufactured by United States facilities" and that "reactor pressure vessel (RPV) fabrication could be delayed by the limited availability of the large nuclear-grade forgings that are currently only available from one Japanese supplier."

The 2005 report concluded that "the necessary manufacturing, fabrication, labor, and construction equipment infrastructure is available today or can be readily developed to support the construction and commissioning of up to eight nuclear units during the period from 2010 to 2017." The ability of U.S. manufacturers to support the construction of eight new nuclear power reactors in an eight-year period stands in sharp contrast to the U.S. industry's previous ability to support construction of 30–40 nuclear plants in a similar timeframe.[113]

Another important development has been the acquisition of all but one American firm engaged in light-water reactor and nuclear-fuel design and manufacture by a non-U.S.-based competitor. As we noted in Chapter 1, Westinghouse—creator of the AP-1000—was purchased by Toshiba in 2006 (Toshiba purchased Westinghouse from British Nuclear Fuels, Ltd., which had acquired Westinghouse from CBS in 1996).[114] Even the sole remaining U.S. vendor of commercial nuclear power plants—the General Electric Company—has partnered with the Japanese companies Hitachi and Toshiba to form Global Nuclear Fuel; GE retains 51 percent ownership, while Hitachi and Toshiba hold the balance.[115]

Besides the loss of U.S.-based manufacturing and design capability at the firm level, workforce adequacy is a significant challenge for the domestic nuclear industry going forward. Large numbers of skilled design engineers, construction specialists, and operating staff are needed to successfully design, build, and eventually operate a new generation of reactors. The U.S. industry has been working diligently for the past five years to reinforce and streamline processes from their four main workforce sources: labor organizations, community colleges, universities, and the military.

This effort was needed independent of new nuclear construction since a large portion of the current nuclear workforce is reaching retirement age. These workforce pipelines are needed to ensure there is qualified staff available to keep existing plants operating.

Jobs in the nuclear energy industry require a high degree of skill. Given the decades-long hiatus in new nuclear plant builds (prior to Vogtle, the last plant to start construction was Palo Verde, in 1979), the industry did not seem to offer a bright career path and, not surprisingly, the number of young people interested in acquiring these skills dwindled. With enrollment declining,

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[112] MPR Associates, Inc., "DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment," MPR-2776, Rev. 0, October 21, 2005.

[113] American Council on Global Nuclear Competiveness, "The U.S. Domestic Civil Nuclear Infrastructure," p. 15.
[114] *Pittsburgh Business Times*, "Westinghouse sold to Toshiba for $5.4B," February 6, 2006, http://www.bizjournals.com/pittsburgh/stories/2006/02/06/daily3.html.
[115] American Council on Global Nuclear Competitiveness, "The U.S. Domestic Civil Nuclear Infrastructure," p. 16.

universities and technical schools closed their nuclear engineering and related skills-based programs.

While the energy sector generally needs more science professionals, the nuclear energy industry faces a particularly worrisome demographic shift, according to recent reports by the Center for Energy Workforce Development. A 2011 study by the Nuclear Energy Institute (NEI) echoed this conclusion; it found that approximately 39 percent of the current nuclear utility workforce will be eligible to retire in the next five years. The report also found that "general attrition"—that is, people simply changing jobs—will reduce the workforce by an additional 10 percent.[116] The combination of expected retirements and attrition amounts to about 25,000 job vacancies that would need to be filled by the nuclear energy industry by 2016.

The industry has responded to this phenomenon by acting collectively to address workforce development, so that workers at all levels can succeed in nuclear energy jobs. Beginning in 2007, the industry began to reinforce the four main workforce pipelines into the nuclear energy industry. Universities, community colleges, labor organizations, and the military are the main pathways into commercial nuclear energy careers.

Separate and distinct strategies were initiated to ensure these pipelines were functional. These strategies have been successful. The universities with nuclear engineering programs have seen a steady increase in enrollments. Community colleges with nuclear technology programs have been reestablished and have grown from 4 to 37 since 2007. The Building and Construction Trades Department of the AFL-CIO has established training centers and new apprenticeship programs to support nuclear energy careers, and the U.S. Navy has just implemented a first-of-its-kind program that streamlines recruiting efforts for the nuclear energy industry by providing the contact information of all of their separating navy nukes who want to pursue civilian nuclear careers.

Of course, the need for technically trained workers is not confined to the nuclear field. A 2008 study by Tapping America's Potential, a coalition representing a diverse group of high-tech and industrial employers, estimates that by 2015, the country will need to graduate roughly 400,000 students per year with degrees in science, technology, engineering, and math (STEM) to meet overall high-tech workforce demands.[117] In 2006, the number of STEM graduates was 225,660[118]—just a little more than half the number needed to meet the nation's needs a few short years from now.

In addition to increasing throughput of Americans in STEM education programs, broader efforts are underway to increase women and minority graduation from STEM programs. This is because both women and minorities hold a disproportionately low share of STEM degrees.[119] Women make up 50 percent of the population, but only 20 percent of engineering school graduates are women.[120] Although African Americans make up 12 percent of the population, they received just 7

[116] Nuclear Energy Institute, "Help Wanted: 25,000 Skilled Workers for the Nuclear Energy Industry," Summer 2011, http://www.nei.org/resourcesandstats/publicationsandmedia/insight/insight-web-extra/help-wanted-25000-skilled-workers.
[117] Tapping America's Potential: The Education for Innovation Initiative, "Gaining Momentum, Losing Ground," 2008 Progress Report, http://tapcoalition.org/resource/pdf/tap_2008_progress.pdf.
[118] Ibid., p. 3.
[119] U.S. Department of Commerce, "Women in STEM: A Gender Gap to Innovation," August 2011, http://www.esa.doc.gov/sites/default/files/reports/documents/womeninstemagaptoinnovation8311.pdf.
[120] Nadya Fouad and Romila Singh, "Stemming the Tide: Why Women Leave Engineering," University of Wisconsin-Milwaukee, 2011, http://studyofwork.com/files/2011/03/NSF_Women-Full-Report-0314.pdf.

percent of all STEM bachelor's degrees, 4 percent of master's degrees, and two percent of PhD degrees in 2009.[121]

The nuclear energy industry wishes to have the best available workforce for both the operating units and any new units that U.S. firms support. Continuing to support workforce development programs while improving company-specific training programs will continue to be a challenge during the transition from the baby boomer to the millennial generation.

In the next part of this report we turn to a "toolkit" of options for policymakers and the industry to address the challenges described in this chapter.

[121] U.S. Department of Education, National Center for Education Statistics, "Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education," NCES 2009-161, July 2009, http://nces.ed.gov/pubs2009/2009161.pdf.

Chapter 4

RECOMMENDATIONS

This chapter recommends specific actions to ensure (a) that nuclear energy remains available as a viable energy option for the United States and (b) that the U.S. government retains a position of strong influence in international nuclear energy matters. Success in both of these objectives would advance U.S. security interests and deliver environmental and energy diversity benefits for the American people beyond those recognized in the marketplace. It therefore warrants support beyond what the market—left to private considerations of risk and reward alone—will provide.

As discussed in Chapter 3, a large number of new domestic nuclear power plant orders is highly unlikely over at least the next several years owing to many factors, particularly low natural gas prices. So while we believe the federal government and state governments should take steps to facilitate future plant orders, the focus of our recommendations is on the return of U.S. competitiveness in the trade of nuclear technology and equipment. Restored U.S. competitiveness will enhance U.S. influence in international nuclear affairs. Conversely, if U.S. firms are unable to compete in the global marketplace, the lack of a competitive U.S. presence in commercial markets, coupled with a diminishing role for nuclear energy in U.S. electricity generation, will mean the United States will not be able to project its interests in civil nuclear matters and nonproliferation as forcefully.[122]

Of course, there is no single policy step the government can take to restore the strength of the U.S. nuclear industry. And government cannot do it all—industry will still need to develop attractive technology offerings and deliver a quality product or service consistent with the cost and schedule requirements of their customers. The goal of a new U.S. nuclear energy program should therefore be multifaceted. It should facilitate trade opportunities for U.S companies; it should address the barriers and challenges that are inhibiting development of existing domestic projects; it should address opportunities for developing new technologies and intellectual capital; and it should provide a strong basis for extending U.S. influence to shape the global nuclear energy infrastructure as it evolves in the decades ahead. In this chapter, we offer a range of policy actions that can move us toward this goal.

DEVELOPING POLICY SOLUTIONS THAT MEET THE NEEDS OF INDUSTRY AND GOVERNMENT

In designing options for addressing the challenges to a robust commercial nuclear enterprise, and in light of the foregoing discussion, we have striven to evaluate only those policy options that would be most consistent with the needs and objectives of the federal government, state governments, and the private sector.

NEEDS AND OBJECTIVES OF THE FEDERAL GOVERNMENT

- Arresting the decline of U.S. influence in nonproliferation policy and nuclear energy standard setting. With a nearly dormant domestic nuclear energy industry and other countries (China, Russia, South Korea, India) taking leading roles in an expanding global market, the U.S. government is finding it challenging to maintain important policy

[122] American Council on Global Nuclear Competiveness, "The U.S. Domestic Civil Nuclear Infrastructure," p. 27–28.

directions related to all dimensions of nuclear energy. Nonproliferation, trade guidelines, standards for operation, approaches for emergency response are all areas where the United States needs to continue to exert global leadership.

- Confronting a challenging fiscal climate. With so many financial demands, and in a challenging economic environment, providing federal or state incentives or other financial support is difficult. Lawmakers should seek a long-term "budget neutral" level of support, or as close to budget neutral as reasonable, while supporting "program" success. Policies should be designed to ensure that incentives "sunset" or otherwise phase down as conditions for new nuclear improve.
- Overcoming recent controversies with DOE programs, including the loan guarantee program. DOE credibility and the controversy surrounding recent loan guarantee awards is a barrier to progress with the federal nuclear program in its current form. This will only increase the bureaucratic inertia and aversion to informed risk-taking that has stalled and frustrated the implementation of existing incentive programs. At the same time, these programs must be designed to minimize opportunities for waste, fraud, and abuse.
- Encouraging and incentivizing broad risk-taking and investment by the private sector and investor entities so as to minimize federal project risk exposure. The desire to minimize taxpayer exposure will multiply in light of the Solyndra default and other negative publicity associated with the existing DOE loan guarantee program.

NEEDS AND OBJECTIVES OF STATE GOVERNMENTS

- Creating job opportunities and other economic benefits. State and local governments are keenly aware of the need to spur job growth as a way to increase tax revenues and reduce demand for unemployment and other social "safety net" benefits.
- Attracting manufacturing and service company expansion. To the extent that local companies can provide supplies and services for new nuclear power plants in the United States and abroad, state-level political support will be even stronger.
- Maintaining reliable, diversified, and reasonably priced electricity supply. States may be simultaneously attracted by the stable generating costs and alarmed by the high construction price tag and historical cost over-runs associated with nuclear power. State public utility commissions will tend to value the price stability that can come with a diversified electricity supply.

NEEDS AND OBJECTIVES OF THE PRIVATE SECTOR

- Reasonable financial returns. Both the suppliers and buyers of nuclear power plant technology will need assurance that the export of nuclear technologies and services abroad and the construction of new reactors in the United States (as well as the continued operation of existing reactors) can provide financial returns commensurate with their risk.
- Consistent government support for nuclear energy. Wide swings in federal and state government support for nuclear energy will dampen private-sector enthusiasm for investing in the nuclear business.
- Limited financial risks. The level of investment required to construct a new plant should be reduced to the extent possible and, ideally, these investments will receive favorable treatment (such as through tax benefits or inclusion in electric rates).
- Opportunity to maintain a diversified portfolio of electricity supply sources. Electricity generating companies would be more inclined to maintain a diverse generating portfolio

if they were compensated for the societal benefits associated with maintaining a diversified portfolio.

- Variety of solutions so as to address the variety of economic energy environments across the nation (strongly regulated areas, areas with lighter regulation, semi-open competitive markets, and fully competitive market areas). Every electricity generator faces a unique set of regulatory and legislative circumstances; the menu of policy solutions should reflect this reality and allow for the tailoring of incentives.

Based on the analysis in earlier sections of this report and the considerations enumerated above, we have concluded that the following policy options are most likely to be effective in reinvigorating the domestic nuclear energy enterprise.

BOLSTERING U.S. COMPETITIVENESS IN EXPORT MARKETS

As discussed in Chapter 3, U.S. national security interests can be served effectively only if U.S. suppliers of nuclear technology, fuel, and services play an active role in the global marketplace. At present, the ability of U.S. firms to compete in this marketplace is severely hindered by U.S. export policies. Over the longer term, the United States may find itself at a further disadvantage if its nuclear technology offerings fall behind those of other nuclear exporters.

Improving the ability of U.S. firms to compete in the global nuclear marketplace is our highest-priority recommendation. Our reasoning is straightforward. A large-scale, government-supported nuclear construction program in the United States would be cost-prohibitive. On the other hand, there are several other nations that have placed a higher priority on the nonmonetary advantages of nuclear energy and are therefore aggressively investing in new reactors. Rather than rest our hopes primarily on an expensive program of domestic industry supports, we believe that recommendations focused on making it easier for U.S. firms to compete in the international marketplace have a greater likelihood of being implemented and a greater chance of achieving our goals.

Consistent with this objective, we view as positive the administration's recent acknowledgment that most nations will not be willing to give up their NPT rights to enrichment and reprocessing technology, and we support the decision to avoid insisting on the so-called "gold standard" in pending 123 Agreements, such as those with Vietnam and Jordan. The administration's plan to adopt a "case-by-case" policy to negotiating future agreements recognizes that in order to benefit from the nonproliferation advantages that come from nuclear trade, the United States must "negotiate agreements that our partners can accept."[123]

The administration's recognition of the realities of the international nuclear marketplace is certainly welcome but is not sufficient to bolster the competitiveness of U.S. firms. We can and must do more. In particular, the combination of export barriers, insufficient export incentives available to U.S. firms, and the noncompetitive nature of some contract awards, have led to a serious erosion of market share for U.S. nuclear plant providers such that U.S. firms are supplying only a small share (6 percent) of the reactors planned or under construction across the globe, while Chinese, Russian, Korean, and French firms dominate the global market.

[123] Letter from Daniel B. Poneman and Ellen O. Tauscher to Senator John Kerry, Chairman, Committee of Foreign Relations, January 10, 2012.

To help restore the competitiveness of U.S. nuclear energy technology exports, we recommend adoption of the following policies:

- 123 Agreements: The negotiation of future 123 Agreements on a case-by-case basis—rather than insisting that nations cede their NPT rights to nuclear fuel cycle technologies—is the approach most likely to support U.S. nuclear exports. This policy should be the norm and should be recognized as such by the U.S. Congress.
- Part 810 Requirements: Part 810 prohibits U.S. companies from assisting foreign nuclear power programs unless such assistance is authorized by the secretary of energy, following an interagency review process specified by the Atomic Energy Act. These requirements can stand in the way of U.S. nuclear companies' ability to conduct routine business. The current Part 810 rules are already restrictive, but changes proposed by DOE staff in 2011 would only make matters worse. In any revision of the Section 810 rules, efforts should be made to take into full account the concerns raised by U.S. nuclear firms.
- Government Support for Exports and Export Financing: The federal government should issue a clear policy statement in support of nuclear technology exports, should ensure that this policy is implemented consistently by the relevant federal agencies, and should undertake a concerted effort to streamline the cumbersome export approval process. In particular, U.S. exports would be aided by favorable interest rates enabled by loans from the Export-Import Bank of the United States, which was formed for the purposes of financing and insuring foreign purchases of U.S. goods for customers unable or unwilling to accept credit risk. The Ex-Im Bank "assume[s] credit and country risks that the private sector is unable or unwilling to accept." It also "help[s] to level the playing field for U.S. exporters by matching the financing that other governments provide to their exporters."[124]

EXPANDED SUPPORT FOR SMRs AND TECHNOLOGY DEVELOPMENT

To regain a competitive edge in international nuclear markets, U.S. firms will need to offer technology that other nations want to buy. Small modular reactors (SMRs), leading versions of which are under development by U.S. firms, may offer a better fit for nations with smaller or slower-growing electrical demand. As discussed in Chapter 3, cooperative public-private efforts are underway in the United States to explore the commercial potential of SMR technology. Specifically, DOE is engaged in a multiyear program (known as the SMR Licensing Technical Support Program) to help accelerate the timeline for commercializing and deploying SMR technologies. The mission of the program is to overcome first-of-its-kind cost hurdles associated with design certification and licensing activities for two SMR designs through cost-share arrangements with industry partners. DOE has requested a budget of $65 million to continue the program in fiscal year 2013.[125]

Despite this welcome DOE support, there are of course no guarantees that industry will proceed with the construction of SMRs in the United States. To improve prospects for deployment, one option is to allow the Department of Defense (DOD) to participate directly in funding the development and demonstration of SMRs, perhaps through DOE, with the project meeting civil nuclear requirements for licensing and regulation. In recent years, DOD has investigated the

[124] Export-Import Bank of the United States, Mission Statement, http://www.exim.gov/about/library/reports/annualreports/2010/upload/exim_2010annualreport_mission.pdf.
[125] U.S. Department of Energy, "FY 2013 Congressional Budget Request," Volume 3, February 2012, p. 299, http://energy.gov/sites/prod/files/FY13%20DOE%20Congressional%20Budget%20Request%20-%20Volume3.pdf.

potential application of SMRs to provide electricity to deployed troops and to reduce reliance on the domestic electrical grid.[126] A DOE/DOD SMR development and demonstration program would not only create domestic opportunities, it would also provide a pathway for U.S. firms to demonstrate the readiness of SMR technology for deployment overseas.

Meanwhile, DOE's SMR development efforts should be continued and expanded, as envisioned under DOE's current program plans. Going forward, these plans should allow for the parallel development of materials, fabrication, manufacturing, assembly, and operation of SMRs by several different vendors. The idea would be to meet NRC licensing requirements while maintaining flexibility to innovate and iterate throughout the development process.

Assuming success in these development efforts, SMR vendors should be encouraged to pursue global market opportunities while also advancing the highest U.S. standards for safety, security, reliability, and emergency response as applicable to this new technology. The same economic and financial structuring incentives available for light-water reactors should also be made available for SMRs. Commercialization should be accompanied by adherence to traditional regulatory requirements and NRC oversight as a way to build public confidence in the commercial deployment of this technology.

Looking even longer-term, an aggressive government-industry nuclear RD&D program can help form the basis for advanced (Generation IV) nuclear reactor and fuel cycle technologies that may be deployed around the middle of the century. Today, the U.S. DOE's Advanced Reactor Concepts program is supporting R&D on advanced reactor concepts, including liquid metal-cooled fast reactors and liquid fluoride salt-cooled reactors; in addition, DOE is supporting the development of technologies (such as a supercritical CO2 Brayton cycle for energy conversion) that could be applied to many different reactor technologies.[127] The United States should continue to invest in these types of long-term R&D efforts, including investments in the university- and national laboratory-based research infrastructure needed to develop and demonstrate new nuclear technologies.

EXPANDED PARTICIPATION IN INTERNATIONAL NUCLEAR COOPERATION

According to the Blue Ribbon Commission on America's Nuclear Future: "Safety is an inescapable, continuing, expensive, and technologically sophisticated demand that all new entrants to commercial nuclear power will have to confront over the full lifecycle of these systems—from preparing for construction through decommissioning. The nature and scope of the safety challenges involved might not be fully apparent to new entrants. Managing these challenges requires that robust institutional, organizational and technical arrangements be in place at the very early stages of a nuclear program. Also needed are sufficient technical knowledge and experience, strong management, continued peer-review and training, and an enduring commitment to excellence and a robust safety culture."[128]

The United States is widely respected internationally for its strong independent nuclear regulator and its successful industry self-governance model. The accident at the Fukushima-Daiichi nuclear

[126] Richard B. Andres and Hanna L. Breetz, "Small Nuclear Reactors for Military Installations: Capabilities, Costs, and Technological Implications," Strategic Forum, National Defense University, February 2011, http://www.ndu.edu/inss/docuploaded/SF%20262%20Andres.pdf.
[127] U.S. Department of Energy, "FY 2013 Congressional Budget Request," Volume 3, p. 313.
[128] Blue Ribbon Commission on America's Nuclear Future (BRC), Final Report to the Secretary of Energy, January 2012, p. 110.

plant in Japan reinforces the need for the United States to encourage expanded international efforts to promote the safe operation of existing and planned nuclear installations.

As other countries pursue ambitious programs of nuclear investment, the United States can fill an important role by helping them tackle the safe planning, design, construction, operation, and regulation of nuclear energy systems. A strengthened U.S. nuclear industry will help preserve this opportunity and will ensure that developing nuclear nations look first to the United States as a source of nuclear know-how.

As we noted in previous chapters, the NRC is regularly engaged as the benchmark standard setter for regulators in other countries and the Institute of Nuclear Power Operations (INPO) is routinely approached for leadership and assistance in applying the same principles that govern U.S. industry nuclear operations to other operators around the globe. The World Association of Nuclear Operators (WANO), modeled after INPO, is evolving to influence safe operations on a global basis. More recently, the International Framework for Nuclear Energy Cooperation (IFNEC) has evolved as an influential forum, with 62 participating nations, and a five-nation steering committee (United States, United Kingdom, France, Japan, and China); it has been embraced by many countries expanding or seeking to enter the realm of nuclear operations as a key opportunity for gaining insight from the experiences of successful nuclear energy nations. With continued DOE leadership, IFNEC, in particular, offers a promising venue for bringing forward and reinforcing standards and principles for responsible and safe nuclear energy operations worldwide. Through these entities and others, the United States should continue to leverage its regulatory and legal framework and its reputation for excellence, especially in working with emerging nations that are seeking to establish nuclear energy as a new domestic source of electricity.

SOLVING THE NUCLEAR WASTE CHALLENGE

The January 2012 report of the Blue Ribbon Commission on America's Nuclear Future found that "America's nuclear waste management policy has been troubled for decades and is now all but completely broken down."[129] The U.S. nuclear waste management plan was laid out in the 1980s under the Nuclear Waste Policy Act. In 1987, Yucca Mountain in Nevada was selected as the only site to be evaluated for an underground repository for high-level nuclear waste. If the site was found to be suitable, it was to begin receiving waste in 1998. Yet, despite more than 20 years of work and more than $10 billion spent, the Yucca Mountain repository has not been constructed and has been proposed for termination.

Currently, more than 65 thousand metric tons of spent commercial reactor fuel are being stored at about 75 sites around the country. Each year, the operation of commercial nuclear reactors in the United States generates another 2,000 to 2,400 metric tons of spent fuel. DOE is also storing thousands of tons of spent fuel and high-level radioactive waste from defense and research programs at government-owned sites.[130]

Demonstrating a credible path forward for nuclear waste management in the United States would both reduce public concerns about nuclear plant construction and satisfy laws in several states

[129] Blue Ribbon Commission on America's Nuclear Future (BRC), Final Report to the Secretary of Energy, January 2012, p. 110, p. iii.
[130] Blue Ribbon Commission on America's Nuclear Future (BRC), Final Report to the Secretary of Energy, January 2012, pp. 14–19.

that prohibit new plant construction without a solution to the nuclear waste problem. The dual challenges of spent nuclear fuel management and disposal are addressed at length in the final 2012 report of the Blue Ribbon Commission on America's Nuclear Future and the 2011 MIT Report on the Future of the Nuclear Fuel Cycle.[131] We urge that the U.S. government act on the recommendations in these reports as a critical step toward supporting the revival of the nuclear industry in the United States, including:

- Providing access to the funds nuclear utility ratepayers provide for the purpose of nuclear waste management.
- Establishing a new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
- Implementing a consent-based approach to siting future nuclear waste management facilities.
- Pursuing fuel-leasing options for countries that have or are pursuing small nuclear programs. These options should provide incentives to forego uranium enrichment and should incorporate spent-fuel take-back arrangements.
- Undertaking integrated system studies and experiments on innovative reactor and fuel cycle options, and selecting a limited set of options for more detailed analysis.

Industry groups and waste management experts have concluded that implementation of these recommendations is essential to getting the U.S. nuclear waste program back on track and thereby eliminating one of the major obstacles to restoring the U.S. nuclear energy enterprise.[132] As the Blue Ribbon Commission stated: "First, with so many players in the international nuclear technology and policy arena, the United States will increasingly have to lead by engagement and by example. Second, the United States cannot exercise effective leadership on issues related to the back end of the nuclear fuel cycle so long as its own program is in disarray; effective domestic policies are needed to support America's international agenda."[133]

The United States can regain some of its lost influence by working with its allies to offer other countries—especially countries with relatively new or small nuclear programs—upstream and downstream fuel cycle services (i.e., beyond just reactor design, construction, and operation). Such services could be extremely valuable for limiting proliferation risks and ensuring that global nuclear energy development proceeds in a way that protects all countries' safety and security interests. Specifically, the ability to offer not only uranium enrichment services but also spent-fuel takeback and disposal or reprocessing at facilities under rigorous multinational security safeguards and controls could be extremely valuable.

ECONOMIC SUPPORT AND FINANCIAL STRUCTURING FOR NEW U.S. REACTORS

A limited set of "first mover" financial incentives at both the federal and state levels can help jump-start the construction of new nuclear power plants in the United States. Below we present a wide array of options and opportunities for encouraging and facilitating investment in new construction. We recognize that the approaches presented below would all be costly and would be

[131] Several members of this Commission served on or otherwise contributed to the work of the Blue Ribbon Commission and the MIT study group.
[132] For example, see Nuclear Energy Institute, Press Release, "Nuclear Energy Stakeholders Welcome Blue Ribbon Commission Report to DOE," January 26, 2012, http://www.nei.org/newsandevents/newsreleases/nuclear-energy-stakeholders-welcome-blue-ribbon-commission-report-to-doe.
[133] Blue Ribbon Commission on America's Nuclear Future (BRC), Report to the Secretary of Energy, January 2012, p. xiv.

quite challenging to enact in this time of tight government budgets. We offer a range of options, not with the expectation that all of them will be adopted, but with the conviction that implementing any of these options—at the federal level, within individual states, or both—will improve prospects for building several more new plants in the United States and thus help strengthen the U.S. nuclear industry.

When considering how to advance the construction of new nuclear reactors in the United States, it is useful to consider actions that can be taken in the three major phases of nuclear plant construction: design, build, and operate.

- The "design" phase includes all the steps involved in getting a reactor site and reactor design licensed for construction. This phase can be as short as two to three years initially, assuming a standardized version of the design has already been approved by the NRC, and can be even shorter for the fourth or fifth unit constructed at a given site.
- The "build" phase includes all phases of engineering, procurement, and construction, including the startup testing that will be required before the plant can enter commercial service. For purposes of this discussion, we assume the build phase lasts six years.
- The "operations" phase represents those activities after the plant enters commercial operation.

Using our Design/Build/Operate (DBO) model, we illustrate the revenues and expenses for each phase. We assume the design phase lasts two years followed by a six-year build phase. The plant is then assumed to operate for 40 years. While a longer operating life is certainly possible and may be an important factor in considering new plant proposals from the perspective of a generator or a public utility commission, whether a plant operates longer than 40 years is fairly irrelevant to the financial analysis given the long period of discounting that applies.

Critical to finding willing investors for the build phase will be the presence of policies that support the private sector's economic considerations and risk management objectives. While current U.S. nuclear companies may not choose to be part of a build investor consortium, it is possible that several large companies, heretofore not directly involved, could be interested. Such companies would be ones that value the tax credits, can take a long-term view of the economics, and are large enough not to be financially strained by the size of investments required, even when considering multiple projects (5+) over a period of 10–15 years. These could include:

- Large global energy resource companies
- Large global industrial companies
- Large and long-term investors (such as pension funds)
- Investment arms or companies of the largest countries that have a strategic interest in advancing nuclear energy (e.g., China, Russia, France, South Korea)

LOWER THE COST OF BORROWING

On $7 billion of debt, a 1 percent decrease in the interest rate saves $45 million per year after tax in the early years. This reduction in borrowing costs could be achieved in at least two ways:

- Federal loan guarantees—As discussed elsewhere in this report, the DOE loan guarantee program established by the Energy Policy Act of 2005 has been implemented in a manner that is inconsistent with the intent of the program and that has not proved successful in spurring investment in new nuclear construction in the United States. It should be

reviewed and revised in order to provide support for new light-water reactor (LWR) construction and SMR development.

- Relaxed restrictions on foreign investment—Encouraging broad opportunities for foreign ownership in new nuclear construction would ease the investment burden on relatively small market cap firms in the United States. This will require changes to relevant codes and regulations so that sovereign wealth funds, foreign investors, non-U.S.-owned companies, and pension funds are free to invest in U.S. nuclear plants. Foreign ownership should be allowed up to 90 percent of the equity value of the facility, contingent on the requirement that a U.S.-based owner/operator recognized by the NRC retains a controlling interest. All matters related to the safety, security, and reliability of the facility, including the unalterable right to make capital calls on the owners of the facility in support of the safety, security, and reliability needs of the facility, would remain with the U.S. owner/operator.
- The possibility of engaging the investment arms of nations that are making strategic investments in nuclear energy is complicated by rules that restrict foreign interests in U.S. nuclear power plants. Foreign ownership, control, and influence of U.S. nuclear facilities is governed by sections 103d and 104d of the Atomic Energy Act of 1954. Legal writings on this issue have found that "The statutory and regulatory restrictions on foreign ownership, control, and domination should not be read to preclude foreign investment in a nuclear facility, so long as the AEA licensee is a U.S. corporation (or other U.S. entity), provided the licensee is not directly and wholly owned by a foreign corporation or other foreign entity, and U.S. citizens control any decisions on matters affecting the common defense and security, such as the control of special nuclear material. This means, for example, that a licensee under sections 103 or 104 of the AEA could be a wholly owned, indirect subsidiary of a foreign corporation (the foreign corporation could be the 'grandparent' of the NRC licensee), provided that U.S. citizens control any decisions affecting the common defense and security."[134]

REVISIONS TO THE TAX CODE

The federal tax code provides mechanisms for the federal government to incentivize activities that are in the national interest and that the marketplace would not otherwise undertake. The Energy Policy Act of 2005 moved in this direction. Given the experience of the last several years, and the increased gap in the economic viability of new nuclear facilities, further expansion of these mechanisms would be beneficial in the following areas.

- Accelerated depreciation (also known as "bonus depreciation") involves changes to relevant tax codes to provide for depreciation at the time that investments are made. This kind of incentive provides benefits during the construction period, effectively offsetting the capital requirements for a new plant as it is being constructed. One must assume the tax depreciation benefit can be used by a parent company or investors with offsetting earnings. The result is shown as a reduction to debt and/or equity required to build the plant. This method does not require outlays from the government—simply a change in when the tax benefit of depreciation is realized.
- One option that should be considered for new nuclear plants is a 30 percent investment tax credit (ITC) upon project completion. The ITC serves to reduce the net investment in

[134] Martin G. Malsch, "The Purchase of U.S. Nuclear Power Plants by Foreign Entities," *Energy Law Journal*, Vol. 20:263, http://felj.org/elj/Energy%20Journals/Vol20_No2_1999_Art_Purchase%20of%20U.S.%20Nuc.pdf.

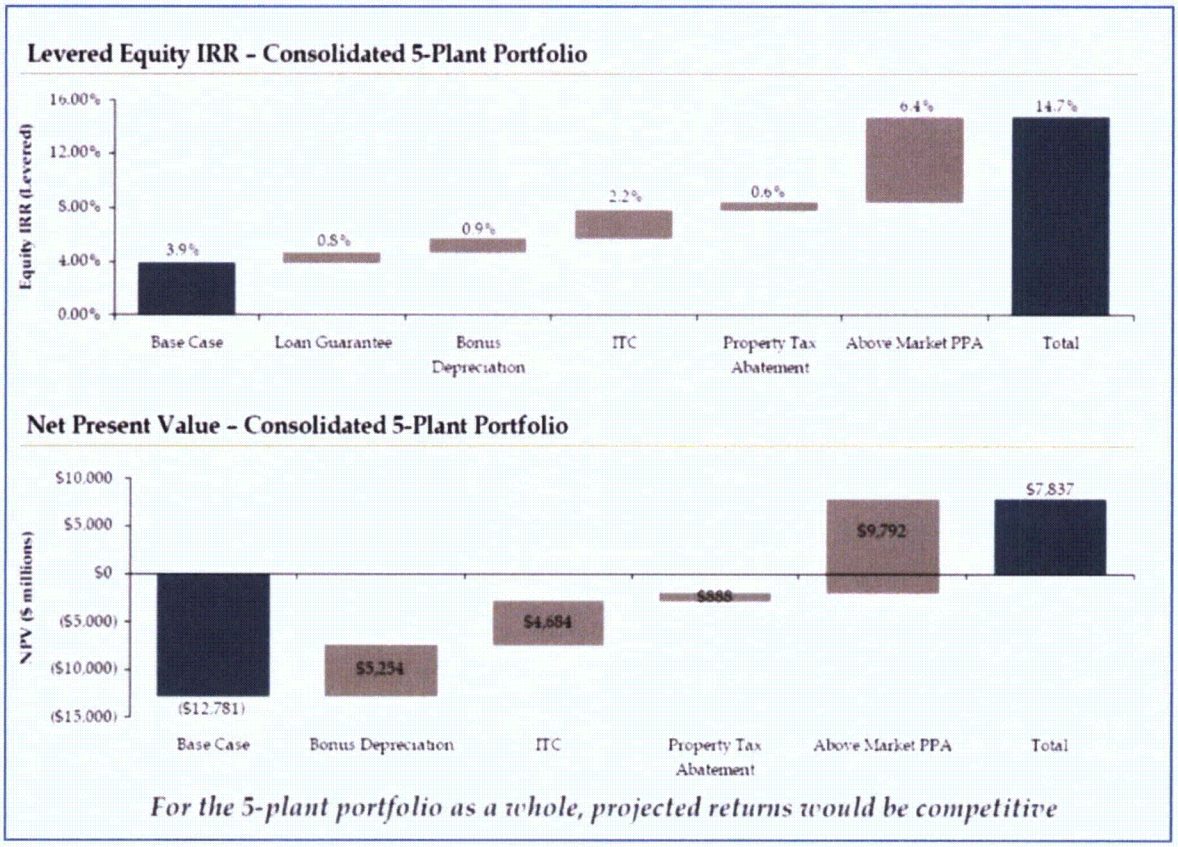
the plant and associated tax depreciation. Thus, the net benefit of the depreciation benefit (applied to a 35 percent tax rate) and the ITC benefit (30 percent tax credit) is not an additive 65 percent reduction in the overall capital requirement (35 percent tax rate + 30 percent ITC), but rather amounts to a 54.5 percent benefit (30 percent ITC + 35 percent on the remaining 70 percent). An ITC might be necessary for only a limited time, as efficiencies gained through experience with the first few plants could make up the difference after that.

- Property tax abatement encourages state and local authorities to support an approach that excludes new facilities from property taxes for the first 10 years of operation, with a phase-in of low tax requirements for the subsequent 5 years. This would allow the expected increase in power prices due to inflation to potentially cover anticipated property tax expenses.

MONETIZATION OF EXTERNAL BENEFITS

Mechanisms to provide monetary recognition of the societal benefits of certain forms of energy supply (such as low emissions and electricity supply diversification) would improve the prospects for new nuclear builds. Such mechanisms would have the effect of increasing the cost-competitiveness of nuclear-generated electricity. Given uncertainty regarding legislation to regulate carbon emissions, a more realistic means of monetizing the external benefits of nuclear-generated electricity may be through power purchase agreements with the U.S. government, including military bases.

These purchases could offer government entities price stability over a long contract period (possibly 20 years or more). Price assurances could be combined with efforts to permit and



Source: Moelis

encourage the development of a nuclear energy facility on or adjacent to a military facility, with provisions for direct support from the military facility (such as land use easements and facility security) included as part of the project.

Combining these options and applying them to the basic financial model presented in Chapter 3, the property tax, accelerated depreciation, ITC, power price, and loan guarantee/financing provisions would result in a positive return on equity for a first nuclear reactor project. Looking at the complete program of five new reactors used in this analysis, the levered equity internal rate of return (IRR) would increase from 3.9 percent to 14.7 percent. The net present value (NPV) of the five-plant portfolio would increase from -$12.78 billion to +$7.84 billion (see the figure above).

The set of policy options discussed above is, of course, not exhaustive. Policymakers who are interested in creating the conditions under which the U.S. nuclear enterprise can be restored will want to consider these and other options as they craft supportive policies.

Scenario	Description	Plant #1 Cost ($ bn)	Plant #5 Cost ($ bn)	Consolidated Portfolio Cost ($ bn)
A	Loan Guarantee [1]	$0.3	$0.2	$1.1
B	Bonus Depreciation	$1.4	$0.8	$5.2
C	Investment Tax Credit	$1.2	$0.7	$4.7
D	Property Tax Abatement	$0.2	$0.1	$0.9
E	Long-Term PPA	$2.2	$1.7	$9.8
	Total	**$5.3**	**$3.5**	**$21.7**

Of course, all of these incentives would come at a cost. The increase in NPV to the plant effectively represents the value transfer from the entity offering the enhancement. This value transfer could amount, on average, to approximately $4.4 billion per plant or up to $21.7 billion for the entire five-plant portfolio.

INTERNAL GOVERNMENT POLICY COORDINATION

Successful implementation of the above recommendations could be better assured if it is backed by senior-level policy coordination within the U.S. government. Such coordination could take many forms and we don't presume to know what arrangements will work best within a given administration or congressional body. Options include but are not limited to:

- A White House-directed activity, providing interagency coordination;
- A Cabinet member assigned responsibility for interagency coordination; and
- Congressional oversight of federal activities, either through a specific mandate to an existing committee(s) or through the establishment of a new oversight entity.

Consideration should also be given to forming a private-sector stakeholder advisory committee with representation from nuclear plant owners and operators, investors, labor groups, nuclear vendors and contractors, the financial sector, state officials, environmental advocates, and other organizations. This group would provide critical expertise and insight from outside the federal government in support of ongoing efforts to maintain nuclear energy as a key component of electricity generation in the United States.

DEVELOPING THE FUTURE NUCLEAR WORKFORCE

As discussed in Chapter 3, new nuclear energy facilities will fuel demand for a whole new generation of skilled nuclear professionals. From design engineers to construction specialists to operating and maintenance staff, a new wave of nuclear plants will create a need for tens to hundreds of thousands of trained nuclear workers. To be fully prepared to design and construct new nuclear facilities, the nuclear energy industry and the U.S. government will need to invest heavily in education, training, and workforce development.

Some of this investment is already taking place to help maintain indispensable skills for the sector. Nuclear-related programs at universities receive annual federal funding in the form of scholarships and grants. With this assistance, students are able to pursue research that is crucial to developing advanced nuclear technologies. Most of this assistance is distributed by the Department of Energy, the National Nuclear Security Administration, and the Nuclear Regulatory Commission, but other agencies, such as the Department of Labor and the National Science Foundation, also play an important role. We clearly support continuation of these programs, given their importance in helping preserve domestic capacity.

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