Revisiting America's Nuclear Waste Policy



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EXECUTIVE SUMMARY

With the first 100 days of the Obama Administration behind us, the Institute for 21st Century Energy presents this nuclear waste policy document that recounts the history of the country's nuclear waste policy, discusses the mechanics of the issue, and offers specific recommendations to the Obama Administration and the U.S. Congress.

Two weeks after the 2008 presidential election, the Institute released dozens of energy policy recommendations for the incoming administration and 111th Congress. Ten recommendations focused on committing to and expanding the use of nuclear energy as well as managing our nation's nuclear waste, including:

> *The President and Congress must commit to a permanent solution to our nations' nuclear waste. As directed by law, and even while the administration considers alternative policies, the President and Congress must act expeditiously to ensure that the NRC's Yucca Mountain licensing process proceeds and if it is licensed, provide full funding for construction and operation of the repository.*
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> *If the President or Congress will not fully commit to this path, they owe it to the American public and the utilities that have paid fees and interest in excess of $28 billion into the Nuclear Waste Fund, to pursue a parallel path of centralized interim storage, industrial deployment of advanced recycling technology, and establish a clear path to siting, licensing, constructing, and operating a permanent geologic repository to more quickly place the U.S. government in compliance with federal law.*

President Obama's submission of a budget blueprint to Congress in February has brought into question the country's nuclear waste policy of the past three decades. This document stated "[t]he Yucca Mountain program will be scaled back to those costs necessary to answer inquiries from the Nuclear Regulatory Commission, while the Administration devises a new strategy toward nuclear waste disposal." On March 11, Secretary of Energy Steven Chu testified to Congress that the administration intends to devise a new nuclear waste strategy that does not involve a repository at Yucca Mountain. Secretary Chu is currently in the process of forming a blue ribbon commission to study and recommend alternative waste strategies.

Irrespective of the rationale for pursuing a new direction, the administration and Congress have an absolute obligation to future generations, as well as the utilities and states currently storing used nuclear fuel and waste, to establish a durable policy that ensures the federal government will meet its legal obligations while creating the regulatory certainty to foster the expansion of commercial nuclear power in the United States.

It is timely to review the country's waste policy given that many of the facts, conditions, and assumptions that were in place in 1982 when the current policy was crafted are no longer accurate or germane. Yucca Mountain has been studied and characterized for more than three decades, and it has been found to be the safest and best option for disposing of the country's used nuclear fuel and nuclear waste given the parameters of U.S. law. However, under no circumstances is Yucca Mountain the only solution, nor is the construction of a repository at Yucca Mountain a prerequisite to building new reactors. Moreover, while on-site storage of used nuclear fuel is safe and secure, it should not be relied upon as a fall-back policy because the federal government will not fulfill its legal requirements.

As the administration and Congress revisit the country's nuclear waste policy, the following questions must be addressed, and are discussed in this document:

- How should we handle the management and administration of our waste policy?
- What steps, if any, should be taken in the interim?
- If we are not going to store used fuel and waste at Yucca Mountain, then where?
- Should we move to a "closed fuel cycle" and recycle our used fuel? If yes, with what technologies and on what timeline?
- What is the best course to handle the Nuclear Waste Fund and future funds collected from the utilities?

Fast Facts on Nuclear Waste

104 Nuclear reactors operating in the United States today

20 Percent of America's electricity mix powered by nuclear energy

2,000 Metric tons of used nuclear fuel generated annually from U.S. reactors. This amount could effectively fit inside a large dumpster

90 Nuclear reactors projected to have exhausted space in their cooling pools to store used nuclear fuel by 2010

REVISITING OUR NUCLEAR WASTE POLICY

Since the first commercial nuclear reactor in the United States at Shippingport, Pennsylvania began generating electricity in 1957, the country has grappled with the issue of nuclear waste disposal. More than 50 years and 60,000 metric tons of used fuel later, we appear no closer to a final answer. Moreover, as the commercial nuclear industry was spawned from the government's nuclear weapons programs beginning with the Manhattan Project of the 1940s, it is important to note that 13,000 tons of high-level waste, primarily defense-related, is stored at governmental sites awaiting final disposition.[1]

The process that led the federal government to decide to design, build, and construct a permanent repository at Yucca Mountain, was based on conditions that were present in 1982 when the seminal law, the Nuclear Waste Policy Act (NWPA), was enacted. Many of these conditions no longer exist. Notably, climate change was not an issue of public concern and economic and political conditions were vastly different. In the 27 years since the NWPA was enacted, the nuclear industry has demonstrated an unrivaled record of safe, reliable, and economical electricity production with its 104 nuclear reactors that supply 20% of the U.S. electricity needs.[2]

Given all of this, the public and policymakers alike are taking a fresh look at the benefits of commercial nuclear power. Public opinion polls show a level of support for nuclear energy not seen since the mid-1970s.[3] All of these factors make it important to take a step back and make a conscious decision on the long-term policy for managing the nation's used nuclear fuel and nuclear waste.

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Nuclear waste policy has become radioactive, both literally and figuratively. The legal obligation of the U.S. Department of Energy (DOE) to take and, ultimately, dispose of the used nuclear fuel and waste accumulated at commercial and Cold-War era government nuclear facilities around the country has taken a new turn with the submission of President Obama's proposed FY 2010 budget to Congress on May 7. In this budget, President Obama proposes the elimination of the Yucca Mountain repository program and requests only $196.8 million, "for DOE to explore alternatives for nuclear waste disposal and to continue participation in the repository license proceeding before the Nuclear Regulatory Commission."[4]

While keeping with his campaign promise to prevent completion and operation of a repository at Yucca Mountain, Nevada, the president's official announcement has generated significant derision from some supporters of nuclear power and great support from some Nevadans and from opponents of nuclear power.

Afterall, over the past three decades, billions of dollars in federal research, dozens of governmental and independent reviews, and a congressional resolution have determined Yucca Mountain is the safest and best option for disposing of the country's nuclear waste given the parameters of U.S. law. However, under no circumstance is Yucca Mountain the only solution.

Whether or not the Yucca Mountain project progresses does not materially impact building the necessary new nuclear power plants to increase our energy

security, reduce greenhouse gas emissions, and support new jobs and economic growth. The president and the 111th Congress have committed to shaping an energy future with significantly less greenhouse gas emissions. While there are many technologies that can contribute to this goal, nuclear energy is the only baseload source of emissions-free power that can significantly be expanded to meet growing demand. President Obama's budget proposal set a midterm goal to reduce greenhouse gas emissions 14% below the 2005 level by 2020.[5] To do this, the United States would have to reduce emissions by about 1 gigaton, which is no small amount. To put this in context, reduction of one gigaton can be achieved by constructing 130 new nuclear power plants to replace the equivalent amount of electricity from coal-fired generation.[6]

As we near the potential expansion of the commercial fleet of nuclear reactors, now is a perfect time to reconsider the country's nuclear waste policy. While we do not support the rationale—stated or unstated—for scuttling the Yucca Mountain repository, reviewing our nuclear waste policy is the best course for our country.

DEMISE OF NUCLEAR PLANT CONSTRUCTION AND RECYCLING

In the early years of commercial nuclear power, there was relatively little question or debate regarding the proper method for waste disposal from a scientific or engineering perspective. In 1954, Chairman Lewis Strauss of the AEC or Atomic Energy Commission (a predecessor to both the Nuclear Regulatory Commission (NRC) and DOE) declared that civilian nuclear power would provide such abundant electricity that it would be "too cheap to meter."[7] The government's plan for waste management was to recycle the used fuel, a logical engineering solution to ensure the most efficient use of valuable natural resources.[8]

The country's weapons programs had provided years of experience reprocessing used fuel that had been irradiated in a nuclear reactor to generate and separate plutonium for weapons, and the AEC's path forward for nuclear waste disposal would mirror that model. Used fuel from commercial reactors would be chemically separated into its elemental components, with the remaining uranium and plutonium to be recycled as fuel back into reactors. The resulting waste (essentially anything other than plutonium or uranium) from this "closed fuel cycle" process would be volumetrically smaller and less radioactive and would be turned into cylinders of glass through a process known as vitrification. Vitrified waste is very stable, more resistant to leaching, and suited for many geologic disposal mediums like clay, granite, or basalt.[9,10] Though the AEC never made a final conclusion, it had notionally selected salt as the medium for a permanent repository and tentatively selected a site near Lyons, Kansas for this purpose.[11]

The AEC was aware that the civilian nuclear industry owed its existence to the federal government's work on weapons and nuclear-powered naval vessels, and there was a desire to move the industry away from a de facto government sponsorship.[12] The AEC therefore decided to make the recycling component of the fuel cycle a private enterprise. Two private recycling facilities were built in West Valley, New York, and Morris, Illinois, in 1966 and 1971, respectively. The West Valley facility proved operationally successful and processed almost 1,000 used fuel assemblies by 1972. However, beginning in 1973, the AEC began issuing additional regulatory requirements. In 1976 the facility shuttered because it was not economical to make the required plant modifications necessary to continue.[13]

The Morris facility employed new technologies to minimize production of radioactive liquid waste. However, technical issues prevented the plant from ever reaching full operation. In 1972, it ceased testing operations due to increased costs to make it fully operational as well as the additional scrutiny the West Valley facility had come under. It ultimately ceased operation in 1974 before processing any used fuel.[14]

Finally, in 1971, construction of a full-scale recycling facility began in Barnwell, South Carolina utilizing the collective lessons learned from its two predecessors. In 1977, the owner had completed the initial phase of the plant and was testing it when President Carter issued a policy to indefinitely defer used fuel recycling in the United States, requiring the NRC to cease all licensing activities for nuclear recycling facilities. The Barnwell facility was never allowed to process any used fuel.[15]

The rationale for President Carter's decision was primarily based on public concern over India's atomic weapon test in 1974. This event provided direct evidence of a country developing nuclear weapon capabilities by using a civilian reactor to produce weapons-grade fuel and sparked global concern over the potential spread of nuclear weapons technology.[16] President Carter's policy, which had been initiated by President Ford in 1976 on a temporary basis, ceased commercial recycling operations to ostensibly set an example for the rest of the world to follow and thus vacated the country's existing nuclear waste strategy. Some 30 years later, it is evident the world did not follow our example as six other countries have operated nuclear fuel recycling facilities, and others are pursuing this path.[17]

Many other factors and events that occurred in the 1970s are as responsible for the demise of the nuclear fuel recycling program as the presidential actions. The Arab oil embargo created a sea change in how Americans consumed energy. At the time, oil-fired power plants produced about 17% of U.S. electricity.[18] When oil supply plummeted, prices skyrocketed, and electricity rates increased accordingly.[19] This caused the country to consume significantly less electricity.[20] Moreover, the subsequent economic "stagflation" produced interest rates exceeding 20%.[21] With less electricity demand and the cost of financing increasing, utilities began scaling

Fast Facts on Nuclear Waste

60,000 Metric tons of U.S. commercial used nuclear fuel accumulated in the past 35 years. All of these used fuel assemblies could fit on a football field and not reach the top of the goal posts

13,000 Metric tons of U.S. government generated used fuel and defense-related high-level waste

121 U.S. locations where used nuclear fuel or waste is stored

39 States that store used nuclear fuel or waste is stored

back their planned increases in generation capacity, and dozens of proposed nuclear plants were cancelled.[22] While nuclear power plants produced electricity at amongst the lowest generation costs of any source, they were and continue to be very capital intensive to build.[23] All of these factors compounded to make construction of new nuclear power plants uneconomical investments for utilities. These same factors made construction of recycling facilities a dubious investment as well.

By the time the recession ended and President Reagan lifted the ban on recycling, the country's power producers had shifted their increased generation needs to new coal and then natural gas-fired power plants. Disjointed licensing procedures at the NRC and an anti-nuclear sentiment reaching new levels in the wake of the Three Mile Island accident made building a new nuclear reactor a risky proposition for any utility.

THE HISTORY OF YUCCA MOUNTAIN

With the demise of America's recycling program in the 1970s, on-site storage of used fuel at the various reactors became the de facto policy and has continued to be the default policy for the country ever since. Both the Carter and Reagan administrations began to focus on a new path forward, which resulted in Congress' passage of the NWPA of 1982. This law committed the country to a "once through" fuel cycle, or direct disposal of used nuclear fuel from commercial reactors, as well as government waste from defense and research activities.

In 1982, the future of commercial nuclear power looked much different than it does today. It was widely assumed that the 82 operating reactors would run the life of their licenses (with or without extensions) and be decommissioned, producing a finite amount of used fuel to manage. Under those circumstances, the government decided that permanent disposal in a geologic repository was the best path forward.[24] However, to preserve the option of extracting the valuable uranium and plutonium from the used fuel in the future, the NWPA required the used fuel to be retrievable.[25] This requirement made the design and engineering of the repository more complicated and opened the door to more regulatory and legal challenges.

The NWPA established a blueprint for the then-newly created U.S. Department of Energy to identify a site and then construct and operate a permanent geologic repository. The act also required DOE to work on a parallel track to site and construct a second repository in a different region of the country.[26] The NWPA required nuclear utilities to execute contracts with DOE, which would mandate that DOE subsequently remove the utilities' used fuel. In return, the contracts require the utilities to pay a fee to the U.S. government for this disposal service. The fee of one mill ($.001) per kilowatt-hour of nuclear generated electricity is collected from ratepayers by utilities. The fees are then deposited in the Nuclear Waste Fund managed by the U.S. Department of Treasury and can only be used by direct Congressional appropriation. These contracts obligated DOE to begin collecting the used fuel from reactor sites by 1998, which has yet to occur more than a decade later.[27]

In 1983 DOE selected nine sites as potential repositories; and in 1986, it narrowed the list to Hanford, Washington; Deaf Smith County, Texas; and Yucca Mountain, Nevada. At about the same time, DOE postponed work on a second repository.[28] In 1987 Congress amended the NWPA and designated Yucca Mountain as the only site for which DOE should conduct a characterization.

In 2000, the National Academies reaffirmed geologic disposal as the only available "scientifically and technically credible long-term solution" that does not rely on active management. In 2002, DOE concluded that geologic storage of used nuclear fuel and high-level waste at Yucca Mountain was safe and scientifically sound and recommended the Nevada site to President Bush, who approved the recommendation. Also, in 2002, Congress passed and President Bush signed the required Joint Resolution, overriding the state of Nevada's procedural veto, designating Yucca Mountain as the site where DOE would build the legally required repository. Several legal challenges and funding shortfalls have delayed progress since the site selection.

DOE's failure to begin collecting used fuel from the utilities means that since 1998 it has been in breach of the contracts it executed. Since 1998, more than 40 commercial reactors have exceeded their existing storage capacity and have been forced to purchase expensive dry storage systems to safely store the excess fuel. It is expected that approximately 90 reactors will have exhausted existing pool storage capacity by 2010 and will have to begin external dry cask storage. This is all in addition to the 12 decommissioned reactors already storing used fuel in dry casks.[33]

More than 60 lawsuits have been brought against DOE for failure to perform its contractual duty to collect used fuel from utilities. The plaintiffs have sought damages to cover the cost of storing the fuel, a service for which they have already paid through the Nuclear Waste Fund.[34] Liability accrues at an average rate of $500 million per year.[35] To date, judgments of about $750 million have been awarded to utilities, and DOE estimates it will likely have to pay another $10 billion in the future.[36] Additionally, the U.S. Department of Justice has spent nearly $100 million on litigation expenses.[37] If the Yucca Mountain project is scrapped entirely as President Obama and some congressional leaders have suggested, these liabilities will grow much higher with one bipartisan congressional estimate reaching $30 billion.[38] These payments are made directly from a special judgment fund in the general treasury, do not require appropriation, and do not affect the balance in the Nuclear Waste Fund.[39]

The Nuclear Waste Fund balance—the difference between the accumulated total of Nuclear Waste Fee payments compounding with interest, less direct appropriations to fund the Yucca Mountain program—is currently about $22 billion. Nuclear utilities are paying more than $760 million into this fund annually.[40] Congressional appropriations for the Yucca Mountain project over the past eight years have been more than $1 billion less than the amounts requested by the President.[41] In the FY 2009 Appropriations Act enacted in March, only $288 million was allocated, about 40% less than was requested.[42,43] This persistent underfunding has continued to hamper progress. In June, DOE submitted a license application to construct a repository at Yucca Mountain, six years later than required by the NWPA.[44] Under provisions in the NWPA, the NRC could take as long as four years to fully review the application.[45] According to DOE's revised timetable, the Yucca Mountain repository will not open before 2020, making it at least 22 years late.[46] That timeline does not take into account potential legal or regulatory delays or lack of congressional funding for the project.

WHERE ARE WE NOW?

Today, there is more than 60,000 metric tons of commercial used nuclear fuel, in addition to nearly 13,000 metric tons of government-held used fuel and defense-related high-level waste, being stored at 121 sites in 39 states.[47] The country's current fleet of 104 light water reactors continues to produce about 2,000 metric tons of used fuel every year.[48] To put these quantities in perspective, that amount of used fuel could effectively fit inside a large dumpster like those seen at construction sites. Moreover, all of the used fuel assemblies currently in storage around the country could fit on a football field and not reach the level of the top of the goal posts.[49]

Additionally, 20 companies have submitted license applications to the NRC seeking authorization to build and operate 26 new reactors.[50] While the first of these reactors will not come on-line before 2016, this expansion of the country's nuclear generating capacity will increase the annual production of used fuel significantly.[51]

Given the precipitous decrease in congressional funding witnessed in the last two annual appropriations bills as well as the stated opposition to the construction and operation of the Yucca Mountain repository by President Obama and some congressional leaders, the future of U.S. nuclear waste policy is as murky as any point in our long history of commercial nuclear power.

President Obama's FY 2010 budget proposal requests only enough funding for the Yucca Mountain project to defend the license application and to explore alternative nuclear waste disposal policies. This pronouncement has significant implications. Most obviously, it means President Obama likely intends to stick with his campaign pledge to effectively take Yucca Mountain off the table as a waste repository. This is supported by DOE Secretary Steven Chu's statement to Congress in March that, "[b]oth the President and I have made clear that Yucca Mountain is not a workable option and that we will begin a thoughtful dialogue on a better solution for our nuclear storage waste needs."[52]

However, the President's budget blueprint also implies that DOE will not rescind the license application, an action that would likely have legal implications regarding DOE's contractual liability to the utilities. Also, by allowing the license application to be subjected to a full review, DOE will gain significant insight and guidance for any subsequent repository license applications. This may be especially true for the issue of public exposure to radiation as governed by the standard issued in 2008 by the Environmental Protection Agency. This standard is an updated version of the standard previously found to be insufficient by the Court of Appeals for the Federal Circuit in 2004.[53]

Fast Facts on Nuclear Waste

20 Utilities that have submitted license applications to the NRC seeking authorization to build and operate 26 new reactors

1 Gigaton (or 1 billion metric tons) of greenhouse gas emissions that would have to be reduced by 2020 to meet President Obama's mid-term climate change goal (equivalent of building 130 new nuclear plants to replace equivalent electricity from coal-fired generation)

11 Years since DOE was legally required to begin taking used nuclear fuel from commercial reactors

America has the opportunity to put all options on the table. Our leaders must weigh the available science, health, and environmental analysis, economics, and public policy implications of each and set a path forward that best suits the country, not only today but also in the future. The consensus may very well be that the course as set out in the NWPA is still the best option, and it should not be foreclosed for political expediency. However, our leaders must come to the table with open minds and do what is best for the country.

Until such time that a critical mass of consensus is reached and new legislation is enacted, the federal government has both a statutory and contractual obligation to continue to pursue the strategy established in the NWPA to license, construct, and operate a repository at Yucca Mountain and remove the used fuel from the various sites around the country. Despite the administration's stated plans, the law is the law, and the NWPA must be implemented.

BLUE RIBBON PANEL

On March 11, 2009, Secretary Chu testified before Congress on his intention to form a blue ribbon panel by early April to review America's nuclear waste policy.[54] The panel would be tasked with delivering recommendations for managing the country's commercially produced used nuclear fuel as well as the government's defense-related waste and used nuclear fuel. Secretary Chu suggested he is looking to receive these recommendations in 2009, "and then we'll take it from there."[55]

Taking a fresh look at the country's nuclear waste policy is a necessary proposal, even if the rationale is motivated more by political considerations than by science or sound public policy. Nevertheless, it is important that the panel be evenly balanced across backgrounds, expertise, regions, and political affiliations. The panel cannot be comprised predominantly from one sector, whether it be academia, government, or industry. If the panel is not seen as properly balanced, its recommendations will not be credible or sustainable over time. Also, if the panel is prohibited from considering ALL options, as some in Congress have proposed, its recommendations will be tainted and lack credibility.[56]

MANAGEMENT REORGANIZATION

One change to current nuclear waste policy that the blue ribbon panel should consider is to change the entity which manages the development and implementation of policy. Supporters from many corners of the debate have suggested that the most salient and effective solution is the establishment of an outside entity—such as a government corporation—that is statutorily empowered to develop the country's waste policy within the confines of U.S. law and then implement it. There are several key reasons why taking this function out of DOE is preferable, but the primary ones are removing some of the day-to-day politics and uncertain annual appropriations that invariably affect this role.

Currently, the director of the office that manages the Yucca Mountain project is appointed by the president and confirmed by the U.S. Senate and reports through the normal chain of command to the secretary of Energy.[57] This process lends itself to relatively frequent turnover as administrations and its appointees come and go. Such turnover hampers continuity of management and ensures that the priority of complying with the NWPA in building and operating a repository at

Yucca Mountain waxes and wanes as the priorities of the current president change from his predecessors.

The safe and efficient management of the country's nuclear waste is a long-term proposition that is too important to allow the normal political nature of government to interfere with well established law. The creation of a government corporation would not be devoid of politics, but any lessening of this external influence ensures better public policy for the country.

Additionally, this entity could be authorized to utilize the Nuclear Waste Fund for its statutory purposes, without requiring direct appropriations from Congress for access. This authority would enable a more efficient use of the funds paid by the utilities and would prevent Congress from comingling and spending these funds for other purposes inconsistent with the NWPA.

INTERIM STORAGE

Regardless of the country's long-term nuclear waste policy, there are actions that the blue ribbon panel should consider in the short term. The used fuel being stored on-site around the country is safe to the public and secure from theft or damage and can remain so for generations to come.

Used nuclear fuel is largely stored in two ways at the nation's nuclear reactors. After about four years of continuous irradiation inside a reactor, the composition of the fuel has changed to a point where it does not efficiently support a fission reaction. At this point, the used fuel is removed from the reactor core and placed in storage pools nearby within the secured facility. The water in the pool cools the fuel and blocks radiation. As previously noted in *The History of Yucca Mountain* section of this report, the majority of the nation's operating reactors have reached, or will soon reach their respective storage pool capacity. Since DOE has breached its contractual duty to remove used fuel from these pools, the reactor operator has little choice but to invest in alternative storage.

For more than 20 years, utilities have been removing used fuel from their cooling pools and placing it in large casks for on-site dry storage.[58] Weighing more than 100 tons, these casks predominantly consist of a large steel container in which the fuel rods are stored, surrounded by an inert gas, which is, in turn, encased in a larger concrete casing. The various layers ensure a safe level of radiation within legally proscribed limits.[59] Each cask costs the operator about $1 million to purchase and is placed on concrete pads on the secured grounds of the facility. To date, some 9,000 tons of used fuel elements are being stored in 900 casks around the country.[60]

The NRC has found used nuclear fuel could be safely stored in these containers for at least 100 years.[61] However, relying solely on dry storage for the next century may not represent the best policy to support an expansion of the reactor fleet in the coming years. Communities where new reactors are being proposed, as well as those currently hosting reactors want to know what the long-term plan for the used fuel will be. Since the beginning of the commercial nuclear industry, the plan has always been to remove the used fuel to be recycled, disposed of, or stored in a repository. This system of removal would enable more centralized storage capitalizing on economies of scale to secure, monitor, and store the fuel. It would also provide the country with the peace of mind that the government can execute a plan to remove used fuel from the various sites across the country and that they will not become de facto permanent repositories.

While the federal government ponders the country's eventual waste strategy, and while the NRC continues to review the license application for the Yucca Mountain repository, Congress and the Obama administration should begin a process of siting and licensing centralized interim storage locations. There are DOE sites that would be (and some that already are) ideal candidates to store used fuel.[62] Additionally, given the appropriate assurances and financial compensation, there are several states and communities that have expressed an interest in temporarily storing used fuel.[63] All of these possibilities should be quickly and aggressively pursued with the most optimal site(s) being selected.

DOE has maintained it is prohibited from sponsoring interim storage facilities under the NWPA. The department argues it is only permitted to sponsor a monitored retrievable storage facility, anywhere outside of Nevada once the NRC grants it authority to construct the repository at Yucca Mountain. While many in Congress disagree with DOE's legal interpretation, it is reasonable, and likely persuasive, if ever challenged in federal court. Thus, Congress has the responsibility to amend the NWPA and grant DOE clear authority to begin the process of siting, licensing, and constructing interim storage facilities, considering all potential locations, and to then begin retrieving spent fuel from the utilities consistent with its contractual obligation.

Some have argued, and the Clinton administration proposed, that DOE can and should "take title" to the used fuel at the various sites around the country, thereby meeting its contractual obligation.[65] While it is true that in most instances this action could relieve further contractual liability, the NWPA does not authorize DOE to take this action. Even if it were legal, such an action does not meet the larger policy goal of centralizing storage and reducing the number of sites that require monitoring and security to a bare minimum.

A PERMANENT REPOSITORY

It cannot be overstated that regardless of which direction is selected, a permanent repository will ultimately be necessary. There are several variables that will determine when a repository will need to be in operation, but there are no viable scenarios that would obviate

Fast Facts on Nuclear Waste

9,000 Metric tons of used nuclear fuel stored in dry casks due to lack of space in cooling pools.

900 Dry cask storage sites in the U.S. for used nuclear fuel

60+- Lawsuits brought against DOE for failure to perform its contractual duty to retrieve used nuclear fuel from commercial reactors

$30 billion
Projected liability of the federal government for failing to remove used nuclear fuel from commercial reactors

the need for a permanent repository to safely store the country's nuclear waste and used nuclear fuel.

Long before the NWPA was enacted, DOE and its predecessor agencies focused millions of dollars and many years evaluating potential sites based on factors such as geology, hydrology, and seismology. Since the NWPA was amended in 1987, DOE has focused solely on studying and characterizing Yucca Mountain per Congress' direction. In the subsequent 15 years before site selection, the Yucca Mountain site became the most comprehensively studied geographical site in the entire world.[66] As such, in 2002, DOE concluded, and Congress ratified, that the site's remote location, its dry climate, its stable geology, and its unique hydrology make it especially suitable for, and will serve as, the deep geologic storage of the country's nuclear waste.[67]

If the blue ribbon panel makes any recommendations that stray from the guidelines set forth in the NWPA, legislation would be required to implement them. Even if DOE ultimately decides to remain on its current path, additional legislation would be required as DOE has previously proposed to increase the authorized amount of materials that can be stored at Yucca Mountain, to withdraw adjacent lands from public use, and to authorize construction of a rail line, among other changes.[68]

While it is true that Yucca Mountain is well suited to store the various forms of high-level waste mandated in law, it is also true that there may be other locations, and more precisely, geologic media, with fewer political, regulatory, scientific, or economic obstacles. The Yucca Mountain site was selected in part because its geology enables it to meet the legal requirement that waste interred must be retrievable. When the NWPA was passed, Congress assumed it was unlikely new nuclear plants would be constructed, and therefore, there would be a finite amount of used fuel requiring storage. Congress also realized this used fuel contains vast amounts of valuable uranium and plutonium that might be needed at some point in the future and required the used fuel be retrievable from the repository as an insurance measure.[69]

If the used fuel were to be recycled—extracting the useful elements from the used fuel—the resulting waste would not need to be retrievable. By eliminating this retrievability requirement, the waste might more efficiently be deposited in geologic formations other than Yucca Mountain's native soil (volcanic tuff), such as salt or clay. The United States has many large salt deposits stretching from the southeastern states through the Midwest, all the way through the Southwest.[70] Salt formations present unique characteristics suitable for storing nuclear waste such as their aridity and the shifting nature of salt flows that encapsulate waste deposits, making retrievability practically impossible.[71] DOE has already accumulated tremendous knowledge and experience with salt formations through its design, construction, and operation of the Strategic Petroleum Reserve (SPR) sites. It utilizes four salt domes to store approximately 700 million barrels of oil as a reserve to be employed against severe market disruptions.[72]

Of greater relevance, DOE has significant experience storing nuclear waste in salt formations at the Waste Isolation Pilot Plant (WIPP) in New Mexico. Operating since 1999, WIPP is the only active deep geological repository in the world.[73] WIPP is especially noteworthy because it is licensed to safely store defense-generated transuranic (TRU) waste, isolating it from the human environment for at least 10,000 years.[74] While TRU waste is significantly different from the high-level waste that would result from recycling used fuel, or from the used fuel itself, its safe disposal at WIPP has not only demonstrated the licensing process

for a long-term nuclear waste storage facility, but it has also produced a wealth of data and analysis on the geology, chemistry, hydrology, and other scientific disciplines of waste disposal in salt. The irretrievable nature of salt is especially beneficial for securing nuclear waste from human contact.[75] There is still need for additional analysis related to the effects of disposing high-level waste in salt, but it presents great promise for the long-term, safe, and secure disposal of the country's nuclear waste.

CLOSING THE NUCLEAR FUEL CYCLE

As previously noted in the *Demise of Nuclear Plant Construction and Recycling* section of this report, recycling used nuclear fuel was originally an integral component of the country's nuclear waste policy. While many countries have pursued recycling, the United States has instead committed to a "once through" fuel cycle. However, with dozens of reactors being proposed in this country and hundreds around the world, the United States has rightly been reevaluating whether to close its nuclear fuel cycle.

Recycling used nuclear fuel presents several benefits. Not only does it reduce the volume of waste requiring permanent disposal, but it also reduces the levels of radiotoxicity of that fuel.[76] Moreover, by reusing the fissionable uranium and plutonium, recycling conserves these valuable natural resources while making the country less dependent on imports. Establishing a recycling enterprise is not cheap, and there remains a legitimate debate around whether the benefits outweigh the financial costs.

The countries that currently recycle used nuclear fuel are the United Kingdom, France, India, Japan, and Russia. These nations largely employ a separations technology originating from the U.S. weapons production efforts. This technology is known as PUREX for "plutonium uranium recovery by extraction."[77] In essence, PUREX chemically separates used fuel into three component parts consisting of uranium (96% of the volume), plutonium (1%), and fission products (3%).[78] In most instances, current recycling processes combine a mixture of the recycled uranium and plutonium, sometimes with additional fresh uranium, to fabricate new fuel for a traditional light water reactor (all of the 104 commercial reactors in the United States are light water reactors). The remaining fission products, which have little or no energy content, are vitrified or made into solid glass.[79] This glass waste is usually stored on the site of the facility pending permanent disposal in a repository.

The primary concern over this method of recycling is the separation of plutonium. Plutonium is fissile, meaning it can fuel a nuclear chain reaction. The right quantities can be fashioned into a nuclear weapon. This should be a concern for every policymaker, and is why the International Atomic Energy Agency strictly monitors the production, movement, and storage of every ounce that is created. More than 240 metric tons of plutonium from civilian production has accumulated around the world and is tightly guarded.[80]

Other technologies have been developed that do not result in the separation of pure plutonium, preventing the threat of the material being directly usable in a nuclear weapon. In 2007, in response to a DOE Request for Expressions of Interest, four commercial consortia proposed the deployment of technologies that would not produce pure plutonium as a near-term recycling option.[81] DOE has also been developing an advanced separation process that would not produce pure plutonium while also allowing further separation of the fission products for waste disposal applications.[82] Technologies like these have yet to be commercialized, but represent a great opportunity for the nation to close the fuel cycle while eliminating one of the most popular arguments against it.

The development of advanced recycling technologies has been under way at several U.S. National Laboratories for more than a decade. In 2006, President Bush introduced the Global Nuclear Energy Partnership (GNEP).[83] As its domestic component, GNEP proposed the development of a process that would greatly reduce the volume and radioactivity of the ultimate waste form through advanced technology that would allow for the separation of many of the various fission products in different combinations.[84] These elements would then be used as fuel in advanced fast neutron reactors. Fast reactors differ from conventional light-water reactors in that they do not moderate fast neutrons, allowing them to more effectively fission or "burn" many of the most troublesome transuranic elements present in used nuclear fuel.[85] Feeding these remaining products into fast reactors could result in an ultimate waste product that would only have high levels of radioactivity for hundreds of years as opposed to the hundreds of thousands of years for used nuclear fuel elements.

Secretary Chu has voiced notional support for the advanced research and development required to produce the technologies originally proposed in GNEP, and DOE has announced, "[t]he long-term fuel cycle research and development program will continue."[86, 87] These advanced technologies are likely at least 20 years away from deployment.[88] However, most of the major commercial nuclear power countries are also working to develop these technologies, representing another area for the United States to reassert global leadership—an area we have effectively ceded over the past 30 years.

Deployment of near-term technology would require upward of a decade, and the development and deployment of advanced technologies could take more than 20 years.[90] These lead times are exactly why the United States must decide whether to close the fuel cycle today because the work on licensing, financing, and siting would have to begin now. It is conceivable that the country's nuclear power generation could double by 2050 to meet climate change concerns as well as expected demand growth. If we do not set out on the path to close the fuel cycle today, we will find ourselves with

Fast Facts on Nuclear Waste

$22 billion
Current balance of the Nuclear Waste Fund

$.001 Fee paid to the Nuclear Waste Fund by rate-payers per kilowatt hour of nuclear electricity generated

$750 million
Amount of money collected annually from the nuclear waste fee

$1 billion Deficit between requested fund-ing for the Yucca Mountain project and what Congress actually appropriated over the past eight years

significantly more used fuel. The previous three decades have demonstrated the difficulty in constructing a single permanent repository. How difficult will it be to site additional repositories as our once-through fuel cycle produces used fuel at twice the rate?

THE NUCLEAR WASTE FUND

What does the future hold for the $22 billion theoretically sitting in the Nuclear Waste Fund (NWF) or the $750 million that the country's utilities are paying into the fund every year? This is a topic that we encourage the blue ribbon panel to evaluate.

If the Obama administration rescinds the license application to build the Yucca Mountain repository before a new waste path is established in law, it has been suggested the utilities may bring suit against the federal government to force repayment of the money collected and not already spent on the project. This scenario is also possible even if the president does not necessarily rescind the license application, but effectively "slow rolls" it through a weak defense during the NRC licensing process that will undoubtedly yield volumes of additional questions for DOE.

Irrespective of the corpus of the NWF, and given the president's commitment to seek an alternative to the Yucca Mountain repository, perhaps a more immediate issue for nuclear utilities is whether the nuclear waste fee should still be collected. Under the present circumstances, it would not seem wise or equitable for the federal government to continue to collect these monies. One alternative is for the fees to be collected in a private escrow account, protecting it from congressional appropriation of the funds to other priorities unrelated to the Yucca Mountain project.

In fact, the NWF is largely a budgetary gimmick. Money is collected from the utilities every year, and less than half of that amount is appropriated by Congress to fund the Yucca Mountain project. This leaves a surplus that has ensured the NWF continues to grow, compounded with interest. However, it is a widely known secret that there really is not an account at the Treasury Department with $22 billion waiting to be spent on the project. Much like the country's Social Security program, the surplus collected annually is generally used for other purposes, namely to offset deficit spending. And just like Social Security, there is a day in the not too distant future when the proverbial bill will come due and the federal government will have to find a way to produce the amount it is legally required to spend on these respective obligations.

Given the uncertainty about the nation's waste disposal, it is difficult to envision a scenario where diverging from existing law will not incur additional financial liabilities for the U.S. taxpayer.

CONCLUSION

As the concern about global climate change continues to increase, the importance of nuclear energy is only magnified. Developing and implementing a stable and workable policy to safely and efficiently manage the country's used nuclear fuel and nuclear waste is crucial to avoiding additional tax-payer liability for inaction as well as to ensuring the viability of this integral energy source for generations to come. While such a policy has been elusive, it remains achievable and the administration and Congress owe it to the American people to provide the necessary leadership to achieve this goal.

Nuclear Milestones

1942: Army Corps of Engineers establishes the Manhattan Engineer District, which would become known as the Manhattan Project and lead to the development of the first atomic bomb. This project led to development of the U.S. nuclear weapons program as well as commercial nuclear power and recycling.

1957: First commercial nuclear power plant in the U.S. opened in Shippingport, Pennsylvania to produce electricity for the surrounding region.

1966: Under the guidance of the Atomic Energy Commission, the first private nuclear waste recycling facility opens in West Valley, New York. It processes 1,000 used fuel assemblies before closing in 1976. Two additional facilities are constructed. One is shuttered in 1972 for economic reasons and the other is never permitted to open.

1977: President Carter announces the U.S. would "defer indefinitely" commercial reprocessing and recycling. The Nuclear Regulatory Commission (NRC) ceases all licensing activities for nuclear recycling facilities.

1982: Congress passes the Nuclear Waste Policy Act (NWPA), which designated deep geologic disposal as the preferred technical solution for nuclear waste disposal.

1987: Congress amends NWPA to designate Yucca Mountain, Nevada as the only site for which the Department of Energy (DOE) should conduct a characterization to prepare for storing waste there. It also requires DOE to enter into agreements to take title of used fuel at reactor sites nationwide.

1998: Per NWPA, DOE is set to begin collecting used fuel from reactor sites, but misses the deadline because of delays and faces dozens of lawsuits.

2002: Congress passes Joint Resolution officially designating Yucca Mountain as the site where DOE would build the nation's permanent repository for spent nuclear fuel and defense related waste, overriding the state of Nevada's procedural veto.

2007: First combined construction and operating license application is submitted to the NRC by NRG Energy to build the first nuclear reactor in the United States in 29 years.

2008: DOE submits license application to build Yucca Mountain Repository to the NRC.

2009: President Obama's FY 2010 budget blueprint declares "the Yucca Mountain program will be scaled back to those costs necessary to answer inquiries from the NRC, while the Administration devises a new strategy for nuclear waste disposal." By the first quarter of 2009, 20 utilities have submitted license applications to the NRC seeking authorization to build and operate 26 new reactors. Secretary of Energy Steven Chu announces his intention to form a blue ribbon panel by early April to review and make recommendations on the nation's nuclear waste challenges.

2016: First nuclear power plant expected to open after a more than 30 year span where no nuclear power plant was licensed for construction in the United States.

2020: Earliest date Yucca Mountain repository would open under the DOE timetable if licensing and construction is allowed to proceed without additional delay and with proper funding.

Endnotes

1 DOE, OCRWM, *The Report To The President And The Congress By the Secretary of Energy On The Need For A Second Repository*, p. 2. December, 2008.
2 Wright, Judith; Conca, James. The GeoPolitics of Energy. p. 76-80. Book Surge Publishing. 2007
3 Field Research Corporation. The Field Poll: Reactions to Rising Gas Prices. July 17, 2008.
4 U.S. Office of Management & Budget, *Terminations, Reductions, & Savings. Budget of the U.S. Government – Fiscal Year 2010,* p. 68. May 7, 2009.
5 *OMB, A New Era of Responsibility; Renewing America's Promise. p. 21. February 26, 2009.*
6 Climate Change Technology Program. *Strategic Plan.* (Numbers converted from carbon equivalents to carbon dioxide.) 2006. (www.climatetechnology.gov)
7 Speech by AEC Chairman Lewis Strauss to the National Association of Science Writers, New York City, September 16th, 1954
8 Andrews, Anthony. *Nuclear Fuel Reprocessing: U.S. Policy Development*, Congressional Research Service. March 27, 2008
9 Cowan, Stephen P., U.S. Department of Energy. *Overview of Current Plans and Activities Involving Vitrification*, Glass as a Waste Form and Vitrification Technology, A Summary of an Internal Workshop. Appendix E-8. National Research Council. National Academies Press, 1996.
10 Byalko, Alexei. Nuclear Waste Disposal. Pp. 52-61. CRC Press, 1994.
11 de la Bruheze, Adri A. Getting New Technologies Together. p. 253. Walter de Gruyter, 1998.
12 U.S. House of Representatives, Committee on Science and Technology, Subcommittee on Investigations and Oversight, *West Valley Cooperative Agreement Hearing Report*, p. 233, July 9, 1981.
13 Hylko, James M. *How to Solve the Used Nuclear Fuel Storage Problem*, Power. p. 2. August 15, 2008 (On-line version accessed at: http://www.powermag.com/issues/features/How-to-solve-the-used-nuclear-fuel-storage-problem_1388.html).
14 *Id.*
15 *Id.*, pp. 2-3.
16 Squassoni, Sharon. *U.S. Nuclear Cooperation with India: Issues for Congress*. p. 1. Congressional Research Service. July 29, 2005.
17 Speier, Richard. *Plutonium Decision-Making in the U.S. Government* (Paper commissioned by the Pacific Asia Regional Energy Security Project). pp. 3-6. February, 1998.
18 EIA. *Table 8.2a Electricity Net Generation: Total (All Sectors), 1949-2007.* Annual Energy Review 2007.
19 EIA. *Table 8.10 Average Retail Prices of Electricity, 1960-2007.* Annual Energy Review 2007.
20 EIA. *Table 8.4a Consumption for Electricity Generation , 1949-2007.* Annual Energy Review 2007.
21 Federal Reserve Statistical Release; Selected Interest Rates. Historical Data (accessed at http://www.federalreserve.gov/releases/h15/data.htm).
22 World Nuclear Industry Status Report 2007, p. 19
23 EIA, An Analysis of Nuclear Power Plant Construction Costs, DOE/EIA-0485. March 1986.
24 Congressional Quarterly Almanac. *Comprehensive nuclear waste plan enacted*. pp. 304-310. 1982.
25 42 U.S.C. 10142.
26 P.L. 97-425, §112(c) (Amended by P.L. 100-203)
27 P.L. 100-203.
28 DOE, OCRWM. *History Of The Nuclear Waste Program* (www.ocrwm.doe.gov/ym_repository/about_project/history.shtml).
29 Board of Radioactive Waste Management. Disposition of High-Level Waste and Spent Nuclear Fuel: The Continuing Societal and Technical Challenges. P. 27. (National Academies Press, 2001)
30 Id. DOE, OCRWM, *The Report To The President*. p. 4.
31 P.L. 107-200.
32 Eureka County, Nevada – Nuclear Waste Office. *The Major Yucca Mountain Lawsuits*. (www.yuccamountain.org/court/case.htm)
33 Nuclear Energy Institute. *Status of Used Nuclear Fuel Storage at U.S. Commercial Nuclear Plants*. February, 2009. (http://www.nei.org/resourcesandstats/nuclear_statistics/nuclearwasteamountsandonsitestorage/)
34 Compiled list available upon request.
35 Sproat, Edward, Director OCRWM. *Testimony to the House Committee on Energy & Commerce*. July 15, 2008.
36 Silberg, Jay E. and Tierney, Christopher F. *Nuclear Waste is Piling Up*. The National Law Journal, January 26, 2009.
37 Hertz, Michael F., Dep. Asst. Attorney General – Civil Division. *Testimony to House Budget Committee*. October 4, 2007.
38 Bingaman, Chairman Jeff, and Murkowski, Senator Lisa. *Senate Energy & Natural Resources Committee's "Views & Estimates" letter on the FY 2010 Budget Blueprint to Senate Budget Committee Chairman Conrad*. March 12, 2009.
39 Id. Hertz.
40 DOE, OCRWM, *Monthly Summary of Program Financial & Budget Information*. p. 4. February 1, 2009.
41 *U.S. Department of Energy, Transition 2008 – HOT Issues Papers, Book 2.*
42 P.L. 111-8.
43 DOE. *FY 2009 Congressional Budget Request – Budget Highlights*. February, 2008.
44 NRC Press Release, *NRC Receives DOE's License Application To Construct High-Level Nuclear Waste Repository at Yucca Mountain*. June 3, 2008. (www.nrc.gov/reading-rm/doc-collections/news/2008/08-106.html)
45 42 U.S.C. §10134(d)
46 Id. Sproat, p. 8.
47 DOE, OCRWM, *The Report To The President And The Congress By the Secretary of Energy On The Need For A Second Repository*, p. 5. December, 2008.
48 Id. p. 2.
49 Barron, Brew, Chief Nuclear Office, Duke Energy. *Discussion*

of Nuclear Waste Management. NARUC 2007 Summer Meetings, July 17, 2007. (http://www.narucmeetings.org/Presentations/DiscussionOfNuclearWasteMgmt_DukeEnergy.pdf).
50 DOE., Office of Nuclear Energy. *Nuclear Deployment Scorecard*. April 9, 2009.
51 Brown, Angela K. *Nuclear Resurgence, NRC Receives applications for 15 new reactors.* Desert News (Associated Press). June 14, 2008.
52 Chu, Steven, Secretary, U.S. Department of Energy. *Testimony to the U.S. Senate Committee on the Budget*. March 11, 2009.
53 N.R.C., *"Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada,"* 73 Federal Register 61256, October 15, 2008.
54 Federal News Service. Senate Committee on the Budget, The President's FY 2010 Budget Proposal for the Depart of Energy. *Unofficial Transcript*. March 11, 2009.
55 Tetreault, Steve. *Chu promises to develop Yucca alternative quickly*. Las Vegas Review-Journal. March 12, 2009.
56 S. 591, "National Commission on High-Level Radioactive Waste and Spent Nuclear Fuel Establishment Act of 2009." Introduced by Senator Harry Reid, March 12, 2009.
57 42 U.S.C. 102224
58 Id. Nuclear Energy Institute
59 NRC, *Dry Cask Storage* (http://www.nrc.gov/waste/spent-fuel-storage/dry-cask-storage.html)
60 Biello, David. *Nuclear waste is either a millennia's worth of lethal garbage or the fuel of future nuclear reactors—or both*. Scientific American, January 28, 2009.
61 Reyes, Luis, Executive Director, NRC. *Statement Submitted to the Committee on Energy and Commerce, U.S. House of Representatives*. p. 2. September 13, 2006.
62 Conference Report Accompanying H.R. 2419, the Energy & Water Development Appropriations Bill, 2006. p. 126.
63 Platts National Wire. *Search Finds Two Potential Sites for Spent Nuclear Fuel Storage*. July 30, 2008.
64 DOE, OCRWM. *Report to Congress on the Demonstration of the Interim Storage of Spent Nuclear Fuel from Decommissioned Nuclear Power Reactor Sites*. p. 7. December 2008.
65 Wald, Matthew L., *Energy Agency Plans Offer to Take Utilities' Nuclear Wastes.* New York Times, February 25, 1999.
66 Wheelwright, Jeff. *Welcome to Yucca Mountain*. Discover September 1, 2002.
67 Id. DOE, OCRWM. *History*
68 Bodman, Samuel W., Secretary of Energy. *Letter to Speaker of the House of Representatives, Nancy Pelosi*. March 6, 2007. (http://www.energy.gov/media/BodmanLetterToPelosi.pdf)
69 42 USC §10142
70 Salt Cavern Information Center. *Major U.S. Salt Deposits*. (http://web.ead.anl.gov/saltcaverns/usdeposit/index.htm)
71 Waste Isolation Pilot Plant. *Why Salt Was Selected As a Disposal Medium*. (www.wipp.energy.gov/fctshts/salt.pdf).
72 DOE, Office of Fossil Energy. *Strategic Petroleum Reserve – Quick Facts.* (http://www.fe.doe.gov/programs/reserves/spr/spr-facts.html)
73 *James Conca: On WIPP and other things nuclear*. February, 2008. Nuclear News (American Nuclear Society)
74 DOE Press Release. *DOE Waste Isolation Pilot Plant Receives EPA Recertification*. March 29, 206.
75 Id. *Waste Isolation*.
76 Stacey, Weston M. Nuclear Reactor Physics. July, 2007. (Wiley-VCH)
77 Oak Ridge National Laboratory. *Nuclear Fuel – Developing New Processes*. Review, 2003
78 Areva NC. *The La Hague plant – Our Mission: reprocessing nuclear fuel ready for recycling*. p. 10.
79 Id. p. 17/
80 Albright, David and Kramer, Kimberly. *Plutonium Watch – Tracking Plutonium Inventories.* Institute for Science and International Security. 2005
81 Buris, Octavia; Gracey, Kyle, Huff, Katy; Ng, Wai Keong. *An Analysis of the Consolidated Fuel Treatment Center Nuclear Reprocessing Initiative*. pp. 10-13. June 4, 2008. University of Chicago.
82 DOE, Office of Nuclear Energy. *Report to Congress on Advanced Fuel Cycle Initiative: The Future Path for Advanced Spent Fuel Treatment and Transmutation Research*. P. I-6. January, 2003.
83 DOE Press Release. *Department of Energy Announces New Nuclear Initiative*. February 6, 2006.
84 Id.
85 World Nuclear Association Information Paper. Fast Neutron Reactors. April 2009. (http://www.world-nuclear.org/info/inf98.html).
86 Id. Senate Committee on the Budget.
87 Nuclear Engineering International, *US GNEP programme dead, DOE confirms*. April 15, 2009. (http://www.neimagazine.com/story.asp?sectionCode=132&storyCode=2052719)
88 Electric Power Research Institute-Idaho National Lab. *The Nuclear Energy Development Agenda: A Consensus Strategy for U.S. Government and Industry*. January 2006.
89 Hook, Michael. Partitioning and Transmutation. p. 3. May 22, 2008. (http://www.tsl.uu.se/uhdsg/Popular/PartTrans.pdf).
90 Boston Consulting Group. *Economic Assessment of Used Nuclear Fuel Management in the United States*. p. 26. July 2006.

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