Backgrounder

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A Free-Market Approach to Managing Used Nuclear Fuel

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The Nuclear Waste Policy Act of 1982[1] attempted to establish a comprehensive disposal strategy for high-level nuclear waste. This strategy has failed. The government has spent billions of dollars without opening a repository, has yet to receive any waste, and is amassing billions of dollars of liability. Furthermore, the strategy has removed any incentive to find more workable alternatives. For those that actually produce waste and would benefit most from its efficient disposal, this strategy has created a disincentive for developing sustainable, market-based waste-management strategies.

The strategy codified in the Nuclear Waste Policy Act seemed straightforward and economically sound when it was developed in the early 1980s. It charged the federal government with disposing of used nuclear fuel and created a structure through which users of nuclear energy would pay a set fee for the service—a fee that has never been adjusted, even for inflation. These payments would go to the Nuclear Waste Fund, which the federal government could access through congressional appropriations to pay for disposal activities.

The federal government has accumulated approximately $27 billion (fees plus interest) in the Nuclear Waste Fund and has spent about $8 billion to prepare the repository for operations, leaving a balance of around $19 billion. Utility payments into the fund total about $750 million annually. Yet the repository has never opened, despite the expenditure of billions of dollars.

The taxpayers have fared no better. The Nuclear Waste Policy Act set January 31, 1998, as the deadline

Talking Points

- Transforming how the United States deals with used nuclear fuel is critical to the long-term success of nuclear power.
- The private sector should be empowered to make decisions on used-fuel management that are based on economic rationality.
- The costs to manage spent nuclear fuel should be folded into the costs of electricity.
- The private sector should decide the best combination of permanent geologic storage, interim storage, used-fuel recycling, and other processes for managing used nuclear fuel.
- The federal government's role in a new strategy to manage used fuel should be to provide adequate oversight to protect public health and safety, to ensure that national security requirements are met, and to take title of any permanent storage facilities after decommissioning.
- Such a system would put the United States well on its way to re-establishing itself as a global leader in nuclear energy.

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for the federal government to begin receiving used fuel. The government's refusal to take possession of the used fuel has made both the federal government and the taxpayers liable to the nuclear power plant operators for an increasingly enormous amount that is projected to reach $7 billion by 2017.[2]

The federal government's inability to fulfill its legal obligations under the 1982 act has often been cited as a significant obstacle to building additional nuclear power plants. Given nuclear power's potential to help solve many of the nation's energy problems, now is the time to break the impasse over managing the nation's used nuclear fuel.

The Current Irrational System

The United States has 58,000 tons of high-level nuclear waste stored at more than 100 sites in 39 states,[3] and its 104 commercial nuclear reactors produce approximately 2,000 tons of used fuel every year. The Yucca Mountain repository's capacity is statutorily limited to 70,000 tons of waste (not to mention the problems associated with even opening the repository). Of this, 63,000 tons will be allocated to commercial waste, and 7,000 tons will be allocated to the Department of Energy (DOE).

These are arbitrary limitations that Congress set without regard to Yucca's actual capacity. As currently defined by the Nuclear Waste Policy Act, Yucca would reach capacity in about three years unless the law is changed. Thus, even if Yucca becomes operational, it will not be a permanent solution, and the nation would soon be back at the drawing board.

The repository's actual capacity, however, is much larger than the current limit. Congress should repeal the 70,000-ton limitation immediately and instead let technology, science, and physical capacity determine the limit. Recent studies have found that the Yucca repository could safely hold 120,000 tons of waste. According to the DOE, that should be enough to hold all of the used fuel produced by currently operating reactors.[4] Some believe the capacity is even greater.

Yet even with an expanded capacity of 120,000 tons, Yucca Mountain could hold only a few more years of America's nuclear waste if the U.S. significantly increases its nuclear power production. According to one analysis, America's current operating reactors would generate enough used fuel to fill a 70,000-ton Yucca right away and a 120,000-ton Yucca over their lifetime. If nuclear power production increased by 1.8 percent annually after 2010, a 120,000-ton Yucca would be full by 2030. At that growth rate, without recycling any used fuel, the U.S. would need nine Yucca Mountains by the turn of the century.[5]

Given the difficulty of opening one repository, relying on future repositories would be extremely risky. With the right mix of technologies such as storage and recycling, Yucca could last almost indefinitely.

Using Resources More Wisely by Recycling

The current U.S. policy is to dispose of all used fuel by moving it directly from the reactors into Yucca Mountain for permanent storage without any additional processing. This is a monumental waste of resources. To generate power, reactor fuel must contain 3 percent to 5 percent enriched fissionable uranium (uranium-235). Once the enriched ura-

1. Public Law 97–425.
2. Committee on Environment and Public Works, U.S. Senate, "Ten Years Overdue: January 31, 2008 Marks the 10th Anniversary of DOE's Deadline to Dispose of Nuclear Waste," *Fact of the Day,* January 31, 2008, at *http://epw.senate.gov/public/index.cfm?FuseAction=PressRoom.Facts&ContentRecord_id=d1891f7e-802a-23ad-459d-26b0cbf6b04f* (February 28, 2008).
3. Samuel W. Bodman, letter to Nancy Pelosi, Speaker of the U.S. House of Representatives, March 6, 2007, at *http://www.energy.gov/media/BodmanLetterToPelosi.pdf* (March 3, 2008).
4. *Ibid.*
5. Phillip J. Finck, Deputy Associate Laboratory Director, Applied Science and Technology and National Security, Argonne National Laboratory, statement before the Subcommittee on Energy, Committee on Science, U.S. House of Representatives, June 16, 2005.

nium falls below that level, the fuel must be replaced. Yet this "used" fuel generally retains about 95 percent of its fissionable uranium, and that uranium, along with other byproducts in the used fuel, can be recovered and recycled. Regrettably, the current system's structure provides no incentive for the private sector to pursue this option.

Many technologies exist to recover and recycle different parts of the used fuel. The French have been the most successful in commercializing such a process. They remove the uranium and plutonium and fabricate new fuel. Using this method, America's 58,000 tons of used fuel contain roughly enough energy to power every household in America for 12 years.[6]

Other technologies show even more promise. Indeed, most of them, including the process used in France, were developed originally in the United States. Some recycling technologies would leave almost no waste at all and would lead to the recovery of an almost endless source of fuel, but none of these processes has been commercialized successfully in the United States, and this will take time. Until the future of nuclear power in the U.S. becomes clearer, it will be impossible to know which technologies will be most appropriate to pursue in this market.

Ultimately, the private sector should make these decisions. Valuing used fuel against the costs of permanent burial is a calculation best done by companies that provide fuel-management services.

Overhauling Used-Fuel Management in the U.S.

The success of a sustained rebirth of nuclear energy in the U.S. depends largely on disposing of nuclear waste safely. New nuclear plants could last as long as 80 years, but to reap the benefits of such an investment, a plant must be able to operate during that time. Having a practical pathway for waste disposal is one way to ensure long-term plant operations. Establishing such a pathway would also mitigate much of the risk associated with nuclear power, but as long as the federal government is responsible for disposing of waste, it is the only entity with any incentive to introduce these technologies and practices.

The problem is that the federal government has never been able to fulfill its current waste disposal obligations, much less introduce new and innovative methods of waste management. Although the Department of Energy under its current leadership has opened the door to reform, that leadership will soon be replaced when the new President appoints his own team. Administrations come and go, but inflexible rules and bureaucracies that oversee waste management seem to endure forever, making it impossible for the government to respond effectively to a rapidly changing industry. When it does attempt to respond, it often acts in ways that make no business sense and are inconsistent with the actual state of the industry.

Many of these efforts culminate in large government programs. While some of these programs have some near-term benefit insofar as they demonstrate political support for nuclear power, encourage private and public research and development, and develop the nuclear industry, they inevitably do more harm than good. They are run inefficiently, are often never completed, cost the taxpayers billions of dollars, and are often not economically rational. Furthermore, they often forgo long-term planning, and this leads to unsustainable programs that ultimately set industry back by providing fodder for anti-nuclear critics and discouraging progress in the private sector.

A New Approach

Introducing market forces into the process and empowering the private sector to manage nuclear waste can solve the problem, but this will require major reform. The federal government will need to step aside and allow the private sector to assume the responsibility for managing used fuel, and the private sector should welcome that responsibility.

The primary goal of any strategy for used-fuel management should be to provide a disposition pathway for all of America's nuclear waste. The basic problem with the current system is that every nuclear power plant needs a place to put its

6. This figure is an extrapolation based on the French experience with recycling.

waste, and Yucca Mountain is simply not big enough to hold it all under the current used-fuel management regime.

In other words, permanent geologic storage capacity is a finite resource on which the industry depends. If used-fuel management were a market-based system, this storage capacity would carry a very high value. A new system should price geologic storage as a finite resource and fold any costs into a fee for emplacing nuclear waste in Yucca Mountain.

Repealing the Mil. The key to this new approach will be to transform how waste management is financed. Once market-based pricing is in place, the fee that nuclear energy consumers pay to the federal government for waste management should be repealed. Under the current system, consumers pay for waste disposition through a flat fee, called the mil, that is paid to the federal government at the rate of 0.1 cents per kilowatt-hour of nuclear-generated electricity. This fee as currently assessed has no market rationale. It is simply a flat fee that rate payers pay to the federal government. It has never been changed, not even for inflation.

In a market-based system, instead of paying a pre-set fee to the federal government to manage used fuel, nuclear power operators would fold waste-management costs into the operating cost, which would be reflected in the price of power. This cost might be higher or lower than the current fee; more important, it would reflect the true costs of nuclear power.

Pricing Geologic Storage as a Scarce Resource. The idea would be to price the space available in Yucca Mountain according to a set of relevant variables, including heat content of the waste, predicted production of used fuel, repository capacity, and lifetime operation costs. Each of these variables would help to determine the price of placing a given volume of waste in Yucca at any specific time.

As the repository is filled, the fee to emplace additional fuel would obviously increase. The fee could also increase, depending on the formula, as new plants are constructed or old plants' licenses are renewed because they would produce additional used fuel, thereby increasing the demand for repository space. Prices would be lower for waste that radiates less heat. Prices would fall if Yucca's capacity is expanded or if waste is reduced through alternative processes.

This would create a market for repository space. The fee could be structured in a number of ways. One example would be to charge a floating fee according to a predetermined formula. Under this scenario, the fee would shift constantly as the price variables change. For example, a volume of waste with less heat content would cost less to emplace than a similar amount with a higher heat profile. An alternative to a floating fee might be one that resets at timed intervals, such as once a year.

The exact structure and implementation of the fee could be determined at some future point. One simple option would be to divide the capacity available in Yucca by the lifetime costs to give a price to emplace an amount (e.g., a ton) of waste in the repository. As the repository was filled, the price per ton would increase.

Nuclear power operators could then decide, given the price to place waste in Yucca, how to manage their used fuel. As the price to access Yucca goes up, so will the incentive for nuclear operators to do something else with their used fuel. This should give rise to a market-based industry that manages used fuel in the U.S.

The market would dictate the options available. Some operators may choose to keep their used fuel on site to allow its heat load to dissipate, thus reducing the cost of placing that waste into Yucca. Companies may emerge to provide interim storage services that would achieve a similar purpose. The operators could choose options based on their particular circumstances.

As prices change and business models emerge, firms that recycle used fuel would likely be established. Multiple factors would feed into the economics of recycling nuclear fuel. Operators would make decisions based not only on the cost of placing waste in Yucca, but also on the price of fuel.

If a global nuclear renaissance does unfold, the prices for uranium and fuel services will likely rise. This would place greater value on the fuel resources that could be recovered from used fuel, thus affecting

recycling. Instead of the federal government deciding what to build, when to build it, and which technology should emerge, the private sector would make those determinations.

Some nuclear operators may determine that one type of recycling works for them, while others may decide that a different method is more appropriate. This would create competition and encourage the development of the most appropriate technologies for the American market.

Such a market for repository space could give rise to a broader market for geologic storage. As waste production causes Yucca storage costs to rise, companies could emerge that provide additional geologic storage at a lower price. This additional space would in turn reduce the value of the space available in Yucca.

Alternatively, as Yucca fills, nuclear operators may decide to develop additional geologic storage facilities in a joint venture. While this may seem unlikely, given the problems associated with opening Yucca Mountain, other communities may be more receptive to hosting a repository once a reliable safety record is established and the economic benefits of hosting a repository are demonstrated. The federal government would still take title to any waste placed in future repositories once they are decommissioned.

Predicting how a market might evolve is impossible, but unlike the government-run process that led to the Yucca Mountain site—a process mired in politics—private entities would establish the path forward by working with government regulators. Private entities would also be able to pursue their plans without having to contend with as much of the bureaucratic inertia that accompanies government-run operations.

Most important, this system would encourage the introduction of new technologies and services into the market as they are needed, as opposed to relying on the federal government. New technologies would not be hamstrung by red tape or overregulation. This system would also allow for the possibility of no expansion of nuclear power. If the U.S. does not expand nuclear power broadly, there is probably no reason to build recycling or interim storage facilities.

Establishing a Private Organization to Manage Yucca Mountain. As permanent geologic storage is commoditized, the problem then becomes one of establishing responsibility for managing that scarce resource. Leaving that responsibility with the government provides no benefits. No overarching need mandates that the government must manage Yucca Mountain or used nuclear fuel. Furthermore, leaving this responsibility in the hands of government comes with all kinds of pitfalls, including inflexibility, inefficiency, politics, and being subject to annual appropriations, to name a few. Similarly, a public–private partnership is not necessary and has no inherent advantages.

Instead, a completely new organization—a private entity (PE)—should be established to manage Yucca Mountain. The PE's purpose would be to ensure that Yucca is available to support the commercial nuclear industry's need for permanent geologic storage indefinitely and to set the fee for placing waste in Yucca. This fee would be the primary mechanism for managing access to the repository. Its one operating mandate should be to remain open to receive waste either until a second repository is opened or until the last commercial nuclear power plant ceases operations.

The federal government should not be part of the management team. The PE could be organized in any number of ways. It could take the form of a nonprofit organization that is independent of but represents the nation's nuclear energy producers. Such a structure would ensure that no operator receives preferential treatment and that the PE operates as a service to all nuclear operators. It also would prevent a profit-seeking entity from holding a monopoly over a key asset on which an entire industry depends. The federal government would provide oversight through the Nuclear Regulatory Commission (NRC) and other appropriate agencies.

The PE should be created as soon as possible and immediately commence a three-year transition plan, which would coincide with the NRC's review of the Department of Energy's application for a Yucca Mountain construction permit. During the transition period, the PE would work with the Department of Energy's Office of Civilian Radioactive Waste Management to move the application for

the Yucca construction permit through the NRC. After three years, when the license is granted, the PE would take control of Yucca operations, which would include overseeing Yucca construction and preparing for long-term operations.

Establishing a Waste Disposal Fund. The NRC requires that each nuclear plant operator establish a funding mechanism to ensure that resources will be available to decommission the plant once operations cease. This is achieved either through guarantees from its parent company or by establishing a decommissioning fund.[7] This protects the taxpayer from the financial obligations of plant decommissioning if the operator becomes financially unable to carry out that responsibility.

A similar funding mechanism should be required for new plant licenses and life extensions to cover the costs of waste disposal once the mil is repealed. This could be included in the decommissioning fund or set up as a separate entity. It would not be a payment to the federal government and would always be controlled by the nuclear operator. The monies set aside should be adequate to finance the geologic disposal of any used fuel held on-site in dry storage. This guarantees that waste disposal funds will be available, even if the operator becomes insolvent.

Other Issues. Changing from the current system of waste management to a market-based system raises a number of issues:

- How will repository construction be funded if it is dependent on disposal fees?
- What will happen to the Nuclear Waste Fund?
- Who is responsible for the disposal of existing nuclear waste, which has already been paid for?
- What happens to defense waste?

The Nuclear Waste Fund and Construction of the Yucca Mountain Repository. The Nuclear Waste Fund was set up by the 1982 Nuclear Waste Policy Act to pay for the costs of waste disposal. The fund has approximately $19 billion, and about $7 billion has been spent so far on repository activities. Congress should abolish the fund and make the money available to the PE for licensing and constructing of the Yucca Mountain repository.

According to a 2001 analysis by the Department of Energy, licensing and pre-emplacement construction will cost an estimated $5.74 billion, and decommissioning will cost $4.04 billion.[8] The Nuclear Waste Fund can cover both of those expenses, according to the 2001 analysis, and still have significant funds at its disposal. The balance should be applied to post-construction operating costs. It must be noted, however, that the Department of Energy is currently reevaluating those costs, and a new price structure could emerge. On the other hand, a private entity could price Yucca's costs differently even from DOE's new assessment.

Once used-fuel management is subject to the open market, it is always possible that no one will use Yucca Mountain, thus depriving it of the funds it needs to maintain operations. Given this possibility, the PE should be authorized to assess nuclear operators a fee to maintain minimum operations at Yucca if revenue streams are not adequate. This fee should be triggered only under predetermined circumstances.

Disposal of Existing Used Fuel. While a new regime to deal with new used fuel may make sense, it will not fix the existing problem created by the federal government's failure to dispose of existing waste despite being paid to do so. As a result of its failure, the government and the taxpayers have incurred an expensive ongoing liability for 58,000 tons of used fuel stored around the country.

The courts have confirmed this liability. As a result, the taxpayers have already paid $94 million in lawyer expenses and $290 million in damages. The government is appealing another $420 million award. The government's long-term liability for used fuel is projected to reach $7 billion by 2017 and $11 billion by 2020.[9] While no solution will satisfy all parties entirely, a resolution that allows a

7. U.S. Nuclear Regulatory Commission, "Decommissioning Nuclear Power Plants," January 22, 2008, at *http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/decommissioning.pdf* (May 23, 2008).
8. The Department of Energy is due to release a new assessment of Yucca's lifetime costs, which could alter the estimates provided by the 2001 breakdown.

sustainable used-fuel strategy to emerge would be in the broad national interest.

One remedy would be to set aside an amount of space in Yucca Mountain for each reactor operator equal to the amount of used fuel that it produced before discontinuation of the waste fee. Operators could use this space without further fees as they see fit, including selling it to other operators.

Given that America's reactors have already produced around 58,000 tons of waste, if the mil were repealed today, the PE would set the fee based on the total available space minus 58,000 tons. The capacity should be set based on scientific and technical parameters of what could safely be stored in Yucca.

Defense Waste. One of reasons that Yucca must be opened is that the United States has significant amounts of defense-related nuclear waste that is slated for disposal. Current plans set aside 7,000 tons of Yucca's capacity for defense purposes.

The federal government would be a customer for waste-management services just as every other operator is and would pay a fee for placing its waste in Yucca. Alternatively, the government could buy waste-management services on the open market to process its waste, thereby minimizing what is placed in Yucca.

Defining the Federal Role in Waste Disposal. Although its involvement in used-fuel management should be minimized, the federal government will continue to have a number of critical roles. During operations, the federal government would have significant oversight responsibilities. As is currently the case, the Nuclear Regulatory Commission would oversee operations, and other federal agencies, such as the Environmental Protection Agency, would continue to play a regulatory role. The national laboratory system would also play a critical role in facilitating research and development.

The federal government would fulfill its final obligation by taking possession of the closed and decommissioned Yucca Mountain whenever that may occur, along with any geologic repositories that may be built in the future. This is a critical role for the federal government because it is the only institution that can maintain assured liability for the waste in perpetuity.

Steps to Overhaul Nuclear Waste Management

To begin the process of overhauling the nation's nuclear-waste management regime, Congress should amend the Nuclear Waste Policy Act of 1982 to encourage development of a market-based management system for used nuclear fuel. Specifically, Congress should:

- **Create** the legal framework that allows the private sector to price geologic storage as a commodity;
- **Empower** the private sector to manage used fuel;
- **Repeal** the 70,000-ton limitation on the Yucca Mountain repository and instead let technology, science, and physical capacity determine the appropriate limit;
- **Create** a private entity that is representative of but independent from nuclear operators to manage Yucca Mountain;
- **Repeal** the mil, abolish the Nuclear Waste Fund, and transfer the remaining funds to a private entity to cover the expenses of constructing Yucca Mountain; and
- **Limit** the federal government's role to providing oversight, basic research, and development and taking title of spent fuel upon repository decommissioning.

Conclusion

The current approach to managing used nuclear fuel is systemically broken. It was developed to support a nuclear industry that was largely believed to be in decline; that is no longer the case. The federal government promised to take title of the used fuel and dispose of it; this removed any incentive for the private sector to develop better ways to manage the fuel that could be more consistent with an emerging nuclear industry. And the federal government has proven incapable of fulfilling its obligations to dispose of the fuel.

9. Committee on Environment and Public Works, "Ten Years Overdue."

The current system is driven by government programs and politics. There is little connection between used-fuel management programs and the needs of the nuclear industry. Any successful plan must grow out of the private sector. The time has come for the federal government to step aside and allow utilities, nuclear technology companies, and consumers to manage used nuclear fuel.

Overhauling the nation's nuclear-waste management regime will not be easy. It will require a significant amendment of the Nuclear Waste Policy Act and a long-term commitment by Congress, the Administration, and industry. But developing such a system would put the United States well on its way to re-establishing itself as a global leader in nuclear energy.

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