

Nuclear Waste Policy Act: Where We've Been and Where We're Headed

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Agenda Setting: The Rise and Fall (and Rise Again?) of the Nuclear Dream

The United States' foray into peaceful atomic power began under the Eisenhower administration. Eisenhower sought to show the global community that the United States' use of nuclear power was not solely relegated to the military sphere (Rosenbaum 2008). Coupled with this concern of global reputation was the real threat of global nuclear proliferation. Nuclear waste was first created in the effort to create and stockpile nuclear weapons during World War II and the Cold War (Macfarlane 2003). This waste was produced as a by-product of reprocessing. Reprocessing is the process of separating plutonium from spent nuclear fuel. This radioactive waste was placed in large tanks filled with water and its presence serves as a reminder of the problems facing the United States in its quest for nuclear waste solutions.

In 1954, the federal government passed the Atomic Energy Act. This piece of legislation facilitated the commercial development of nuclear power. It became easier for private energy companies to build and operate nuclear facilities while giving little thought to the back end (i.e., waste producing) of the fuel cycle. In 1957, the government further subsidized the budding nuclear energy program by passing the Price-Anderson Act. This act limited a nuclear utility's insurance liability to \$540 million for any single reactor accident (Rosenbaum 2008). This cap on liability ensured that the industry would be able to obtain necessary insurance coverage. The passage of this act removed a problematic roadblock many commercial nuclear facilities were facing.

Governmental support of commercial nuclear interests via subsidies and favorable legislation paved the way for the first commercial nuclear reactor in Shippingport, Pennsylvania, which began generating electricity in 1957. By the mid-1970s, the Nuclear Dream seemed unstoppable. In 1975, the United States was home to 56 functioning commercial nuclear reactors, 69 additional reactors were under construction, and 111 more were planned in the

coming years (Rosenbaum, 2008). This favorable trend would not last. In 1979, the United States witnessed its first and most significant nuclear accident. In what was arguably the most damaging episode in the program's history, the accident at Three Mile Island turned national focus to safety risks (both human and environmental) and raised awareness of the general lack of knowledge about this nascent technology. This event, followed by the Chernobyl disaster in 1986, effectively killed the Nuclear Dream in the United States. By the end of the 1980s commercial nuclear power found itself economically and technologically burdened and politically disastrous.

By 1982, the federal government began acknowledging that radioactive waste creates potential risks and thus required safe disposal (with respect to both humans and the environment). Further, Congress acknowledged that the country was now facing a problem with accumulated nuclear waste from (1) spent nuclear fuel from nuclear reactors and (2) radioactive waste resulting from medical research, diagnosis and treatment and "other sources" (Nuclear Waste Policy Act 1982). Although the nuclear industry fell out of favor with the American public in the 1980s, commercial nuclear energy production has come back into favor with many scientists and *some* environmentalists as the world is faced with the prospect of global warming.

The nuclear industry is advertising itself as the only viable option to the use of fossil fuels when it comes to electricity generation. In 2007, 20% of America's electricity was powered by nuclear energy (United States Chamber of Commerce 2009). Currently, there are 103 operating commercial nuclear reactors licensed to electrical utilities within the United States (Rosenbaum 2008). These nuclear reactors generate 2,000 metric tons of spent nuclear fuel annually. Ninety nuclear reactors are projected to have exhausted their storage capabilities for spent nuclear fuel by 2010 (United States Chamber of Commerce 2009).

The United States is at a crossroads. Under current decommissioning schedules, half of

the present reactors will be decommissioned by 2015 and the remainder will be decommissioned by 2075 (Rosenbaum 2008). Either the United States will end its foray into nuclear energy or she will move forward with nuclear possibilities. Either way, the industry's continuing environmental impact and unresolved technological issues will need to be addressed.

Policy Formulation: Solutions for High-Level Nuclear Waste

The most politically and technologically difficult problem facing a resurgence of nuclear energy production is the treatment of nuclear waste. The federal government has been struggling to find an efficient and equitable solution to this problem with heated debates forming in all corners of the discussion. Early scientists did not envision the storage and disposal problems facing the United States today or the political conflict that would result from these disposal problems. Originally, scientists operated under the assumption that nuclear waste would be reprocessed and reused in turn only requiring a small amount of nuclear waste to be stored at any given time (Rosenbaum 2008). This, of course, is not how things transpired.

Before investigating the chain of events that has led the United States to her current nuclear waste policy, a discussion of types of nuclear waste and radiation is warranted. "Nuclear waste results from uranium mining, civilian nuclear power plants, military nuclear weapons programs, hospitals, educational institutions, and research centers" (Rosenbaum 2008, 266). There are three classifications of nuclear waste: (1) high-level waste, (2) intermediate-level waste, and (3) low-level waste. Within each of these groupings there are different types of waste being eliminated from several sources.

High-level nuclear waste is the most dangerous waste. This waste is typically comprised of spent nuclear fuel and transuranic elements. High-level nuclear waste generates large amounts of heat and requires special handling during transportation as well as storage in a cooled facility (Angino 1977; Nuclear Waste Management 2007). Intermediate-level waste, while not

as dangerous as high-level waste, still requires special handling. Intermediate-level waste can be in the form of chemical sludge, reactor components, as well as contaminated materials from the decommissioning of a nuclear reactor (Nuclear Waste Management 2007). Low-level waste is not dangerous to handle in the same respects as high- and intermediate-level wastes but still requires careful disposal. It is comprised of items used in laboratories as well as industry and contains only small amounts of radioactivity. A fourth type of nuclear waste (sometimes included under the low-level risk category) is uranium mill tailings. Uranium mill tailings comprise the largest volume of nuclear waste produced in the fuel cycle (Lester 1982). This waste is the result of mining and milling uranium. The tailings contain small amounts of unrecovered uranium and can be dangerous for centuries.

Just as there are different types of nuclear waste, there are also different types of radiation. Alpha decay is the least dangerous type of radiation. Alpha decay can be shielded with a piece of paper or one's hand and is effectively harmless unless exposed to lung tissue (Nuclear Waste Management 2007). Beta decay, unlike alpha decay, can penetrate the human body. But, like alpha decay, beta decay can be easily shielded—in this case with a sheet of aluminum foil (Nuclear Waste Management 2007). Gamma radiation is much more dangerous than alpha and beta decay. Gamma radiation penetrates the human body causing damage throughout the system (e.g., radiation poisoning and increased incidence of cancer). Unlike the aforementioned types of radiation, gamma radiation can only be shielded with lead, concrete, or about three feet of water (Nuclear Waste Management 2007). Finally, and most dangerous, is neutron radiation. Neutron radiation passes through most materials can only be shielded effectively by concrete, paraffin wax, polyethylene, or water. Although neutron radiation is the most dangerous, it is also the most rare form of radiation as it does not occur naturally and is only found within nuclear reactors. Much of the government debate over nuclear waste revolves

around high-level, gamma-irradiated waste.

When nuclear technology was in its infancy, scientists and the federal government envisioned reprocessing and reusing spent nuclear fuel. The Atomic Energy Commission (predecessor to the Nuclear Regulatory Commission) declared early on that a reprocessing component of the atomic fuel cycle was to be a private enterprise. Two private recycling facilities were built: one in West Valley, New York in 1966 and the second in Morris, Illinois in 1971. These facilities prepared to reprocess spent nuclear fuel, a procedure which uses chemicals to reduce spent nuclear fuel into its constituent elements thereby allowing the reprocessing facility to recycle the uranium and plutonium as fuel to be placed back into the reactors. The remaining waste would be converted into cylinders of glass through a process of vitrification. Vitrified waste is much more stable than spent nuclear fuel. It is more resistant to leaching and is well-suited for many geologic disposal mediums (e.g., clay, granite, basalt, etc.). Neither the West Valley nor Morris facilities were successful. While the West Valley facility was able to reprocess a small amount of spent nuclear fuel, stringent regulations put in place by the Atomic Energy Commission proved too costly and the plant closed in 1976. The Morris facility never became fully operational and closed in 1974 before processing any spent fuel. A third facility, located in Barnwell, South Carolina, was slated to open in 1977. Before the Barnwell plant went online President Carter issued a moratorium on reprocessing spent nuclear fuel. Carter's moratorium was the result of India's detonation of a nuclear weapon created from diverted plutonium from its civilian nuclear program (Macfarlane 2003). As a result, private sector nuclear reprocessing facilities were no longer an option. So began the accumulation of nuclear waste at reactor sites around the country.

Nuclear planners did not anticipate the failure of private nuclear reprocessing in the United States (Rosenbaum 2008). Planners also did not foresee the need to store nuclear

materials for long periods of time (sometimes longer than the containment apparatus was designed to last); instead, they envisioned storing nuclear waste just until it was ready to be reprocessed—approximately three years (Macfarlane 2003; Rosenbaum 2008).

Due to the moratorium on reprocessing spent nuclear fuel, an alternative solution had to be found. Scientists quickly asserted that storing nuclear waste on the earth's surface would be problematic. The logical solution, then, was to bury the waste (Angino 1977). While the burial of high-level nuclear waste could be a short-term solution, the scientific community cautioned against thinking that geologic storing would be a viable long-term solution. The scientific community was also quick to point out that some of the waste being disposed would be lethal for time periods incomprehensible by human timelines. For example, some transuranic waste can be lethal for one million years (i.e., its half life is one million years). Creating storage facilities that would contain this waste for time periods thousands of times longer than the average human lifespan proved daunting. Debates as to whether nuclear waste should be stored in geologic formations, buried within ice sheets, or under the seabed were rampant in the scientific journals (see for example, *Science* from 1975 to 1985). Although consensus on the location of a nuclear repository could not be reached, scientists largely agreed that a few concentrated storage sites were much preferred to myriad smaller sites and that geologic storage was preferable to the other options available (Angino 1977; Burwell, Ohanian, and Weinberg 1979).

Policy Legitimization: Yucca Mountain and Beyond

In 1982 Congress addressed these debates by passing the Nuclear Waste Policy Act. This policy mandated that spent nuclear fuel and other high-level waste be disposed of in a mined geologic repository (Nuclear Waste Policy Act 1982; Macfarlane 2003; Rosenbaum 2008).

According to the legislation, the Department of Energy would select and manage the disposal

sites, the Environmental Protection Agency would create safety and pollution standards for the sites, and the Nuclear Regulatory Commission would enforce the standards mandated by the Environmental Protection Agency (Nuclear Waste Policy Act 1982; Macfarlane 2003). When selecting a site, the Department of Energy was to be as detailed and impartial as possible, relying on sound scientific evidence in making its decision. All possible locations were to be studied and a list given to the president from which he (or she) would select two: one east of and one west of the Mississippi River (Nuclear Waste Policy Act 1982; Rosenbaum 2008).

In 1985 following the procedures laid out by the Nuclear Waste Policy Act, the Department of Energy recommended three permanent sites west of the Mississippi River for consideration: Deaf Smith County, Texas, the Hanford Nuclear Reservation in Washington (state), and Yucca Mountain, Nevada (Nuclear Waste Policy Act 1987; Rosenbaum 2008). Representatives from Texas, Washington, and Nevada quickly refused to house a federal nuclear repository. They sought protection from the courts and dug their heels in for what could be a long battle. Rather than becoming wrapped up in controversy and entangled in the court system, Congress chose a simpler solution. In 1987, Congress amended the Nuclear Waste Policy Act and designated Yucca Mountain as the first permanent nuclear repository (Macfarlane 2003, Rosenbaum 2008).

Questions as to the selection of Yucca Mountain, a “volcanic ridge that sits astride a little-known transition area at the juncture of the Mojave and Great Basin deserts” rose immediately after the announcement (Macfarlane 2003: 713). The selection of the Yucca Mountain site was likely largely due to politics. Yucca Mountain is located on federally owned land. By placing a federal nuclear waste repository on federal land, Congress would avoid costly negotiations with private landowners or uncomfortable discussions of eminent domain. Nevada has a relatively small population (2.6 million), which is clustered around two major cities

(United States Census Bureau 2008). The population concentrations meant that there was an abundance of remote test sites available for use within the state (e.g., Yucca Mountain). Furthermore, the Yucca Mountain site is adjacent to nuclear test sites where the military conducted above- and below-ground nuclear weapons tests during the 1940s and 1950s. Due to these tests, large swaths of the land were already polluted which made the Yucca Mountain location an even better choice as far as containment of pollution was concerned. Finally, Nevada was a weak state politically. At the time Congress announced the Yucca Mountain amendment to the Nuclear Waste Policy Act, Nevada had two junior senators in Congress; neither had the power or influence to make a difference in Congress' decision.

Implementation: Not In My Back Yard

Geologic disposal relies on the natural environment to protect and isolate radioactive materials. The Federal Government has a responsibility to ensure that nuclear waste is disposed of and/or stored properly as it is a matter of public health and safety. This method of storage helps to protect humans and the environment from the hazards of atomic radiation by removing the waste from the ecosystem until it can be safely handled. In 2003, the International Atomic Energy Agency listed four general criteria a desirable location site would meet:

1. Long-term (millions of years) geologic stability in terms of major earth movements and deformation, faulting, seismicity and heat flow;
2. Low groundwater content and flow and repository depths, which can be shown to have been stable for periods of at least tens of thousands of years;
3. Stable geochemical or hydrochemical conditions at depth, mainly described by a reducing environment and a composition controlled by equilibrium between water and rock forming minerals'
4. Good engineering properties that readily allow construction of a repository, as well as operations for periods that may be measured in decades (International Atomic Energy Agency 2003 as presented in Macfarlane 2003: 787).

The United States has been searching for a site with meeting these criteria since the 1970s. The

decision to select Yucca Mountain, according to the Department of Energy, reflects the fact that a facility housed in this area will be able to contain nuclear waste for at least 10,000 years.

Opponents to the selection of Yucca Mountain argue that the decision reflects political motivations rather than scientific ones. They further argue that Yucca Mountain is located in a region that has recent (in geologic terms) seismic and volcanic activity. As recently as 2002, an earthquake measuring 4.4 on the Richter Scale struck the Yucca Mountain vicinity and raised questions about the stability of the Bow Ridge fault line (Macfarlane 2003). Opponents also argue that there is no reason to suspect that the volcanic activity in the region has ended. There is evidence of (relatively) young volcanic cones in the valley visible from atop Yucca's crest line. Still other objections come from the complaint that the UO_2 (uranium dioxide) in spent nuclear fuel is not stable under the oxidizing conditions found at the Yucca Mountain site (Ewing and von Hippel 2009). Under the conditions found at Yucca Mountain, the uranium dioxide has the potential to convert to more soluble oxides, which have a greater potential to escape storage and contaminate surrounding areas.

Nevadans have launched a not-in-my-backyard (hereafter, NIMBY) movement in protest of the Federal Government's decision regarding Yucca Mountain. While critics of NIMBY movements are quick to label protesters as selfish and irrational, the NIMBY protesters in Nevada are atypical of this stereotype (Kraft and Clary 1991). At nuclear siting hearings, NIMBY protesters were well informed and rational (e.g., they did not use emotional pleas). Their protests have proved effective. Due to both political and scientific concerns, the storage facility plans for Yucca Mountain have not materialized. There is no date planned for operation and President Obama's administration has effectively shut the door on the "Yucca Mountain Question" by eliminating the Yucca Mountain Repository Program from its 2010 spending plan (Paulson 2009).

Policy Evaluation: The Failure to Agree

The Nuclear Waste Policy Act has been largely unsuccessful in attacking the nuclear waste problem. President Obama's commitment to finding other solutions to store nuclear waste has effectively removed Yucca Mountain from the ongoing debates. Government moratoriums on reprocessing spent nuclear fuel have both narrowed the debate over viable options and allowed the storage problem to become much worse. Transuranic (i.e., long-lived, high-level) wastes require isolation for up to 1 million years before they can be handled safely. It has been argued that reprocessing spent nuclear fuel would reduce the half-life of transuranic waste by a factor of 100, meaning waste would only require isolated storage for 1,000 years (Angino 1977). Reprocessing radioactive waste is not a panacea, however. During the chemical separation and reprocessing of uranium and plutonium, a reprocessing plant can emit 15,000 times more radiation into the environment than nuclear power reactors (Rosenbaum 2008). The radiation emitted by these plants can cause health problems to individuals working in the plant and living in the surrounding areas. For instance, health studies of individuals living near reprocessing plants indicate higher rates of childhood cancers (Rosenbaum 2008). Although these health reports do not prove causation, the correlation cannot be denied.

As we move further into the 21st century, more and more nuclear reactors are requiring decommissioning. The lifespan of a nuclear reactor is approximately 50 years. The debate over how to manage nuclear waste largely ignores the massive quantities of waste that are quickly going to accumulate as nuclear relics of the Cold War era reach the end of their lifecycle. Once a nuclear facility (civilian or military) has reached the end of its productive life, the Nuclear Regulatory Commission and the Department of Energy require that the owners decommission the site (Rosenbaum 2008). Decommissioning a nuclear reactor requires the removal of all radioactive materials from the site including: land, groundwater, buildings, contents, and

equipment (Rosenbaum 2008). Once a site has been decommissioned, the amount of residual radiation should be low enough that the property can safely be used for any other function. Decommissioning a nuclear facility adds to the problem of safe-storage of spent nuclear fuel and compounds the problem by requiring the storage of radioactive building and site materials as well.

According to the Nuclear Energy Institute (2010), twelve nuclear power plants are currently undergoing decommissioning. The US Nuclear Regulatory Commission has established regulations on nuclear power plant decommissioning. For instance, each plant must file a “post–shutdown activities report” with the NRC and is further required to set aside funds for decommissioning. These funds are not under direct control of the company and cannot be used for any other purpose than decommissioning. Although the NRC oversight and requirement for decommissioning funds suggests that the government is encouraging corporate responsibility for nuclear waste, decommissioning plans are not always carried out in a timely or efficient manner.

The NRC has outlined three decommissioning options: DECON, SAFSTOR, and ENTOMB. Under the DECON plan, all radioactive components are dismantled and shipped to a low-level disposal site, or they are stored “temporarily” on site. According to the Nuclear Energy Institute, the process can take *at least* five years and during this time, the site can be “reused for other purposes.” Under the SAFSTOR option, the nuclear plant is kept in tact and placed in protective storage for up to 60 years. This method involves locking the part of the plant containing radioactive material and monitoring it with an on-site security force. Once the plant has been left idle for 60 years, many of the radioactive elements inside the facility will have decayed to lower levels; at that point, the plant can be dismantled under the DECON plan. Finally, the third option is ENTOMB. This option involves encasing radioactive structures in

concrete. The encased plant would be monitored in ways similar to those in safe storage (i.e., SAFSTOR) until the radioactivity decays to levels that permit the termination of the plant's license (this is the option that has been floated for Japan's crippled Fukushima Daiichi reactor site).

According to the NRC, the majority of the nuclear facilities undergoing decommissioning in the United States are utilizing the SAFSTOR or ENTOMB decommissioning plans rather than the DECON plan. Many of these plants currently undergoing decommissioning have been offline for decades. For instance, the Pacific Gas and Electric-owned (hereafter PG&E) Humboldt Bay Nuclear Power Plant was shut down in 1976 after only 13 years of operation. PG&E announced plans to decommission the site in 1983 and the NRC changed the operating license for the facility to "possess-but-not-operate" and the plant was placed into a SAFSTOR status. Since then, the NRC has updated the status of the plant to DECON with an expected closure date of December 31, 2015.

The decision to utilize SAFSTOR and ENTOMB plans before moving to DECON plans stems from the fact that DECON decommissioning costs can reach \$1 billion. According to the article "Decommissioning a Nuclear Plant can Cost \$1 Billion and Take Decades," operators of nuclear power stations rely on utility subscribers for their decommissioning funds. When plants go offline, they no longer have a revenue source so they delay cleanup plans while they let decommissioning funds (collected while online) collect interest. During this period (oftentimes several decades), the plant must be maintained and surveilled for contamination leaks and security breaches. For instance, in 2005 the NRC filed a report stating that the PG&E facility at Humboldt Bay, which was in SAFSTOR at the time, had three nuclear fuel rods that were unaccounted for (NRC 2005). After a \$1 million investigation, PG&E could not find the three missing fuel rods, but assured Eureka residents that there was "every reason to believe they were

right were they were supposed to be all along” (Hall 2005).

Until a cost-effective long-term storage solution for nuclear waste is achieved, nuclear facilities will only partially decommission the plants while continuing to store nuclear waste on the premises. This decision, unsurprisingly, poses high risk. As plants are partially decommissioned, staffing is reduced and maintenance is neglected. In the late 1980s, inspections of military nuclear facilities revealed negligent waste storage, radioactive leaks, and decades-long pollution to the surrounding environment. There is no reason to believe that private industry will be more cautious.

The embattled Yucca Mountain storage facility and nuclear waste mismanagement has proven disastrous for the nuclear industry. Revelations of safety risks and technological deficiencies have only fueled public apprehension about the prospect of nuclear energy. Until the science of nuclear waste management can compete with the politics of nuclear waste management there is no real solution in sight.

Suggestions: Reevaluating US Nuclear Policy

As we move further into the 21st century, more and more nuclear reactors are requiring decommissioning. This number is sure to rise after the Fukushima Daiichi crisis following the 2011 earthquakes in Japan. The incidents at reactors two and four illustrated problems with the design of the reactor sites—a design implemented in many of the reactors in the United States. These design flaws have led to calls for decommissioning existing plants and abandoning nuclear energy altogether.

The United States faces an environmental problem with no satisfying solution. Due to the structure of federalism, the United States has a few options with how to proceed with nuclear waste management. The Environmental Protection Agency can continue to set minimum standards regarding the treatment of nuclear waste and allow individual states more authority in

storage or reprocessing decisions. Currently, the federal government, via the Environmental Protection Agency, sets standards and it is the responsibility of individual states to provide funding, implementation, and enforcement of these federally mandated standards (Vig and Faure 2004). Of course, political considerations influence standards at both the federal and state level creating the ability to shirk on enforcement commitments. States have incentives to be lax in their enforcement of environmental standards especially when their industries are the beneficiaries of weakly enforced environmental laws. A solution might be to create stronger enforcement mechanisms to ensure that states will maintain and enforce federal standards.

Abandoning plans for the Yucca Mountain repository only means that another location will need to be selected. Restarting the process of site selection, geologic tests, and political battles is not enticing to anyone. There is little motivation to restart a process that has proven so unsuccessful. The federal government is unlikely to find a location that satisfies the geologic requirements of scientists and the political requirements of politicians; no one is excited about the prospect of housing a permanent nuclear repository in their state. An alternative to centralized storage is to allow private industry to store nuclear waste at their facilities indefinitely. This is also unappealing due to decommissioning and its effects on nuclear safety.

With no satisfactory storage solutions in sight, discussion can return to reprocessing. Although reprocessing generates nuclear waste, the quantity and radioactivity of this waste is much more manageable. However, reprocessing nuclear waste is not economical and certain health risks have not been adequately investigated (Ewing and von Hippel 2009). The longstanding moratorium on nuclear reprocessing never allowed this nascent technology to develop. Creating a reprocessing infrastructure at this point is out of the question.

A new nuclear waste policy is required. More state and regional autonomy is necessary. While federal standards mandated by the Environmental Protection Agency are necessary to

ensure that at least a minimum level of safety is achieved, the Department of Energy should not be saddled with the task of disposing commercial nuclear waste. States using and producing nuclear energy should be charged with finding acceptable storage solutions while maintaining federal standards. Leaving final siting decisions to the states will allow for more local input on long-term storage solutions, which may result in fewer Yucca Mountain episodes. Until a devolved nuclear waste policy is created, the only economically, technologically, and politically feasible solution is continued on-site waste storage.

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