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THE ROLE OF POLICY IN REVIVING AND EXPANDING THE UNITED STATES' GLOBAL NUCLEAR LEADERSHIP

Timothy A. Frazier

MARCH 2017

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PREFACE

This paper is one of a series of three being released by the Center on Global Energy Policy (CGEP) at the School of International and Public Affairs (SIPA) of Columbia University that focuses on the future of nuclear energy. These papers were made possible, in part, by a grant from the Sasakawa Peace Foundation (SPF) of Japan. SPF played no role, however, in the drafting or review of this paper series.

The series consists of the following three papers:

- "A Comparison of Advanced Nuclear Technologies," by Dr. Andrew Kadak
- "The Role of Policy in Reviving and Expanding the US Global Nuclear Leadership," by Tim Frazier
- "The Geopolitics of Nuclear Power and Technology," by Dr. Nicola de Blasio and Richard Nephew

CGEP chose three different sets of authors to prepare these papers to ensure a wide, diverse range of experiences and perspectives. CGEP also chose to work on these papers more or less in concert, with primary research and drafting of the paper on advanced nuclear reactor design taking place slightly earlier than the two policy papers. As such, though each of these papers reflects some understanding of the research, ideas, and concepts articulated in the other two, there are organic differences in emphasis, concentration, and interest.

There are also areas of clear convergence and stark divergence between and among the three papers. For example, all three papers operate from a baseline that views nuclear power as a useful – if not a necessary – part of the global energy mix. The broader, and important, debate of whether there is a role for nuclear power in a low-carbon society is outside the scope of these papers.

Even with this basic agreement, each of the three papers diverges on key aspects of nuclear power (such as the treatment of and concern with the threat of nuclear proliferation from widespread use of nuclear power). There are other areas in the papers in which differences of opinion exist, and most important, differing conclusions are reached—even when looking at the same historical episodes and present circumstances.

CGEP strongly believes in the importance of bringing together unique perspectives to address the most pressing energy issues. In the competition and comparison of ideas, and in debate and disagreement, the institution sees the acme of academic purpose. We hope this series of papers prompt a discussion about nuclear power and the trade-offs that exist in its pursuit.

EXECUTIVE SUMMARY

This paper presents a historical perspective that highlights key decisions that have impacted US leadership, provides a status of nuclear power in the United States and identifies policy options for an Administration that wishes to revive and expand US nuclear leadership.

Policy has a clear role in maintaining and enhancing the global nuclear leadership of the United States. Unfortunately, the global nuclear leadership role of the United States has been diminished by policy choices. These policy choices—made by past presidents over many decades—when taken separately appear to be innocuous and even prudent, but when taken together, they have been, in fact, deleterious to the continued global leadership of the United States and hindered our nuclear research and development (R&D) and technology capabilities and the commercial nuclear industry (both nuclear suppliers and generators of nuclear power). The detrimental effect of an intensive focus on supporting renewables, for example, has had an unintended consequence for the nuclear industry, resulting in the premature shutdown of some nuclear power plants in the United States and undermining the value of their investment.

Historically, the United States has been a global leader in nuclear technology and provided leadership since the late 1940s. This leadership was primarily driven by nuclear defense activities, nuclear R&D efforts, various nuclear reactor development, and commercial nuclear power plant construction and operation.

- President Dwight D. Eisenhower's "Atoms for Peace" speech at the UN General Assembly on December 8, 1953, was the first international nuclear policy implemented by the United States. Under the Atoms for Peace Program, the United States championed the peaceful uses of nuclear technologies and sought to harness the power of the atom for good rather than for war.

- In the 1940–1970s, the United States supported its global nuclear leadership power with several institutions that pushed US industry and science forward. These steps included the creation of the Atomic Energy Commission (AEC) to manage the nuclear weapons effort, establishing the Joint Committee on Atomic Energy (JCAE) in Congress to work closely with the AEC and to support nuclear energy, and expanding AEC and JCAE's role to encourage commercial application of nuclear technologies.

- In more recent years, we have had the Energy Policy Act of 2005 (EPACT2005), which included incentives to the commercial nuclear industry to build and operate new reactors in the United States and led to the so-called Nuclear Renaissance. Also, in the same time frame, President Bush proposed his Global Nuclear Energy Partnership (GNEP) as a massive program, including reprocessing and recycling, to support the safe, secure, and sustainable global expansion of nuclear waste.

Several policy choices have negatively affected the United States' credibility and standing as a global nuclear leader:

- The first was President Carter's 1977 decision—based partly on policy work done in the Ford administration—to "defer indefinitely the commercial reprocessing and recycling of plutonium" and effectively limit our involvement as the world moved forward to recycle spent nuclear fuel and recycle the plutonium this fuel contained.

- The decisions by the Clinton administration to shut down two fast reactors in the early 1990s left the United States with no source of fast neutrons, forcing our researchers and developers to seek fast neutrons internationally.

- The decision by the Obama administration to scrap GNEP once again removed the United States from a leadership position in reprocessing and recycling.

- The decision to abandon Yucca Mountain as the nation's repository for spent nuclear fuel and high-level waste after considerable investment and without a back-up plan.

- Finally, there was the decision to terminate the Mixed Oxide Fuel Fabrication Facility, which was to produce a mixed-oxide fuel for light-water reactors from thirty-four metric tons of weapons-grade plutonium from the United States pursuant to an agreement with Russia.

If the United States is to play a positive and constructive role in the worldwide expansion of nuclear power, it must revive and expand its position as a global nuclear leader. US leadership can ensure that nuclear power is pursued within the highest possible standards, but such leadership will not come merely from declarations made in Washington. Rather, the key to US leadership will be the development of a world-class nuclear R&D program, including enrichment and reprocessing, with support given to create a robust nuclear industry—including nuclear suppliers and operating nuclear power plants.

For these reasons, the United States should consider making changes to its existing policies and approaches and invest in the nuclear industry domestically through such actions as:

- making a presidential policy statement on the United States' commitment to nuclear leadership;
- developing world-class nuclear facilities for R&D and technology development;
- reviving Yucca Mountain;
- reversing the decision to abandon the Mixed Oxide Fuel Fabrication Facility;
- loosening nonproliferation views on reprocessing;
- establishing an indigenous enrichment capability;
- maintaining current nuclear eet;
- becoming the world's leading supplier of nuclear technology; and
- leading the development and marketing of advanced, innovative reactors.

INTRODUCTION

Nuclear power is expanding around the world to meet energy demands in a manner consistent with reduced carbon emissions. Most of this expansion is taking place in emerging markets, not the developed world, where nuclear power's share of the overall mix remains modest. The nature of this expansion has raised questions about the degree to which it will be sustainable, safe, secure, and consistent with global nonproliferation needs.

Given the history of the global nuclear enterprise and its overall significant economic and technical clout, one would assume that the United States would be at the forefront of this expansion. However, due to a combination of policy decisions and commercial factors, the nuclear industry in the United States has atrophied since the 1970s. In particular, these policy choices—made by past presidents over many decades—when taken separately appear to be innocuous and even prudent, but when taken together, they have been, in fact, deleterious to US capabilities and hindered the continued global leadership of the United States. An unintended consequence has been the decaying nuclear power industry in the United States.

If the United States is to play a positive and constructive role in the worldwide expansion of nuclear power, it must revive and expand its position as a global nuclear leader. US leadership can ensure that nuclear power is pursued within the highest possible standards, but such leadership will not come merely from declarations made in Washington. Rather, the key to US leadership will be the development of a world-class nuclear research and development program, including enrichment and reprocessing, with support given to create a robust nuclear industry—including nuclear suppliers and operating nuclear power plants.

This paper presents a historical perspective that highlights key decisions that have impacted US leadership, provides a status of the nuclear power in the United States and proposes options to ensure continued carbon-free nuclear electricity generation, and identifies policy options for reviving and expanding US leadership.

HISTORICAL PERSPECTIVE

US nuclear leadership began in the 1940s with the Manhattan Project. Since then, the United States has continued to support research into nuclear technology and its military and peaceful applications. The focus was primarily driven by nuclear defense activities but quickly turned to a broader slate of applications, including nuclear reactor development and eventually commercial nuclear power plant construction and operation. In fact, though many of the foundational technologies behind nuclear power were primarily developed as a means of producing the materials necessary for nuclear weapons—such as uranium enrichment, nuclear reactor design, and spent-fuel reprocessing—scientists recognized that these technologies could also support a nuclear power program. The question was how to turn the Cold War–era nuclear weapons competition, which blossomed between the United States and Soviet Union after the first Soviet nuclear test in 1949, into a different sort of pursuit.

Atoms for Peace

President Dwight D. Eisenhower's "Atoms for Peace" speech at the UN General Assembly on December 8, 1953, was the first international nuclear policy implemented by the United States. Under the Atoms for Peace Program, the United States championed the peaceful uses of nuclear technologies and sought to harness the power of the atom for good rather than for war. The speech was also part of a broader effort to inform the public on the potential benefits of nuclear power while attempting to allay fears and concerns of an escalating arms race and potential nuclear war with the Soviet Union.

The United States also wanted to initiate nuclear R&D in countries around the world in an attempt to share the benefits of nuclear power while controlling its use for weapons. There was a Cold War competition motivation in this endeavor, part of the attempt to win over "hearts and minds" around the world, but there was also a legitimate interest in seeing the benefits of nuclear energy spread around the world. In so doing, the United States took a looser approach to the nonproliferation and security dynamics that had previously governed its approach to nuclear technology. In the 1950 and 1960s, the United States sold research reactors to many countries along with highly enriched uranium (HEU) to fuel those reactors. Since HEU is also one of the materials that can fuel nuclear weapons, this was a remarkable decision, and, in fact, the United States has an ongoing program to repatriate US-origin HEU from those countries and accept foreign-origin HEU from others. The table below highlights the countries that the United States provided HEU and which still retain it and those from which the US-origin HEU fuel has been removed. The table shows that the United States has provided over six thousand kilograms of HEU worldwide. For perspective, according to the International Atomic Energy Agency, only twenty-five kilograms of HEU is needed for a nuclear weapon.

Table 1. Civil HEU (Initial Mass) Per Country, End 2014[1]

Non-Nuclear Weapon States (NNWS) that received US-origin HEU		
Argentina	0.002-0.006[g]	
Australia	0.002[h]	
Belgium	0.555-0.605[i]	
Canada	1.035[j]	
Germany	1.26[k]	
Indonesia	0.003[l]	
Iran	0.006[m]	
Israel	0.022[n]	
Italy	0.115-0.130[o]	
Jamaica	0.0008[p] (All removed in 2015)	
Japan	1.8[q]	
Netherlands	0.55-0.65[r]	
Norway	0.004[s]	
Pakistan	0.016[t]	
South Africa	0.7-0.75[u]	
Switzerland	0.002-0.010[v] (All removed in 2015)	
Others	0.0004-0.001[w]	
	Countries that received US-origin HEU that reached "Zero" HEU through DOE's GTRI Program[x]	Austria, Brazil, Chile, Colombia, Denmark, Greece, Mexico, Philippines, Portugal, Rep. of Korea, Romania, Slovenia, Spain, Sweden, Taiwan, Thailand, Turkey (and Iraq)[y]
Subtotal	**6.073-6.300 tonnes (6,073-6,300 kg)**	

Source: Institute for Science and International Security

But, the present need to repatriate HEU aside, the 1950s and 1960s were a time in which the United States sought to expand its global nuclear footprint and to establish itself at the forefront of technology development. At home, two bureaucratic decisions helped to shape developments: the creation of the Atomic Energy Commission (AEC), and the formation of the Congressional Joint Committee on Atomic Energy (JCAE).

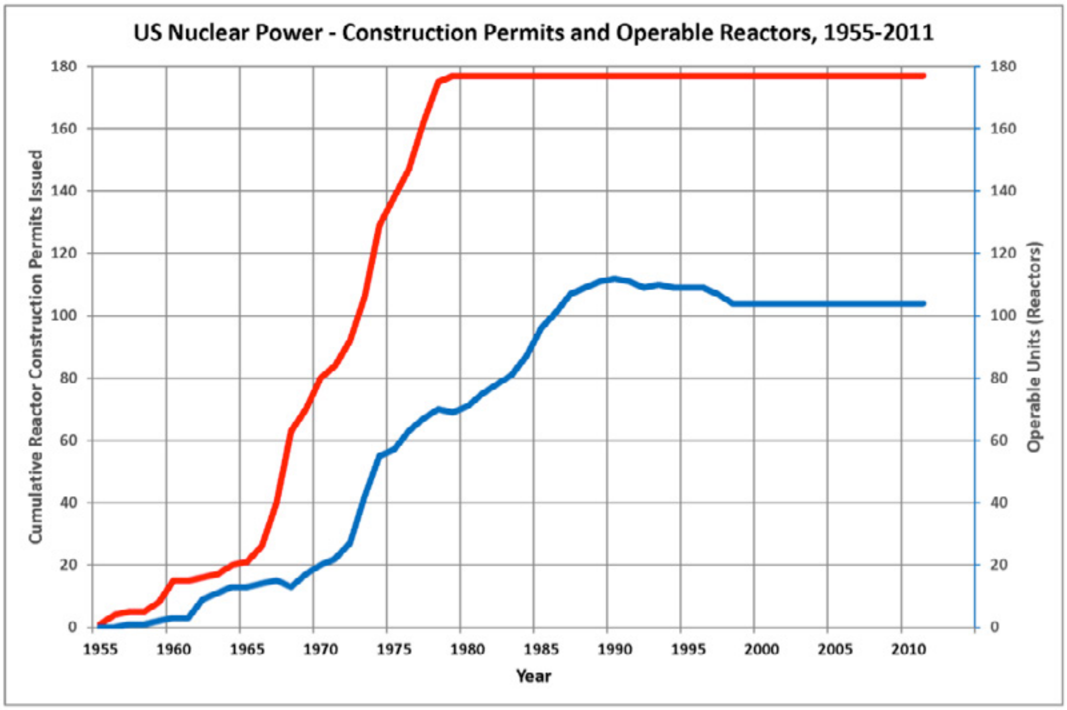
Atomic Energy Commission

The Atomic Energy Commission (AEC) was created by Congress in the Atomic Energy Act of 1946 that was signed into law by President Truman. The AEC took over complete control of the United States' nuclear programs, including the production of nuclear weapons. But one of the main purposes of the AEC was to promote the nonmilitary uses of nuclear technologies.

The Atomic Energy Act was amended in 1954, providing for the commercial use of nuclear technologies. This amendment broadened the AEC's scope to include commercial nuclear activities and encourage commercial nuclear development, and it also allowed the AEC to cooperate with the private industry to develop what would become the nuclear industry in the United States. After the AEA was signed, commercial companies could access what had previously been tightly controlled technical data regarding nuclear energy and nuclear power production, including the production of fissile material. In 1955, the AEC requested proposals for prototype reactors. They received four proposals, and the nuclear industry in the United States was born. In 1957, the first commercial nuclear power plant went into operation: the Shippingport Atomic Power Station located on the Ohio River in Pennsylvania.

Shippingport operated until 1989, and in those thirty-two years of operations, the number of nuclear reactors in the United States grew to 109. In the 1980s, forty-six nuclear reactors were built and brought into operation. The figure below shows temporally the expansion of the nuclear reactors from 1957 through 2011.

Figure 1. US Reactor Construction Permits Issued (Red) and Operating Nuclear Power Reactors (Blue), 1955–2011



Source: US EIA

Joint Committee on Atomic Energy

As with the AEC, the Joint Committee on Atomic Energy (JCAE) was established by the Atomic Energy Act of 1946. Per the act, the JCAE was to "make continuing studies of the activities of the Atomic Energy Commission (AEC) and of problems relating to the development, use, and control of atomic energy."[2] Additionally, all resolutions, bills, and any other matters in Congress related to the AEC or the use of "atomic" energy were referred to the JCAE. The JCAE had incredible power and was very effective at overseeing and supporting the nuclear expansion in the United States from 1946 until 1977, when it was abolished by the House and Senate because most of its jurisdictional oversight had been moved to other standing congressional committees.

Aided by its direct and specific focus on solely nuclear issues, the JCAE was a steadfast proponent of nuclear power and its peaceful uses. This kind of congressional support was vital to the growing nuclear industry in the United States and, therefore, leadership by the United States. In fact, the JCAE was so successful that the United States' 9/11 Commission recommended the JCAE as a model for a joint committee on intelligence for "centralizing and strengthening congressional oversight of intelligence and homeland security issues."[3]

Energy Reorganization Act of 1974

Twenty years after the AEA was passed, there was growing concern regarding a single entity—the AEC—being both a promoter of nuclear power and the regulator of nuclear power. The Energy Reorganization Act of 1974 created the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC). The nuclear weapons production and support for civilian nuclear power from moved from the AEC to ERDA.* The NRC was assigned the regulatory authority over civilian nuclear power.

A key to the success of the AEC was its singular focus on nuclear technologies and the development of commercial nuclear power. This was not the case with respect to ERDA, much less the Department of Energy, which succeeded ERDA three years later. Absent a single, consolidated, focused entity like the AEC, support for nuclear R&D and similar activities lagged. But even more important were changes being introduced with respect to policy on the nuclear fuel cycle due both to enhanced concerns over nuclear proliferation (which saw in the decade prior both the acquisition of nuclear weapons by China and France and the suspected development of nuclear weapons by Israel and India) and commercial necessity.

Changing Views on the Fuel Cycle

Reprocessing

In October 1976, President Ford, after an internal review, announced that "the reprocessing and recycling of plutonium should not proceed unless there is sound reason to conclude that the world community can effectively overcome the associated risks of proliferation…that the United States should no longer regard reprocessing of used nuclear fuel to produce plutonium as a necessary and inevitable step in the nuclear fuel cycle, and that we should pursue reprocessing and recycling in the future only if they are found to be consistent with our international objectives."[4] Subsequently, President Jimmy Carter issued a nuclear power policy statement[5] in April 1977 after "completing an extremely thorough review of all the issues that bear on the use of nuclear power." The Carter administration concluded from the review that "the serious consequences of proliferation and direct implications for peace and security—as well as strong scientific and economic evidence—require: a major change in U.S. domestic nuclear energy policies and programs; and a concerted effort among all nations to find better answers to the problems and risks accompanying the increased use of nuclear power."

There were seven decisions taken in the statement. The relevant one here is the very first decision, quoted here: "First, we will defer indefinitely the commercial reprocessing and recycling of the plutonium produced in the U.S. nuclear power programs. From our own experience, we have concluded that a viable and economic nuclear power program can be sustained without such reprocessing and recycling. The plant at Barnwell, South Carolina, will receive neither Federal encouragement nor funding for its completion as a reprocessing facility."

Without federal encouragement or funding for commercial reprocessing, this essentially ended the United States' domestic commercial reprocessing efforts. Federal funding was fundamental to establishing commercial reprocessing in the United States because of the high capital costs and operating costs. Moreover, the sufficient supply and low cost of uranium made reprocessing uneconomical absent government support. Many believe Carter deferred reprocessing indefinitely over proliferation concerns, but the quote above indicates it was not needed for a viable and economic nuclear power program. The review did, however, conclude that "serious consequences of proliferation" drove the major change in the US domestic nuclear energy policies and programs. The Carter administration was well intentioned and hoped that by demonstrating leadership in renouncing reprocessing as a component of the United States' civilian nuclear energy program, other countries could be convinced to do the same. But that was not the case.

*ERDA became the Department of Energy when President Carter signed the Department of Energy Organization Act of 1977.

This decision limited the United States' involvement and standing in the global nuclear industry as the world moved forward with reprocessing SNF and recycling the extracted plutonium into a mixed-oxide fuel (MOX). The "Report on the Proliferation Implications of the Global Expansion of Civil Nuclear Power, April 7, 2008,"[6] from the Department of State's International Security Advisory Board was subsequently critical of the Carter Administration's decision. The report stated, "The United States ultimately fell back to a posture of attempting to set an example for the rest of the world by abolishing all reprocessing of our nuclear spent-fuel wastes. At the time, the United States believed that by making such a pronouncement against separation and reuse of fuels on proliferation grounds, both the European nations and Japan would abandon their reprocessing plans—a notion that history has proven to be naïve."

The report goes on to say, "Now, after nearly 30 years since those U.S. decisions, the fact is that no other nation has chosen to follow the U.S. lead in this regard. Instead, the other industrial powers around the world have elected to reprocess their fuel."

Furthermore, "Past U.S. opposition to reprocessing has left us isolated from being a stronger player in the development of common solutions to these problems and lessened our influence in emphasizing proliferation concerns as this work proceeds."

Other countries acting in their sovereign right and in their own interest pursued nuclear power and reprocessing of spent nuclear fuel as a matter of energy security. Unlike the United States, which has significant natural resources—uranium, natural gas, and oil—used for energy, some of the smaller countries are resource limited. Two prime examples are France and Japan. Both have limited natural resources for energy production, and both have chosen to reprocess their SNF and fabricate a mixed-oxide fuel from the plutonium and uranium recovered in the process. By doing so, they intend to utilize the useful energy from the constituents of the spent nuclear fuel rather than dispose of it intact. France and Japan are also investigating transitioning to fast reactors to ensure an almost endless supply of fissile material for their future and energy security.

It should be noted that President Reagan changed this policy in 1981 by "lifting the indefinite ban which previous administration placed on commercial reprocessing activities in the United States." In 1993, President Clinton issued a policy statement, saying, "The United States does not encourage the civil use of plutonium and, accordingly, does not itself engage in plutonium reprocessing for either nuclear power or nuclear explosive purposes. The United States, however, will maintain its existing commitments regarding the use of plutonium in civil nuclear programs in Western Europe and Japan." President Clinton did not reinstitute "defer indefinitely."

Enrichment

One instance where the US government did provide a significant amount of funding is with enrichment. The United States was leading provider of uranium enrichment services worldwide until the early 1970s. Since then, the United States has fallen far behind as other countries have established enrichment capability—so far behind that, today, the United States has no indigenous domestic enrichment capability since the shutdown of three large uneconomical gaseous-diffusion plants in 1985, 2001, and 2013. There is, however, a foreign-owned and controlled enrichment plant in New Mexico.

The United States tried to move civilian enrichment operations to a private corporation, the United States Enrichment Corporation (USEC). USEC initially leased two of the then-operating gaseous-diffusion facilities from the Department of Energy as it attempted to establish its centrifuge capability. Ultimately, the attempt to establish a private centrifuge plant failed because of technical difficulties identified by the Department of Energy and the Oak

Ridge National Laboratory and the poor financial health of USEC. USEC went into bankruptcy and is now known as Centrus. The lack of indigenous enrichment capability has left the commercial nuclear power industry in the United States dependent on foreign sources.

While the United States could rely on the open market for enrichment services, having no indigenous enrichment capacity to backstop the global supply of enrichment is a risk. With 20 percent of the United States' electricity provided by nuclear power, an intentional or punitive disruption from foreign enrichment services would be catastrophic. As a nuclear weapons state, there are national nuclear defense requirements in the future that must be considered that cannot be met by foreign-supplied enrichment.

Lastly, if the United States had its own indigenous enrichment capability, there are nonproliferation benefits.

- The United States could participate in assured fuel supply/enrichment regime offering service to those countries that have not sought their own enrichment capability.

- The United States would regain enrichment leadership and lead the development of advanced enrichment technologies.

- With an indigenous enrichment capability located in the United States, the United States could host the production of higher-assay enrichment of uranium-235 required by some of the innovative advanced reactor designs. For these, designed to have longer lived cores with a higher power density, many—if not all—of the innovative advanced reactor designs are using fuel with uranium 235 enrichments of greater than 5 percent but less than 20 percent.

Nuclear R&D

Beyond the broader issue of the nuclear fuel cycle and civil nuclear power support in the United States, there has also been a considerable diminution in the amount of funding and support given to nuclear R&D in the United States if not related directly to defense needs or conducted on a purely commercial basis.

Three important facilities for advanced R&D were shut down in the 1980s and 1990s, which had a particularly deleterious effect on US capabilities. They were closed in part because of a broader search for budgetary savings as well as because of the absence of a direct, concrete mission for them. But their shutdown had a significant impact on US ability to conduct important research on advanced reactor technology.

Clinch River Breeder Reactor Project

On July 4, 1971, President Nixon committed to a liquid-metal fast-breeder reactor demonstration by 1980, saying it was the "best hope for meeting the growing demand for economical clean energy."[7] The project was intended to demonstrate the viability of a sodium-cooled fast reactor to produce electricity. This would have had the benefit of being more efficient and potentially easier to operate than existing light-water reactors. Unfortunately, it was not strongly supported by the Carter Administration, and even with the subsequent support of President Reagan, Congress voted to eliminate funding in 1983. The program was terminated shortly thereafter.

Fast-Flux Test Facility (FFTF)

FFTF was a Department of Energy–owned and operated four-hundred-megawatt thermal (MWth) sodium-cooled fast reactor. It was successfully operated from 1982 to 1992 as a state-of-the-art R&D facility and had been originally designed to test advanced fuels and other materials for the Liquid Fast-Breeder Reactor Program. With Carter's decision to move away from fast-breeder reactors, other R&D activities took advantage of the facility. It provided R&D and testing of fuels and materials for the nuclear industry. FFTF also produced medical and industrial isotopes in relatively small quantities, as well as cooperative international research.

In late 1993, the Clinton administration decided to shut down the facility given the lack of a clear, viable, and economic future mission. It stopped operation in 1992 and was eventually placed in long-term surveillance and maintenance condition in 2009.

Experimental Breeder Reactor II

The Experimental Breeder Reactor-II (EBR-II) was a sodium-cooled fast reactor built and operated by the Argonne National Laboratory at the Argonne National Laboratory–West site (now the Idaho National Laboratory Materials and Fuel Complex) in Idaho Falls, Idaho. EBR-II was to demonstrate the breeder reactor technology and onsite reprocessing of its metallic fuel.

Once demonstrated and because it was a fast reactor, EBR-II was utilized for material testing and material evaluations. But, along with the FFTF, it was shut down in 1994. It was the last source of fast neutrons in the United States when it was shut down, leaving the United States without a source of fast neutrons.

By the turn of the century, the United States had effectively withdrawn from doing substantial research into nuclear power and the associated nuclear fuel cycle. The rationales varied, but a combination of cost cutting, nonproliferation policy making, and disinclination for government involvement in nuclear R&D motivated the cuts. As a nuclear weapon state, the United States retained its overall sense of leadership in the international community's approach to nuclear technology, but without a similar, corresponding stake on commercial terms.

As a consequence, pursuit of new nuclear projects flagged markedly in the 1990s. New reactors were continuing to be built, but mostly as legacy projects from the 1970s and 1980s, given the long lead time required for development and construction. Momentum had been lost and, apart from a few parts of the US government and private sector, there was minimal interest in retaking the position of leadership we once had possessed.

Energy Policy Act of 2005

The Energy Policy Act of 2005 (EPACT2005) and its emphasis on nuclear power was intended to reverse this decline. Signed into law on August 8, 2005, by President George W. Bush, it was the culmination of significant effort by former senator Pete Domenici (R-NM), an ardent supporter of nuclear power. EPACT contained several incentives intended to increase domestic nuclear power. They included production tax credits, risk insurance to address regulatory delays, loan guarantees for advanced (GEN III+) reactors, Price-Anderson Act[**] extension to protect reactors constructed prior to 2026, and funding and support for advanced nuclear R&D.

**The Price-Anderson Act (officially the Price-Anderson Nuclear Industries Indemnity Act) addresses liability-related issues for the nuclear power plants constructed in the United States before 2026. It was initially passed in 1957 and has been extended several times.

EPACT 2005 led to what was called at the time the "Nuclear Renaissance." From 2007 to 2009, the NRC received applications for construction and operating licenses to build thirty-one new nuclear reactors from thirteen different companies. By comparison, there were no applications made to the NRC for new reactors in the preceding almost thirty years.[8]

Several parts of the law were important in prompting this resurgence, but perhaps none more than the Department of Energy's Loan Guarantee Program (LPG). The LPG addressed the fundamental problem in developing nuclear reactors: the long lead time in construction and extended nature of the returns for investment that nuclear involves, sometimes taking decades for nuclear reactors to prove profitable. In 2008, the Loan Guarantee Program received nineteen applications from seventeen utilities for the construction of twenty-one new reactors, with an associated total electrical generation estimated to be 28.8 gigawatts electric (GWe).[9] But, thereafter, there was a substantial chill in the program. The only nuclear-related loan-guarantee requests received in the Obama administration came late: In February 2014, the Department of Energy issued $6.5 billion in loan guarantees to Georgia Power Company and Oglethorpe Power Corporation and, in June 2015, an additional $1.8 billion in loan guarantees to Municipal Electric Authority of Georgia for the construction of Units 3 and 4 at the Vogtle site in Georgia.

The LGP also received two applications for the construction of uranium enrichment facilities.[10] One application was from the United States Enrichment Corporations (USEC) for their American Centrifuge Project, and the other was from AREVA Enrichment Services for their proposed Eagle Rock Enrichment Facility. In May 2010, the Department of Energy issued a $2 billion conditional loan guarantee to AREVA Enrichment Services LLC for construction of their Eagle Rock Enrichment Facility near Idaho Falls.

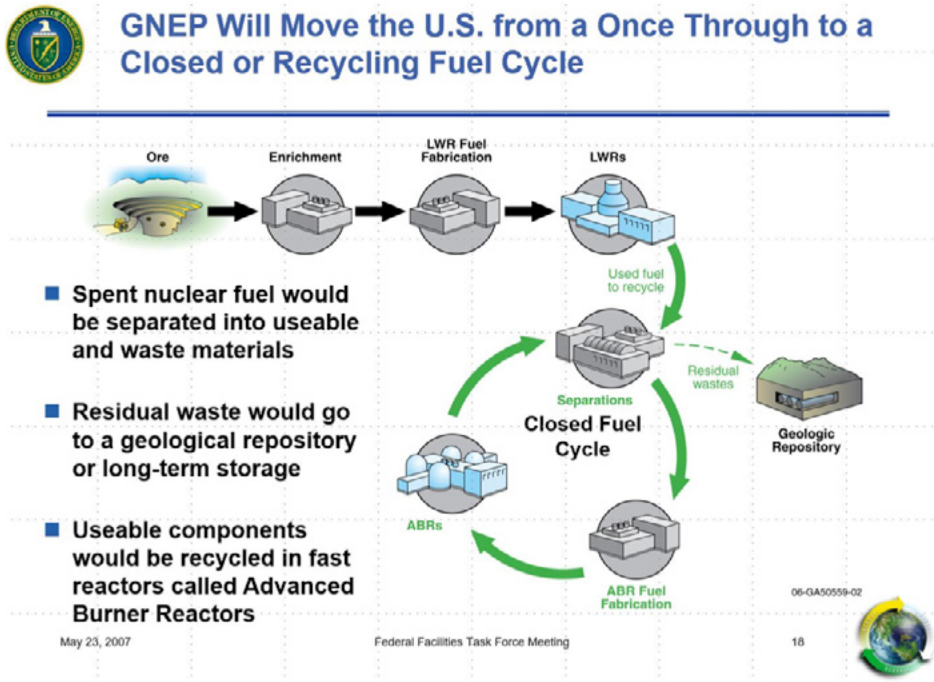
Global Nuclear Energy Partnership

President Bush followed up to the domestic policy shifts contained in EPACT2005 with the rollout of the Global Nuclear Energy Partnership (GNEP) in February 2006 as part of his Congressional Budget Request for FY2007 to Congress. GNEP sought to support the safe, secure, and sustainable global expansion of nuclear energy. Almost immediately the partnership received international praise for the scope of the effort and for leadership exhibited by the United States.

There were two components to GNEP, one international and one domestic. The domestic effort included developing enhanced nuclear safeguards, developing and implementing advanced spent-nuclear-fuel-recycling technologies, developing and implementing advanced reactors to consume transuranic elements separated from the spent nuclear fuel, and improving waste management. The international effort included facilitating global deployment of nuclear power through responsible stewardship, establishing reliable international fuel services, and supporting grid-appropriate exportable reactor development and deployment.[11]

In the Unites States, GNEP sought to reverse the policy decision begun by Presidents Ford and Carter with respect to reprocessing. To accomplish this, GNEP envisioned building three large nuclear facilities in the United States. These large facilities were a large nuclear fuel advanced reprocessing facility, a facility that would manufacture the fuel for a fast reactor from transuranic elements recovered by the reprocessing facility, and a large sodium-cooled fast reactor that would use the fuel fabricated from the transuranic (see figure 2 below). These facilities would put the United States squarely in the role as a world leader on advanced reprocessing, advanced fuel fabrication, and large-scale destruction of transuranic elements in a fast reactor.

Figure 2. Closing the Fuel Cycle with GNEP Facilities



Source: Department of Energy, 2007

The international effort of GNEP was driven by the desire to have international partners that supported the elements of the partnership. GNEP international activities had four key engagement areas: policy (partnership development), technical (advanced fuel-cycle technologies and grid appropriate reactors), framework development (fuel service, bands, and centers), and infrastructure support (countries seeking first nuclear power, regulatory, expertise, and financial). GNEP had partners, observers, and potential partners as show in the figure below from April 2008.[12]

Figure 3. GNEP Partners, Candidate Partners, and Observers

Source: Department of Energy, 2007

The Report on the Proliferation Implications of the Global Expansion of Civil Nuclear Power, April 7, 2008,[13] from the Department of State's International Security Advisory Board was—unsurprisingly, given its criticism of the previous decision to abandon reprocessing—supportive of GNEP. The report stated,

> Opening up the U.S. plans to consider reprocessing of spent fuel [GNEP] can put us in an improved position to partner with the other leading nuclear power nations to collaborate in developing more acceptable solutions worldwide. Already Russia, the United Kingdom, France, China, and Japan have indicated interest in such joint efforts. U.S. participation in global cooperation with the nuclear power supplier states—to jointly solve and implement solutions to the current problems of the tail-end of the nuclear fuel cycle—can be a motivator to simultaneously strengthen nonproliferation protections as well. Past U.S. opposition to reprocessing has left us isolated from being a stronger player in the development of common solutions to these problems and lessened our influence in emphasizing proliferation concerns as this work proceeds.

But, far from being a settled matter, GNEP proved to be short lived. There were two fundamental problems with the concept, neither of which was resolved by the time President Bush left office. First, GNEP would have significant budgetary impact, and there remained questions about the economic sustainability of the program, particularly with respect to commercial reprocessing. Second, there were questions about the nature of the intended technologies and concerns about their readiness for use, especially given the cost. A 2007 report by a National Academy of Sciences committee sponsored by DOE noted that "the technologies required for achieving GNEP's goals are too early in development to justify DOE's accelerated schedule for construction of commercial facilities that would use these technologies."[14] The National Academy of Sciences's report suggested instead that more funding and support be dedicated to the development and construction of new nuclear power reactors.

Obama Administration's Decision to Terminate GNEP

With the end of the Bush administration and the beginning of the Obama administration, GNEP was essentially terminated as a large program when the Programmatic Environmental Impact Statement was cancelled. The Federal Register notice states, "Via this notice, DOE announces that it has decided to cancel the GNEP PEIS because it is no longer pursuing domestic commercial reprocessing, which was the primary focus of the prior Administration's domestic GNEP program."[15]

The Obama administration had elected to move back to an open or once-through fuel cycle and, as stated in the president's FY2010 budget request, focus their efforts on "long-term, science based R&D of technologies with the potential to produce beneficial changes to the manner in which the nuclear fuel cycle and nuclear waste are managed."[16]

In the same period, there were setbacks to uranium enrichment work in the United States. AREVA delayed their project due to financial concerns and then placed it on hold. USEC's American Centrifuge Project applied substantial political pressure for the loan guarantee, but perceived technical difficulties and USEC financial concerns led the Department of Energy to ask USEC to withdraw the application. USEC did not withdraw its application and, in August 2010, provided a substantial update. The update did not affect the LPG's decision not to award a guarantee to USEC.

Yucca Mountain

The Nuclear Waste Policy Act of 1982 (NWPA) began the relatively short process that would end with Yucca Mountain being selected as the United States' repository—a repository for SNF from commercial nuclear power plants and SNF and high-level waste (HLW) from defense-related activities. The Department of Energy identified ten separate sites located in six different states in 1984 for initial consideration. As one can imagine, there was considerable opposition from elected officials from potentially affected states and their members in the US Congress.

In 1986, the Department of Energy narrowed down the ten sites to three sites. These three sites would be subject to a much more detailed characterization. These sites were the Hanford Site in the state of Washington, Deaf Smith County in Texas, and, the Yucca Mountain Site in Nevada.

After considerable consternation and the recognition by Congress that costs were ever increasing and little progress was being made, Congress passed the NWPA Amendment Acts of 1987. This bill came to be known as the "Screw Nevada" bill because it short-circuited the process of reviewing characterizing all three sites and directed the Department of Energy to only proceed with Yucca Mountain.[17] Yucca Mountain is located about one hundred miles northwest of Las Vegas on federal property near the Nevada Test Site.

In February 2002, the secretary of the Department of Energy issued its recommendation to proceed with Yucca Mountain.[18] That led to then-governor of Nevada Kenny C. Guinn issuing a "Notice of Disapproval of the Designation of Yucca Mountain in Nevada as the Site for the Nation's High-level Nuclear Waste Repository" and provided the reasons why.[19] In the notice of disapproval, the governor concluded with the following:

- The state of Nevada would continue and strengthen its ability to bring "science and law" back to the SNF and HLW program and sanity back to America's nuclear energy security.
- A growing number of scientists and reviewers had expressed serious concerns.
- Yucca Mountain was one of the most characterized sites in the world, and a "hundred more years of storage" would not change the fact that Yucca Mountain had a fatally flawed geology.
- Yucca Mountain was more than just a Nevada problem with transportation of SNF to Yucca Mountain impacting "as many 44 states, 703 counties, and 109 cities with populations of 100,000 or great."
- He recognized that Congress had the right under the NWPA to override his notice of disapproval by a majority vote and signature by the president.

With the recommendation from the secretary having been issued, Congress moved to override the notice of disapproval from the governor of the state of Nevada, and President George W. Bush signed the joint resolution into law on July 23, 2002.

The Bush administration would work under difficult funding constraints over the next six years to prepare a license application for Yucca Mountain. The 8,600-page license application was submitted to NRC on June 3, 2008. On September 8, 2008, NRC placed the Yucca Mountain license application on their docket and accepted the Department of Energy's environmental impact statement, which triggered a three-year period for the review established by Congress.[20]

The Obama administration began in January 2009, just seven months after the Department of Energy had submitted the license application and a mere four months after NRC placed the license application on the docket. In the February 2009, President Obama followed through on a campaign promise while issuing his FY2010 request to implement "the Administration's decision to terminate the Yucca Mountain program while developing nuclear waste disposal alternatives."[21] OCRWM was essentially disbanded, and no further funding was requested for Yucca Mountain in subsequent years. The Obama administration immediately adopted the phrase "Yucca Mountain is not a workable solution" to explain their actions. As a result, the United States moved to start over and develop a new plan and path forward. That was the task of the Blue Ribbon Commission on America's Nuclear Future.

The Obama administration attempted to withdraw the license application in March 2010 but was denied by the NRC's Atomic Safety and Licensing Board.[22] The NRC commissioners were evenly divided—along party lines—and could neither affirm or overturn the board's decision. Congress had appropriated minimal funds for the NRC review in that time frame, and the commission ordered the NRC staff to shut down the Yucca Mountain review process in an orderly fashion.

Washington State, home of the Department of Energy's Hanford Site and a considerable amount of HLW, sued to keep the Yucca Mountain project alive in April 2010. This suit was joined by South Carolina, home of the Department of Energy's Savannah River Site (also with HLW). The case was dismissed in July 2011 because the NRC had not ruled on whether or not to accept the board's denial of the Department of Energy's request to withdraw the license.[23]

The states of Washington and South Carolina filed a second suit in July 2011 requesting the court direct the NRC to resume the Yucca Mountain license application review.[24] In August 2013, the court ordered NRC to resume its review. Using available funds, the NRC staff finished the Safety Evaluation Report (five volumes) for Yucca Mountain in January 2015. Volume 2 covered repository safety. In it the NRC staff concluded that "with reasonable assurance, subject to proposed conditions, DOE's application [for Yucca Mountain] meets the NRC's regulatory requirements."[25]

There remained a number of outstanding issues related to Yucca Mountain that must be resolved before a license could be issued. But Yucca Mountain quickly claimed the conclusion by NRC to be a vindication of the Yucca Mountain project and its viability as a repository for nuclear waste.

Blue Ribbon Commission on America's Nuclear Future and the Administration's Response

On January 29, 2010, President Obama requested then Secretary of Energy Steven Chu to "establish a Blue Ribbon Commission on America's Nuclear Future (Commission) and appoint its members…The Commission's business should be conducted in an open and transparent manner."[26]

The commission was to "conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of civilian and defense used nuclear fuel and nuclear waste. This review should include an evaluation of advanced fuel cycle technologies that would optimize energy recovery, resource utilization, and the minimization of materials derived from nuclear activities in a manner consistent with U.S. nonproliferation goals."

The commission was chartered under the Federal Advisory Committee Act, as amended, and per the direction of the president was to provide a final report within two years of the date of the letter to Secretary Chu. The commissioners appointed by Secretary Chu to complete the charter were as follows (with their titles at the time of their appointment included):

Congressman Lee Hamilton (D-IN), Co-Chair

General Brent Scowcroft, Co-Chair

Mark Ayers, President, Building and Construction Trades Department, AFL-CIO (deceased)

Vicky A. Bailey, Principal, Anderson Stratton Enterprises LLC

Albert Carnesale, Chancellor Emeritus and Professor, UCLA

Senator Pete V. Domenici (R-NM)

Susan Eisenhower, President, Eisenhower Group Inc.

Senator Chuck Hagel (R-NE)

Jonathan Lash, President, World Resources Institute

Dr. Allison Macfarlane, Associate Professor of Environmental Science and Policy, George Mason University

Dr. Richard A. Meserve, President, Carnegie Institution for Science

Dr. Ernie Moniz, Professor of Physics and Cecil and Ida Green Distinguished Professor, Massachusetts Institute of Technology

Dr. Per Peterson, Professor and Chair, Department of Nuclear Engineering, University of California–Berkeley

John Rowe, Chairman and Chief Executive Officer, Exelon Corporation

Congressman Phil Sharp (D-IN), President, Resources for the Future

The charter for the commission generally echoed the president's letter to Secretary Chu but specified these issues that should be addressed:[27]

- Evaluation of existing fuel cycle technologies and R&D programs. Criteria for evaluation should include cost, safety, resource utilization and sustainability, and the promotion of nuclear nonproliferation and counter-terrorism goals.

- Options for safe storage of used nuclear fuel while final disposition pathways are selected and deployed;

- Options for permanent disposal of used fuel and/or high-level nuclear waste, including deep geological disposal;

- Options to make legal and commercial arrangements for the management of used nuclear fuel and nuclear waste in a manner that takes the current and potential full fuel cycles into account;

- Options for decision-making processes for management and disposal that are flexible, adaptive, and responsive;

- Options to ensure that decisions on management of used nuclear fuel and nuclear waste are open and transparent, with broad participation;

- The possible need for additional legislation or amendments to existing laws, including the Nuclear Waste Policy Act of 1982, as amended; and

- Any such additional matters as the Secretary determines to be appropriate for consideration.

Of note is the absence of Yucca Mountain in the charter. In fact, the commission was specifically directed by Secretary Chu at the first Commission meeting on March 25, 2010, to not address Yucca Mountain. Secretary Chu said in the public meeting responding to a question from Senator Domenici, "It is correct to say that we are going to look to the future and we're going to look to see what we can do going forward. And so what I don't want the committee [Commission] to be going is just spending time and saying by looking at past history was Yucca Mountain a good decision or a bad decision and whether it can be used as a future repository."[28]

Over the course of the two years, the commission held a number of public meetings across the United States and visited the United Kingdom, France, Finland, Sweden, Russia, and Japan. The most impactful of these overseas visits was the trip to Sweden, which had structured a competition of sorts between two communities vying host the Swedish deep geological repository.

The Commission released its final report on January 26, 2012. It contained the following eight recommendations:

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 US innovation in nuclear energy technology and for workforce development.

8. Active US leadership in international efforts to address safety, waste management, nonproliferation, and security concerns.

Key of these recommendations were consent-based siting and a new entity with the single purpose of managing the back end of the nuclear fuel cycle. These recommendations were endorsed by the Obama administration in January 2013 when the Department of Energy issued its Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste.[29] The strategy stated that "the Administration endorses the key principles that underpin the BRC's recommendations."

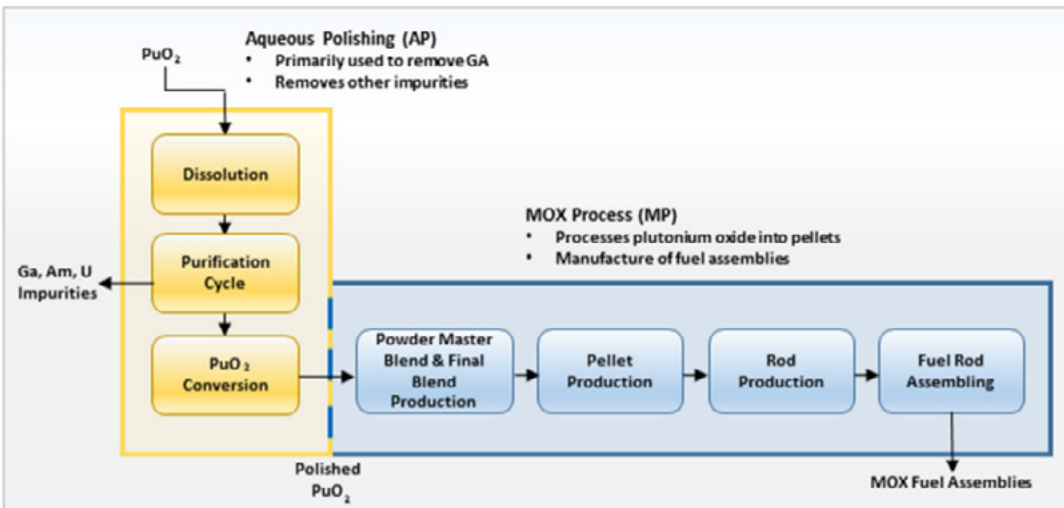
Since mid-2015, the Department of Energy has been working on developing a consent-based siting process and recently issued a draft process for review and comment.[30]

The United States is poised to regain leadership in the area of SNF and HLW disposal. It is not clear what path the Trump administration will follow. Whether it will seek to revive Yucca Mountain or implement a consent-based siting process to site, construct, and operate a deep geological repository remains to be seen.

The MOX Project

In 2000, the United States and Russia entered into the Plutonium Management and Disposition Agreement[31] to dispose of surplus weapons-grade plutonium.[***] The agreement specified that each party was to dispose of no less than thirty-four metric tons (34,000 kg) of weapons-grade plutonium. Russia chose to dispose of their commitment by using it as fuel in a fast reactor (a reactor with a fast neutron spectrum). The United States chose to dispose of their commitment by fabricating a mixed-oxide (MOX) fuel for use in commercial light-water reactors here in the United States. Mixed-oxide fuel is a fuel that contains a mixture of plutonium and uranium, in this case about 5 percent plutonium and 95 percent uranium-238 (not enriched). For comparison, light-water reactor fuel is about 4–5 percent uranium-235 and the remainder uranium-238.

Figure 4. MOX Production Process



Source: MOX Services LLC

For the United States to comply with its commitment to use MOX, the MOX Project was initiated to build the Mixed-Oxide Fuel Fabrication Facility (MFFF). The National Nuclear Security Administration (NNSA) estimated in 2002 that the cost to design and build the MFFF to be about $1 billion and selected the Department of Energy's Savannah River Site located in South Carolina. At the start of construction in 2007, the cost estimate had increased to over $4.8 billion and has continued to increase. In the fiscal year (FY) 2014 budget request, MFFF construction was estimated to be $7.78 billion.

The first sign of trouble for the MOX project—other than increasing cost estimates—was in FY2013 and FY2014, when the department slowed the construction while evaluating alternatives to MOX. In President Obama's FY2015 budget request, the total projected lifecycle cost for the MOX project had grown to almost $30 billion, and the department stated, "As part of an ongoing analysis of options to dispose of U.S. surplus plutonium, it has become apparent that the Mixed Oxide (MOX) Fuel Fabrication Facility will be significantly more expensive than anticipated, and therefore, the Budget Request places the MOX Facility in cold stand-by while the Department evaluates plutonium disposition options."[32]

***Weapons-grade plutonium is generally considered to be >93 percent plutonium-239; i.e., >93 percent of all the plutonium isotopes present are plutonium-239.

The Obama administration subsequently chose the "dilute and dispose" option for the thirty-four metric tons of material and, in their FY2017 budget request, included $270 million for the termination of the MOX project and the MFFF.

As a result of these actions, in late 2016, Russia publicly withdrew from the Plutonium Management and Disposition Agreement, citing the "inability of the U.S. to deliver on the obligation to dispose of excessive weapons plutonium under international treaty."[33]

Given that we have a new president and a new administration, the fate of the MOX project is not clear. There is considerable support in House of Representatives for the project, and Senator Graham (R-SC) is leading the charge in the Senate. In the House, the Appropriations Subcommittee on Energy and Water Development and Related Agencies approved $340 million for the MOX project in an effort to keep the project alive. However, in April 2016, the Senate Appropriations Subcommittee on Energy and Water Development approved the FY2017 request for $270 million requested to terminate the project.

The impacts of the Obama administration's action will not truly be known until the direction the Trump administration takes is clear. If President Trump supports the project and completes the MFFF, the United States would have a state-of-the-art fuel-fabrication facility with the intention of using MOX in commercial nuclear power reactors as is done routinely throughout the world.

STATE OF PLAY FOR NUCLEAR POWER IN THE UNITED STATES

At present, the nuclear industry in the United States remains troubled with respect to nuclear R&D, power reactors, and a domestic nuclear fuel cycle.

R&D

Large-scale R&D projects have been largely put on hold or terminated, with inconsistent budgetary support. Nuclear research has continued, but on a smaller scale and less relevant for substantial improvements in power production or sophistication. Many R&D and test facilities in the United States are located at the nation's national laboratories and are, therefore, difficult for the innovative nuclear reactor developers to access. The bureaucracy alone for a private company to do work at one of the national laboratories is daunting. The lack of accessibility—and often the available capabilities—of R&D or test facilities has driven some innovative nuclear reactor developers to seek facilities outside the United States, particularly as relates to the use of fast neutrons, for which there is no domestic source.

Nuclear Power Reactors

The United States currently has ninety-nine operating nuclear power reactors in thirty states. There are four new reactors under construction, two in South Carolina and two in Georgia. Since 1977, the NRC has approved over 7,300 MWe in power uprates at existing nuclear power plants, adding the equivalent of seven reactors to the United States commercial fleet. Of the ninety-nine operating nuclear power reactors, eighty-three have received a twenty-year license renewal, extending the operating license from forty to sixty years. Fifteen additional nuclear power reactors are expected to apply for a twenty-year extension.[34]

At the same time, six nuclear power reactors have permanently shut down in the last four years. These reactors were prematurely shut down; they all had years of operation remaining under their license granted by the NRC. Several other nuclear power plants have announced intentions to permanently shut down or are at risk of being permanently shut down.

Most of these premature shutdowns can be attributed to economics or a combination of economics and market conditions. For example, California's Pacific Gas and Electric (PG&E) announced that they would not seek a license extension to operate in Diablo Canyon beyond the current license, which expires in 2025. PG&E referenced California's energy policies that would reduce the need for electricity produced at Diablo Canyon, which included a prioritization of the use of renewable energy sources.[35]

The major conditions are as follows:

- Low cost of natural gas. This factor is obvious. It becomes the owner's fiduciary responsibility to shut down a nuclear plant that is losing money by continuing to operate. Low natural gas prices have helped to shove nuclear power plants out of the market.

- Federal production tax credits for renewable provide significant advantages to renewable energy. In fact, in some regions of the country, wind power can pay customers to take their electricity by bidding negative into the market. This is because the production tax credit allows wind power to still be economically viable even though bidding negative into the market.[36]

- Lower demand for electricity due to slow growth and the recession of 2008. The slow growth in demand has allowed renewables to gain a foothold and meet the small increase in demand. The slower growth in demand—coupled with cheap natural gas and production tax credits—reduced the relative attraction of a major investment in nuclear power.

Nuclear Fuel Cycle

And, last, the United States continues to lack a credible, indigenous uranium-enrichment or spent-fuel-reprocessing capability. Today, all the enrichment capability in the United States is foreign owned and controlled. Foreign-controlled companies and technologies enrich all nuclear fuel for the United States' nuclear power reactors. While it is not likely, a foreign-controlled company could potentially decide to limit the enrichment services they supply for the US fleet. Limiting or even stopping enrichment for the US fleet puts almost 20 percent of the electricity supply at risk—electricity that is baseload power and vital to grid stability given the intermittent generation of power by renewables. In addition, lack of domestic enrichment has impacted our ability to participate in any effort to provide an assured nuclear fuel supply to nations who might seek to develop an enrichment capability.

NONPROLIFERATION POLICY DECISIONS IMPACTING US LEADERSHIP ABROAD

Beyond the nuclear science limitations that the United States faces, US nonproliferation policy has also complicated our ability to exert leadership.

Reprocessing

The Carter policy decision—based partly on the Ford administration's review—to indefinitely defer commercial reprocessing has limited our leadership with those countries who have chosen to reprocess the SNF. As highlighted in the "Report on the Proliferation Implications of the Global Expansion of Civil Nuclear Power, April 7, 2008" from the Department of State's International Security Advisory Board,[37] "Now, after nearly 30 years since those U.S. decisions [to indefinitely defer], the fact that no other nation has chosen to follow the U.S. lead in this regard..." undermines the contention that our policy stance and leadership would change other states' decisions on reprocessing. The International Security Advisory Board made this recommendation: "The Department of State should consider endorsing U.S. fuel reprocessing options as a key step toward undermining other nations' rationale for obtaining reprocessing and/or enrichment technologies."[38]

The United States could enhance its technical leadership and technology development by participating in reprocessing and mixed-oxide fuel (MOX) fuel fabrication. Nonproliferation goals can be maintained or enhanced by the continued development of more proliferation-resistant process and fuel-fabrication techniques.

123 Agreements

The United States' and the United Arab Emirates' (UAE) Agreement for Peaceful Civilian Nuclear Energy Cooperation was signed in December 2009. It cleared the way for the UAE to receive nuclear technology, material, and equipment from the United States. The agreement has come to be known as the "gold standard" because in exchange for the agreement with the United States, the UAE will not pursue enrichment or reprocessing because of the potential for proliferation.

The policy of seeking the "gold standard" 123 agreement in all agreements with countries rather than just requiring a robust safeguards and security regime is potentially limiting the leadership role of the United States internationally. Many believe that pursuing the "gold standard" would simply drive the prospective country to deal with France, Russia, or China, who perhaps would only require compliance with enhanced IAEA safeguards protocol rather than give up its sovereign rights.

Impacts of the application of the "gold standard" by the United States are not readily quantifiable, as such an assessment would require clear evidence that a country chose not to do business with the United States because of its onerous nonproliferation policy approach using the 123 agreement. A potential example may be the Egyptian agreement with Russia for a loan of $35 billion dollars and their purchase of nuclear reactors from Russia.

Export Controls

The Department of Energy has the responsibility to authorize the transfer of nuclear technology and assistance to foreign governments (whether located in the United States or internationally). The regulations are implemented Part 810 of Title 10, Code of Federal Regulations (Part 810). The nuclear industry in the United States is often negatively impacted by the long timelines and delayed approvals of the Part 810 authorization process. The nuclear industries in other countries do not have as stringent requirements and reviews allowing them to respond more nimbly and take advantage of the United States' delay.

POLICY RECOMMENDATIONS TO REVIVE AND EXPAND US GLOBAL NUCLEAR LEADERSHIP

US leadership in the global nuclear energy enterprise is important because the United States can help set the standards for safety, security, proliferation resistance, and efficiency in the facilities if the United States is both seen as a serious global player in nuclear industry and if its industry helps to set the standard. As of right now, the United States can exert influence because its technology remains an important element of the nuclear industry, even if US companies are not the leaders of the field. But this is a potentially tenuous advantage, particularly as the nuclear industries of China and Russia take advantage of our restrictive international policies and relatively weak R&D and manufacturing base at home. The result is potentially less-effective approaches to safety, security and nonproliferation and certainly an economic and political loss for the United States.

This is particularly important to note in the context of the growth of the nuclear industry, which will be less concentrated in the developed world and more in emerging markets. Though the Cold War no longer motivates US thinking, the original concept of Atoms for Peace—in which nuclear power is seen as a way of building bridges between the United States and developing countries—still has salience. Beyond this, there are important economic advantages for US industry as well as for managing issues as diverse as climate change and nonproliferation.

For these various reasons, the United States should consider making changes to its existing nuclear policies and approaches, as well as an investment in the nuclear industry domestically, in order to revitalize the industry and demonstrate global leadership. Part of such an effort will require U.S. government funding. The Department of Energy is spending almost $1 billion a year on nuclear R&D, but this number would need to be increased significantly to address the expansion of U.S. nuclear infrastructure sufficient to support world-class R&D facilities, including a new test reactor to enable continued science-based technology advancement and innovative fast-reactor design. And part of such an effort will require U.S. willingness to consider policy changes, even when controversial or inconsistent with longstanding practice. Many of the recommendations below may strike some readers as impossible given funding or policy concerns, and certainly a healthy debate can and should be had over them. Some of these recommendations will take time, discussion, further analysis and perhaps even Congressional legislation. But, in the author's view, they are necessary to take a bold new step to revitalize this once dominant U.S. industry. Other readers might note that increased funding may not be easily obtained given the downward pressure on the budget by the Trump Administration and that it might be a struggle to even maintain the current budget for nuclear R&D. As with other aspects of these recommendations, presidential commitment is vital.

Presidential Policy Statement on the United States' Commitment to Nuclear Leadership

The president should make it clear that as a matter of policy, that the United States will use its resources to enhance and maintain its worldwide nuclear leadership. This would include the steps that the executive branch intends to pursue and achieve those actions that are required to revive and expand the global nuclear leadership of the United States. The president must make it clear that he will work with Congress to pursue the required resources while providing strong leadership and clear direction to the relevant agencies and offices (DOE, NRC, the Office of Management and Budget, and the National Security Council).

The president should acknowledge that the march back to being the global nuclear leader will take time and a sustained leadership commitment, resources in the form of government funds, and the participation of the commercial nuclear industry in the United States.

Develop World-Class Nuclear Facilities

The United States should encourage and pursue advanced nuclear test facilities. These facilities should include but not be limited to a replacement for the FFTF's capabilities and the development of a "configurable" test reactor capable of mimicking the behavior of various advanced innovative reactor designs. This effort should be expedited with a goal of having the facilities operational by 2025.

To accomplish this, the United States should question the US and global nuclear community to determine which R&D facilities are required; develop plans, schedules, and budgets to revitalize its nuclear R&D facilities; prioritize the facilities; and aggressively implement the agreed approach.

Nonproliferation Views

The United States should change it views on reprocessing to be more in line with the rest of the world and resume leadership by acknowledging that reprocessing spent nuclear fuel is no longer the shortest path to a nuclear weapon and, in fact, a valid resource utilization and waste-management strategy. The United States could then play a more active role in the expansion of nuclear power around the world and interacting with those countries that have or may plan to—for energy security reasons of their own—reprocess.

At the same time, the United States could maintain its position against separating pure plutonium from the spent nuclear fuel. There are advanced reprocessing techniques, like GNEP's UREX series of processes and AREVA's COEX™ process, that separate plutonium with other elements contained in the spent nuclear fuel at the same time. For example, COEX™ separates and recovers plutonium with uranium from the spent nuclear fuel, never having plutonium by itself. These types of processes, along with enhanced IAEA safeguard, would limit the nonproliferation impacts of reprocessing.

The United States should also consider modifications to its present "gold standard" approach to nuclear fuel-cycle activities abroad. The "gold standard" should be the goal of the United States' 123 agreements, but a case-by-case approach to developing and signing a 123 agreement with countries should be encouraged.

Yucca Mountain

The United States should revive the Yucca Mountain project consistent with the NWPA. However, every effort should be made to reach a hosting agreement with the state of Nevada. The guiding principles and key attributes from the department's draft consent-siting process should be utilized in achieving this hosting agreement. Additionally, the United States has spent about $15 billion on the Yucca Mountain project, and to not move forward on the project would see all those funds go to waste.[39]

The MOX Project

The United States should reverse the Obama administration's decision to abandon the MOX project for the "dilute and dispose" method of dispositioning thirty-four metric tons of weapons-grade plutonium. The United States should make very clear it is committed to completing the MFFF and disposing of the weapons-grade plutonium via MOX fuel in commercial light-water reactors in the United States as previously planned and agreed with the Russians. The increasing costs—a key concern by many—should be addressed. This could potentially be done by commercializing the effort; that is, make this a commercial adventure with commercial facilities. The United States would then become a customer of the MFFF rather than the designer, builder, and operator.

Enrichment Capability

The United States must commit to establishing an indigenous-domestic enrichment capability as quickly as possible. This would not only support national security,[40] energy security, and the enrichment needs of the nuclear power fleet in the United States but also position the United States to participate in an assured fuel-availability framework and support their enrichment objective and requirements. This would also enable the United States to supply innovative nuclear reactors requiring fuel enrichments greater than 5 percent but less than 20 percent. The United States could and should position itself as the leader of higher enrichments.

With Russia taking action now to expand its enrichment capacity by 50 percent over 2013 levels by 2020 and China expanding more than six thousand separative work units (SWU) by 2030,[41] the United States should move quickly to reestablish a domestic-indigenous enrichment capability. One approach would be to sign a long-term contract with a commercial entity to buy SWU. By contractual agreement with the United States, the commercial entity would have an assured market for the SWU when its capability was established—essentially a take-or-pay contract. The commercial entity could use the contract to get project financing and then amortize the capital costs over time. This has the advantage of alleviating a large capital acquisition and capital outlay by the United States.

Maintain Current Nuclear Fleet

An active nuclear industry and operating reactors are vital to the United States maintaining leadership internationally and meeting global clean-air initiatives; the United States must have a stake in the game. With the potential of additional shutdowns, the United States should take action to enable all operating plants to continue until the end of their useful life—be it forty or sixty years and potentially beyond – in order to take full advantage of the investment made in the construction of these facilities in the first place.

Central to this would be the expansion of renewable-production tax credits to include the nuclear fleet in acknowledgment of the importance of all non-carbon-emitting sources of clean energy to an "all of the above" strategy. A small production tax credit (or a "breakeven" tax credit[****] or even New York State's zero-emission credit) to those nuclear plants at risk should allow them to continue to operate. Beyond emission-related credits, US policy should also credit nuclear reactor's base-load capacity and positive effect on grid stability.

Taking such an approach would distort energy markets to some extent, as the U.S. government and participating state governments would effectively be picking nuclear as a winner over potentially cheaper market options. However, this is no more of a distortion on nuclear's behalf than already takes place with respect to renewable energy and for largely the same reasons of reducing U.S. carbon emissions. Moreover, there is also energy security benefit for the United States in having multiple sources of energy, reducing dependence on any one source that could create vulnerability to future market conditions or resource scarcity.

Become the World Supplier of Nuclear Technology

The US government could work with US nuclear industry to effectively streamline the Part 810 process. The United States could also review the Part 810 requirements and revise as necessary to ensure competitiveness with other countries.

****This refers to a tax credit to offset the loss of the operator until the plant returns to profitability.

The United States has a nuclear industry that can become the world's supplier. If the Part 810 process could be further streamlined and predictable, it would enable US industry to effectively engage in markets around the globe. The Part 810 process should be brought more into line with the requirements imparted on their nuclear industry by France, Russia, Korea, and China—the other leaders in the world market.

Lead in the Development and Marketing of Advanced Innovative Reactors

With more than forty innovative nuclear reactor developers located in the United States, the United States should lead the way for the deployment of these innovative nuclear power systems around the world.

The United States should encourage the domestic innovative nuclear reactor development efforts to move forward as quickly as possible, recognizing that the market for the industry has amazing potential. Making the development, production, and deployment of advanced innovative nuclear reactors a key component of policy would firmly establish US leadership for many decades to come.

Key to this effort is the recognition that government support in some form will be needed for these designs whether in the form of capital costs (perhaps loan guarantees) and/or unfettered and streamlined access to the national laboratories of DOE.

The United States should put policies in place to enable the licensing of these innovative reactors in eight years. To that end, emphasis should be placed on expediting the "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness"[42] to allow licensing in eight years.

The United States could and should bring all the domestic innovative nuclear reactor developers together and determine deployment strategies for each system. The Department of Commerce can get more involved in the global marketing of these advanced nuclear systems.

CONCLUSION

Policy can and should play a role in maintaining and enhancing the United States' nuclear leadership. Through a series of policy changes and presidential initiatives, the United States can quickly regain its mantle as the world leader in nuclear power and nuclear technologies.

This expanding leadership and expanding capabilities are vital to enable a strong presence across the globe as the use of nuclear power continues to grow in countries that have nuclear power and those that are new to the use of nuclear power.

The United States can shore up its nonproliferation leadership by recognizing that reprocessing is no longer the significant proliferation risk it once was and focus on the proliferation of enrichment technologies and capabilities.

The United States can and should be flexible on the requirements of 123 agreements and handle the agreements on a case-by-case basis rather than insisting on the "gold standard." Stringent application of the "gold standard" to 123 agreements may not be helpful and could boost the attractiveness of an agreement with other countries.

The US nuclear industry can compete on the global nuclear business stage given the correct tools and support from the United States. Further streamlining the Part 810 process and giving the nuclear industry predictable timelines for approvals will allow them to respond to countries seeking their services.

The United States can become the preeminent global nuclear leader. The United States may even, in time, be able to pursue a global expansion of nuclear power that improves energy security and access for presently impoverished populations, just as Eisenhower argued in 1953. It will simply take a commitment of the president and Congress to make it so. To not make the commitment now will see the global nuclear leadership of the United States continue to dim.

NOTES

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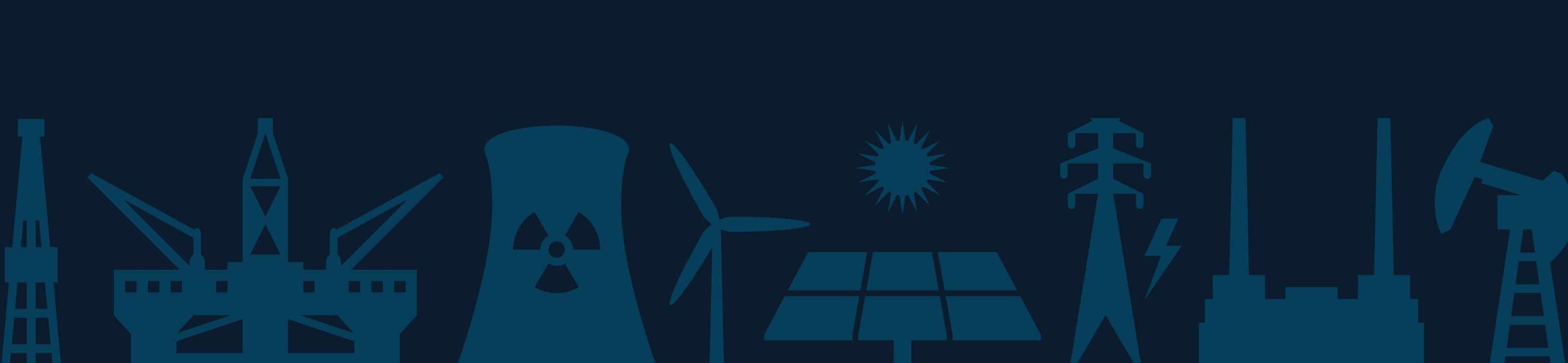

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