All Piled Up and Nowhere to Go: The Problem of Permanent Disposal of Spent Nuclear Fuel in the United States

Lingren Meng*

I. Introduction

Nuclear energy has been a crucial power source helping to fuel modern society for over sixty years.[1] In 1957, the first commercial nuclear power reactor in the United States began operations in Shippingport, Pennsylvania.[2] As of April 2017, thirty countries worldwide are operating 449 nuclear reactors for electricity generation and sixty new nuclear plants are under construction in fifteen countries.[3] In the United States, nearly 20% (798.0 Billion kWh) of all the electricity generated comes from nuclear power plants.[4]

Safe and permanent disposal of highly radioactive nuclear waste generated by the commercial nuclear power sector has been a top concern of the United States government. As the former United States Secretary of Energy Steven Chu stated in 2013, "[a]n unfailing commitment to protect public health and safety, security, and the environment is essential to ensuring that nuclear power remains part of our diversified clean-energy portfolio . . . safe, long-term management and disposal of used nuclear fuel and high-level radioactive waste must remain a national priority."[5]

Congress passed the Nuclear Waste Policy Act of 1982 ("NWPA"), indicating its intent to establish repositories for radioactive waste.[6] The purpose of the repositories was to protect both the public and the environment.[7] To this end, the Act offered a broad grant of administrative power to the Department of Energy ("DOE").[8] The Act, however, has not fulfilled its promise.[9]

The selection of a permanent high-level nuclear waste repository has been met with waves of resistance on all fronts.[10] In particular, the project has received strong opposition from the State of Nevada, the location of Yucca Mountain.[11] The mountain was the only location selected for the development of a repository.[12] The precarious fate of the Yucca Mountain Project was effectively sealed under President Obama. The President sought to deliver on a campaign promise by working closely with the Senate majority leader and Nevada Senator Harry Reid to terminate the project.[13]

Since the enactment of the NWPA, billions of dollars have poured into the research and development of a permanent depository to no avail.[14] In the meantime, the volume of high-level nuclear waste in the United States continues to grow, causing severe overcapacities in temporary on-site

** Lingren Meng is a 2018 J.D. candidate at The George Washington University Law School. He received his B.A. with distinction in Public Relations and B.A. in History from the Pennsylvania State University.* *The author would like to thank his family and friends for their support. He would also like to thank Prof. Andrew Satten for his insight and guidance throughout the Note-writing process.*

1. *See* Alan M. Herbst & George W. Hopley, Nuclear Energy Now: Why the Time Has Come for the World's Most Misunderstood Energy Source 34 (2007).
2. Bonnie A. Osif et al., TMI 25 Years Later: The Three Mile Island Nuclear Power Plant Accident and Its Impact 78 (2004).
3. *World Statistics: Nuclear Energy Around the World*, Nuclear Energy Inst., https://www.nei.org/resources/statistics/world-nuclear-power-plants-in-operation [https://perma.cc/Q32Y-FKQZ] (last visited Jan. 24, 2017).
4. *World Nuclear Power Reactors & Uranium Requirements*, World Nuclear Ass'n, http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx [https://perma.cc/LKR8-XURV] (last visited Jan. 24, 2017).
5. Steven Chu, *Preface* to U.S. Dep't of Energy, Strategy for The Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (2013), https://energy.gov/sites/prod/files/2013%201-15%20Nuclear_Waste_Report.pdf [http://perma.cc/JQ58-A8TV].
6. 42 U.S.C. § 10131(b)(1) (2012).
7. *Id.*
8. § 10132(a)-(b).
9. The Department of Energy has had to pay over five billion dollars in the last decade for its failure to set up radioactive waste facilities. *See* Mark Fahey, *How the Department of Energy Became a Major Taxpayer Liability*, CNBC (July 6, 2016), http://www.cnbc.com/2016/07/05/how-the-department-of-energy-became-a-major-taxpayer-liability.html [http://perma.cc/3VEP-CDZ9].
10. Richard B. Stewart, *U.S. Nuclear Waste Law and Policy: Fixing a Bankrupt System*, 17 N.Y.U. Envtl. L.J. 783, 795 (2008).
11. *Id.* at 797.
12. *Id.*
13. Megan Easley, Note, *Standing in Nuclear Waste: Challenging the Disposal of Yucca Mountain*, 97 Cornell L. Rev. 659, 673 (2012).
14. *See* Darius Dixon, *The $38 Billion Nuclear Waste Fiasco,* Politico (Nov. 30, 2013), http://www.politico.com/story/2013/11/nuclear-waste-fiasco-100450 [http://perma.cc/2Z5C-5BA6].

nuclear storage facilities.[15] The Trump Administration is discussing the possibility of dealing with this problem by reviving a permanent geological nuclear waste depository, particularly the Yucca Mountain project.[16] With the "most ardent" opponent of Yucca Mountain project, Senator Harry Reid, having left the Senate in 2017, the possibility of revival has seemingly increased.[17]

Building on the lessons from the failed efforts to establish a permanent repository in the U.S., as well as from the two successful examples in the European Union, this Note discusses the short-term and long-term solutions necessary to resolve the current conundrum.[18] Part II offers a panoramic view of the global nuclear industry. Part III examines the difficulties facing the United States commercial nuclear power industry with regard to the storage of spent nuclear fuel. Part IV examines the legislative response to the problem. Part V offers solutions to ease the administrative difficulties of developing a permanent depository that the United States urgently needs.

II. The Overview of Commercial Nuclear Power Industry

A. The Nuclear Power Industry in the United States and Its Environmental Benefits

Commercial nuclear power plants play a pivotal role in the energy makeup of the United States. There are 100 commercial power plants currently licensed to operate, and the nuclear power sector in total contributed around 20% of all the electricity produced in 2015.[19] The two biggest sources of electricity production in the United States are still natural gas and coal. Natural gas was the source of 34% of electricity and coal contributed around 30% of the electricity in the United States in 2016.[20] Despite that fact that commercial nuclear power plants have been around for more than six decades and it is now facing significant financial difficulties,[21] nuclear energy, which produces zero greenhouse gas during the power generation, will remain as a favorable option given that the international community is determined to move away from its dependence on fossil fuels including coal, natural gas, and oil as major energy sources.[22]

B. The Life Cycle of Nuclear Power Production

1. The Production of Nuclear Fuel

Uranium is an abundant and slightly radioactive metal found in the Earth's crust; it is also the key ingredient that is used to produce electricity in commercial nuclear power plants.[23] After extracting uranium ore from the orebody, the ore, through the process of milling, is concentrated as uranium oxide (U_3O_8), which may contain more than 80% uranium.[24] After enrichment, the uranium is suitable for commercial power plants.[25] The enriched uranium is then converted to uranium dioxide (UO_2) in the form of pellets. The pellets are subsequently placed inside thin metal casings called fuel rods. Fuel rods compose the "core" of the nuclear reactor.[26]

2. Power Generation

Fission is a nuclear reaction that occurs when a neutron splits the nucleus of an atom,[27] releasing additional neutrons and creating sustainable chain reactions that produce large amounts of heat.[28] Several hundred fuel assemblies (each of which may contain 200 or more fuel rods)[29] make up the core of a reactor. The nuclear energy is closely packed: usually, forty-four million kilowatt-hours of electricity can be produced from one ton of natural uranium.[30] By comparison, the production of the same amount of electrical power from fossil fuels would require the burning of over 20,000 tons of black coal or 8.5 million cubic meters of gas.[31] The heat generated from the continuous fission of uranium turns water into steam that in turn spins a turbine connected to a generator to produce electricity.[32]

15. *See* Ronald A. Hardert, Button Up: Secrecy and Deception in the Nuclear Fuel Cycle 140 (2014).
16. Jennifer A. Dlouhy, *Trump Advisers Eye Reviving Nevada Yucca Nuclear Waste Dump,* Bloomberg (Nov. 14, 2016), https://www.bloomberg.com/politics/articles/2016-11-14/trump-advisers-eye-reviving-nevada-s-yucca-nuclear-waste-dump [http://perma.cc/44VD-PVXD].
17. *Id.*
18. *Id.*
19. *Nuclear Power in the USA*, World Nuclear Ass'n, http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx [http://perma.cc/F9QW-XHT9] (last visited Jan. 24, 2017).
20. *Electricity Explained*, U.S. Energy Info. Admin., https://www.eia.gov/energyexplained/index.php?page=electricity_home [http://perma.cc/DHK6-QSPH] (last updated Oct. 25, 2017).
21. *See* Jim Polson, *More Than Half of America's Nuclear Reactors Are Losing Money,* Bloomberg (June 14, 2017), https://www.bloomberg.com/news/articles/2017-06-14/half-of-america-s-nuclear-power-plants-seen-as-money-losers [http://perma.cc/8C4L-ATXS].
22. *See* Press Release, Int'l Atomic Energy Agency, Nuclear Power Remains Important Energy Option for Many Countries, IAEA Ministerial Conference Concludes (June 29, 2013), https://www.iaea.org/newscenter/pressreleases/nuclear-power-remains-important-energy-option-many-countries-iaea-ministerial-conference-concludes [http://perma.cc/C85M-F339].
23. *The Nuclear Fuel Cycle*, World Nuclear Ass'n, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/nuclear-fuel-cycle-overview.aspx#ECSArticleLink5 [http://perma.cc/4L7H-ZP5Y] (last updated Mar. 2017).
24. *Id.*
25. *Id.*
26. *Id.*
27. In the case of nuclear power plants, U-235 atoms. *Id.*
28. *Id.*
29. *Fuel Assembly (Fuel Bundle, Fuel Element),* U.S. Nuclear Regulatory Comm'n, https://www.nrc.gov/reading-rm/basic-ref/glossary/fuel-assembly-fuel-bundle-fuel-element.html [http://perma.cc/B6YU-HDZK] (last updated July 6. 2018).
30. *Nuclear Fuel Cycle*, U.S. Dep't of Energy: Office of Nuclear Energy, https://www.energy.gov/ne/nuclear-fuel-cycle [http://perma.cc/T9KJ-AXPW] (last visited Jan. 20, 2018).
31. *The Nuclear Fuel Cycle*, *supra* note 23.
32. *How a Nuclear Reactor Makes Electricity*, World Nuclear Ass'n, http://www.world-nuclear.org/nuclear-basics/how-does-a-nuclear-reactor-make-electricity.aspx [http://perma.cc/l9ja-scw3] (last visited Feb. 10, 2018).

3. Back End and the Danger of Spent Nuclear Fuel

When the nuclear fuel can no longer efficiently produce energy, which may range from eighteen to thirty-six months, the used fuel is removed from the reactor.[33] Spent nuclear fuel ("SNF") is composed of highly radioactive elements. Many of these elements have half-lives spanning thousands of years.[34] For example, Plutonium-239 has a half-life of 24,100 years.[35] The extraordinarily long life of the radioactive elements presented in the SNF renders it particularly difficult to handle and store.[36]

Government Accountability Office ("GAO") documents summarizing key research in this area show that radiation released from storage sites could "harm human health or the environment."[37] The GAO reports that the probability of "widespread release of radiation" is potentially undervalued by the Nuclear Regulatory Commission.[38] High dose exposure can lead to organ failure and hemorrhage, almost certainly fatal in humans.[39] Long-term exposure to mild-dose nuclear radiation can damage genes and lead to various forms of cancer, and can especially affect children, pregnant women, and fetuses.[40]

III. Current State of United States Nuclear Waste Management

A. *The Problem Facing the Stockpile of SNF in the United States*

The United States is among the few countries that employ a "once-through" fuel cycle in its commercial power generation.[41] In this method, once the SNF is removed from the reactor core and placed in storage, the used fuel rod will not be reprocessed and reused.[42] The SNF is first placed in on-site containment pools.[43] The water, which serves as coolant, will slowly cool the SNF and defray some of the radiation.[44] After five to six years, the SNF can be further moved to on-site storage.[45]

The once-through fuel cycle, however, presents a serious problem. Because the depleted fuel goes directly to disposition as opposed to being reprocessed and reconcentrated into a new fuel rod, such approach accelerates the need for repositories.[46] Despite the global prevalence of commercial nuclear power programs, there are few countries with sites geologically suited for the final disposal of SNF, and those that have potential sites, are engaged in decades-long legal and political battles over site development.[47]

For the United States, the problem is especially urgent. The majority of nuclear power plants were licensed during the 1960s and 1970s under a now outdated licensing process.[48] Under this old procedure, the operating license would be granted based on its initial design, and sale and environmental impacts. The final disposal of nuclear waste, however, would be addressed after the permit was issued.[49] The inherent shortcoming in the licensing procedure was compounded by a major policy shift in the 1970s when most of the nuclear plants operating today had already began operation or were under construction.[50] Before 1977, the United States did not plan to employ a once-through nuclear cycle approach in treating the nuclear waste.[51] In 1977, President Carter signed an executive order that stopped the recycling of fuel for commercial reactors.[52] Because the design and construction of those pre-1977 nuclear plants did not have the once-through nuclear cycle under which the nuclear waste is disposed in mind, those nuclear plants only had relatively small on-site storage.[53]

According to the final report issued by the Blue Ribbon Commission ("BRC"), as of 2013, the industry, as a whole, generated 2,000 to 2,400 metric tons of spent fuel on an

33. *The Nuclear Fuel Cycle*, *supra* note 23.
34. An element's half-life is the time it takes for half of it to decay into a lighter, non-radioactive form. *Backgrounder on Plutonium*, U.S. Nuclear Regulatory Comm'n, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/plutonium.html [http://perma.cc/B6YU-HDZK] (last updated May 1, 2017).
35. *Id.*
36. Laura Rodríguez-Penalonga & B. Yolanda Moratilla Soria, *A Review of the Nuclear Fuel Cycle Strategies and the Spent Nuclear Fuel Management Technologies*, 10 energies 1, 2 (2017). (Moreover, it is essential to address this issue properly because the periods of time required to manage SNF are extremely long and involve future generations).
37. *Introduction* to U.S. Gov't Accountability Off., GAO-12-797, Spent Nuclear Fuel: Accumulating Quantities at Commercial Reactors Present Storage and Other Challenges (2012) [hereinafter *GAO Report*].
38. *Id.*
39. *Radiation Health Effects*, U.S. Envtl. Prot. Agency, https://www.epa.gov/radiation/radiation-health-effects [https://perma.cc/CUE3-2PP7].
40. *Id.*
41. *Nuclear Fuel Cycle*, American Nuclear Soc'y, http://www.ans.org/store/item-750075/ [http://perma.cc/Z96E-V785] (last visited Sept. 18, 2018).
42. *See id.*
43. *Id.*
44. NRC, Spent Fuel Pools, https://www.nrc.gov/waste/spent-fuel-storage/pools.html [https://perma.cc/MJF6-3SRF] (last visited Feb. 10, 2018).
45. American Nuclear Soc'y, *supra* note 41.
46. Baldev Raj & P.R. Vasudeva Rao, *For Sustainable Nuclear Energy, a Closed Fuel Cycle,* Bull. of the Atomic Scientists (Apr. 9, 2015), http://thebulletin.org/reprocessing-poised-growth-or-deaths-door/sustainable-nuclear-energy-closed-fuel-cycle [https://perma.cc/B6HK-A8H7].
47. *See id.*
48. Emily Casey, *Waist Deep in Nuclear Waste: How the NRC Can Rebuild Confidence in a Stalled Waste Management Program*, 33 J. Nat'l Ass'n Admin. L. Judiciary 723, 735 (2013). *See also U.S. Commercial Nuclear Capacity Comes From Reactors Built Primarily Between 1970 and 1990*, U.S. Energy Info. Admin. (June 30, 2011), http://www.eia.gov/todayinenergy/detail.php?id=2030 [https://perma.cc/U8MN-KHHR]. ("Plans for nuclear capacity additions slowed dramatically in the late 1970s reflecting decreasing growth rate in electric power demand, higher nuclear construction costs, higher investment risk from licensing challenges, higher cost of capital, and design changes resulting from the Three Mile Island accident in 1979. However, given the length of the construction and permitting processes, considerable amounts of nuclear capacity committed to at an earlier date continued to come online through the early 1990s.").
49. Casey, *supra* note 48, at 767; *Fact Sheets: Licensing New Nuclear Power Plants*, Nuclear Energy Inst. (Nov. 2016), https://www.nei.org/Master-Document-Folder/Backgrounders/Fact-Sheets/Licensing-New-Nuclear-Power-Plants [https://perma.cc/R49P-8EFZ].
50. Casey, *supra* note 48, at 735-36.
51. Jason Hardin, Note, *Tipping the Scales: Why Congress and the President Should Create a Federal Interim Storage Facility for High-Level Radioactive Waste*, 19 J. Land Resources & Envtl. L. 293, 294-96 (1999).
52. *Id.*
53. Lawrence Flint, *Shaping Nuclear Waste Policy at the Juncture of Federal and State Law*, 28 B.C. Envtl. Aff. L. Rev. 163, 167-68 (2000).

annual basis.[54] And "nearly all of the nation's existing spent nuclear fuel is being stored at the reactor sites where the SNF was generated."[55] At the same time as the final report from the BRC was published, the available on-site spent fuel storage across the nation is nearing capacity and, at some locations, have exceeded the cooling pool capacity.[56] The published GAO report shows that these commercial on-site storage facilities span thirty-three states and account for around 70,000 metric tons.[57] Under the high-growth scenario, the BRC anticipates that the nation's accumulated spent fuel inventory would substantially exceed 200,000 metric tons by mid-century—far surpassing the current capacity of on-site storage.[58]

B. The Need for a Permanent Consolidated Nuclear Storage Site and the Financial and Social Cost of Failure to Develop One

There is an urgent need to find a viable solution to the difficulties facing the nuclear waste disposal situation in the United States. Not only does the current method under which the excess of SNF is stored pose potentially serious health risks,[59] the impasse over a permanent solution may cost the federal government billions of dollars[60] and hinders the nuclear power industry's future.

The cooling pools where three quarters of the SNF is stored offer the least protection against natural and man-made catastrophes.[61] The SNF storage pools require electricity to circulate and cool the water that is heated up by a fuel rod, which still emits enormous amounts of heat and radiation.[62] The Fukushima nuclear disaster was the second worst nuclear disaster of all time, next only to Chernobyl. The disaster demonstrates the inherent danger posed by storing SNF in such a delicate and complex system.[63] The earthquake and the ensuing tsunami disabled the primary and auxiliary power generators, which led to the failure of the cooling system in the nuclear power plants.[64] Without a continuous supply of coolant, the SNF proceeded to meltdown, and during that process released radiation that contaminated the entire power plant.[65] In the United States, the potential danger of a nuclear disaster is exacerbated by an excessive accumulation of SNF. The Nuclear Regulatory Commission has permitted many US nuclear power plants to store up to five times the amount of spent fuel rods in their cooling pool as authorized in the plant's original licenses.[66]

Dry cask storage is considered safer and more secure than pool storage because the fuel is vitrified before going into the cask and there is no coolant involved.[67] All the SNF is still required to be cooled in the contamination pools for several years before it can be sealed in the cask.[68] Additionally, the cost of storing SNF in an individual cask made of steel and concrete, which only has a limited capacity, is not as cost-effective.[69]

Besides the inherent public health risk posed by the methods by which SNF is stored, the delay in the construction of a permanent nuclear waste repository has cost the federal government billions.[70] The DOE has contractual obligations to construct a repository for the operators as mandated under the amended Nuclear Waste Policy Act of 1987 ("1987 NWPA").[71] DOE has been challenged in court more than seventy times for its partial breach of contracts where it committed to accepting SNF by the scheduled date.[72] Since 2000, the federal government has been paying claims for the commercial utility costs for SNF storage.[73] The federal government has already paid $6.1 billion in damages to electric utilities, and DOE estimates that remaining liability will total to $24.7 billion if the department can start receiving SNF before 2025.[74] If the schedule for a permanent repository is further delayed, however, the anticipated cost of damages,

54. Blue Ribbon Comm'n on America's Nuclear Future, Report to the Secretary of Energy 14 (2012), https://www.energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf [https://perma.cc/J6EU-BD43] [hereinafter *BRC Report*].
55. *Id.*
56. Jonathan Fahey & Ray Henry, *Storage Sites Overfilled With Spent Nuclear Fuel*, NBC News (Mar. 22, 2011), http://www.nbcnews.com/id/42219616/ns/business-us_business/t/us-storage-sites-overfilled-spent-nuclear-fuel/#.W6G4rehKjIU [https://perma.cc/4BCK-PR6J].
57. *GAO Report*, *supra* note 37, at 5.
58. *BRC Report*, *supra* note 54, at 14.
59. *See* Robert Alvarez, *Spent Nuclear Fuel Pools in the U.S.: Reducing the Deadly Risks of Storage* (May 24, 2011), https://ips-dc.org/spent_nuclear_fuel_pools_in_the_us_reducing_the_deadly_risks_of_storage/ [https://perma.cc/YLN2-TN9G] (If this were to happen at one of the Indian Point nuclear reactors located 25 miles from New York City, it could result in as many as 5,600 cancer deaths and $461 billion in damages).
60. *See* Dixon, *supra* note 14.
61. Robert Alvarez, *Improving Spent-Fuel Storage at Nuclear Reactors*, 28 Issues in Sci. & Tech. 77, 79 (2012) (Storing spent radioactive fuel in dry form rather than in increasingly jammed cooling pools is much safer, and can be done with already available funds).
62. Staff of Rep. Edward J. Markey, Fukushima Fallout: Regulatory Loopholes at U.S. Nuclear Plants 9-10 (2011), https://www.nrc.gov/docs/ml1113/ML111390565.pdf [https://perma.cc/FUD3-4M99].
63. *See Fukushima Accident*, World Nuclear Ass'n, http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-accident.aspx [https://perma.cc/K7Q3-HKWF] (last updated Oct. 2018).
64. *Id.*
65. *See* Charles Miller et al., U.S. Nuclear Regulatory Comm'n, Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights From the Fukushima Dai-ichi Accident 10-14 (2011), https://www.nrc.gov/docs/ML1118/ML111861807.pdf [https://perma.cc/F3UP-MNQE] (outlining the sequence of events during the tsunami at each reactor).
66. *Safer Storage of Spent Nuclear Fuel*, Union of Concerned Scientists, http://www.ucsusa.org/nuclear-power/nuclear-waste/safer-storage-of-spent-fuel#.WhLoZLpFw2w [https://perma.cc/M5CQ-YWF2] (last visited Nov. 20, 2017).
67. Richard B. Stewart & Jane B. Stewart, *Solving the Spent Nuclear Fuel Impasse*, 21 N.Y.U. Envtl. L.J. 1, 21, 27 (2014); Alvarez, *supra* note 61 (concluded that dry-cask storage offered several advantages over pool storage. Dry-cask storage is a passive system that relies on natural air circulation for cooling, rather than requiring water to be continually pumped into cooling pools to replace water lost to evaporation caused by the hot spent fuel).
68. Stewart & Stewart, *supra* note 67, at 29.
69. *Id.* at 27-28.
70. Robert L. Ferguson With Michele S. Gerber, Nuclear Waste in Your Backyard: Who's to Blame and How to Fix it 122 (2014).
71. 42 U.S.C. § 10222 (a)(5)(B) (2012).
72. James D. Werner, Cong. Research Serv., R42513, U.S. Spent Nuclear Fuel Storage 7 (2012).
73. *Id.*
74. U.S. Off. of Inspector Gen. & U.S. Dep't of Energy, OAI-FS-17-04, Audit Report: Department of Energy's Nuclear Waste Fund's Fiscal Year 2016 Financial Statement Audit 22 (2016).

which will ultimately be coming out of taxpayers' pockets, will climb rapidly.

Furthermore, the unsolved question of permanent SNF disposal may affect investment in the sector and cast shade over further prospects of the commercial nuclear industry. An American Physical Society Panel consisting of former NRC chairmen stated in a 2007 report that, "there is a concern that the buildup of spent fuel at reactor sites and lack of progress on final disposition could be serious constraints on the growth of the domestic nuclear power industry by discouraging investment in new nuclear power plants . . ."[75] Given the urgent need for a replacement for fossil fuel-based power generation, potential investment should not be hindered by the waste disposal problem.

IV. Decades of Legislative Efforts to Solve the SNF Problems

A. *The Pre-1982 Era*

In 1946, Congress created the Atomic Energy Commission ("AEC"), delegating to it authority over the military and non-military application of nuclear power.[76] In its broad grant of administrative power, the AEC was to provide, "[a] program for Government control of the production, ownership, and use of fissionable material to assure the common defense and security and to insure the broadest possible exploitation of the fields."[77] The Agency and its successor, the Nuclear Regulatory Commission ("NRC"), however, were never granted the jurisdiction over nuclear waste or its disposal.[78] During the nuclear power industry's first few decades, the disposal of SNF did not penetrate the industry culture.[79] Research on the subject of permanent disposal of nuclear waste was a relatively low priority, particularly against the backdrop of the cold war, which focused on nuclear weapon production.[80] Until 1977, many commercial nuclear power plants were built under the assumption that the SNF they generated would be reprocessed and reused.[81]

Following a series of nuclear accidents in the 1960s and the subsequent public concern over the safety of nuclear energy, there was a major reorganization of nuclear energy regulation.[82] Congress passed the Energy Reorganization Act in 1974.[83] The Act divided the former AEC into the Nuclear Regulatory Commission and the Energy Research and Development Administration ("ERDA").[84] Under title II of the Act, the "licensing and related regulatory functions of the Atomic Energy Commission," are "transferred" to the newly created independent agency, the NRC.[85] In 1977, shortly after its creation, the ERDA merged with several other agencies to become the present-day DOE.[86]

B. *The Nuclear Waste Policy Act*

Beginning in the 1970s, developed countries started to notice the potential problems associated with nuclear waste disposal.[87] Numerous approaches to the problem of permanent disposal were studied and implemented during that period.[88] After the major reorganization of the AEC, the federal government continued to try to regulate the nuclear industry in the 1970s as a result of President Carter's emphasis on energy policy as one of the central objections of his administration.[89] Also, the public confidence in the safety of nuclear energy was at its nadir after the partial core meltdown at Three Mile Island nuclear power stations in Pennsylvania.[90]

The combining force of all these factors produced a perfect storm for a sweeping change in the control of civilian nuclear power industry. In 1979, The NRC had issued a Notice of Proposed Rulemaking to "reassess its degree of confidence that radioactive wastes produced by nuclear facilities will be safely disposed of, to determine when any such disposal will be available, and whether such wastes can be safely stored until they are safely disposed of."[91] In 1982, Congress took decisive action by passing the Nuclear Waste Policy Act, which imposed a responsibility on the federal government over nuclear waste disposal.[92]

Congress divided the regulatory power among three separate federal agencies: the DOE, the EPA, and the NRC. The NWPA assigns the DOE the responsibility of "the construction, operation, and maintenance of a deep geologic test and evaluation facility" for the SNF.[93] Second, Congress directed EPA to develop standards for protection of the general environment from offsite releases of radioactive material in repositories and protective standard of the site selected over time.[94] Finally, the Act grants the NRC the administrative power to

75. *Consolidated Interim Storage of Commercial Spent Nuclear Fuel: Executive Summary*, American Physics Soc'y., https://www.aps.org/policy/reports/popa-reports/consolidated.cfm [https://perma.cc/K8GN-DUKQ] (last visited June 2, 2018).
76. The Atomic Energy Act of 1946, Pub. L. No. 79-585, 68 Stat. 921 (codified as amended at 42 U.S.C. § 2011 (2012)).
77. *Id.*
78. *See* 42 U.S.C. § 2201 (2012).
79. *See* Eugene A. Rosa & William R. Freudenburg, *The Historical Development of Public Reactions to Nuclear Power: Implications for Nuclear Waste Policy*, *in* Public Reactions to Nuclear Waste: Citizens' Views of Repository Siting 32, 33-34 (Riley E. Dunlap et al. eds., 1993).
80. Stewart, *supra* note 10, at 788.
81. *Id.*
82. *See id.* at 788-89.
83. Sharon Squassoni et al., Ctr. for Strategic & Int'l Studies, Governing Uranium in the United States 14 (2014), https://csis-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/140228_Squassoni_GoverningUranium_WEB.pdf [https://perma.cc/7XUL-26Y3].
84. *See* Energy Reorganization Act, Pub. L. No. 93-438, 88 Stat. 1233 (1974) (codified at 42 U.S.C. § 5841 (2012)).
85. *Id.*
86. *See* Marc Allen Eisner et al., Contemporary Regulatory Policy 274-77 (2d ed. 2006).
87. Easley, *supra* note 13, at 665.
88. *Id.*
89. *Id.* at 665-66.
90. *See id.* at 665. *See also* G.R. Corey, *A Brief Review of the Accident at Three Mile Island*, 21 Int'l Atomic Energy Agency Bull., No. 5, 54, 54 (1979), https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull21-5/21502795459.pdf [https://perma.cc/XB96-4P8Y].
91. Storage and Disposal of Nuclear Waste, 44 Fed. Reg. 61,372-73 (Oct. 25, 1979) (to be codified at 10 C.F.R. pt. 50-51).
92. 42 U.S.C. § 10131(b) (2012).
93. 42 U.S.C. § 10191 (2012).
94. 42 U.S.C. § 10141(a) (2012).

license DOE's site selection and construction application, but only if the DOE meets EPA's standards and all other relevant requirements.[95]

Although Congress stated that "the Federal Government has the responsibility to provide for the permanent disposal of high-level radioactive waste and such spent nuclear fuel as may be disposed of in order to protect the public health and safety and the environment," the financing of the repository should be laid on the "generators and owners of such waste and spent fuel."[96] Owners entered into standard contracts with the DOE in which the owners paid fees into the Nuclear Waste Fund ("NWF").[97] Consequently, the DOE was contractually obligated to take title to the SNF generated by the civilian nuclear power plants and start the disposal process on the fixed dates specified in section 10222(a) of the NWPA, no later than January 31, 1998.[98]

In 1986, the DOE suggested three recommended locations for further study: Dead Smith County in Texas, Hanford in Washington, and Yucca Mountain in Nevada.[99] The site selection process was met with strong local opposition.[100] Subsequently, Congress amended the original NWPA in 1987 to cancel all ongoing research on repository programs, except the Yucca Mountain project.[101]

C. Yucca Mountain Project: An Example That Epitomized the Failure of Current Mode of SNF Regulation

As a result of the exclusive focus on Yucca Mountain, it has become one of the most extensively studied cases for waste disposal. It lasted fifteen years from the enactment of the 1987 amendment to 2002 when the official in the DOE approved the official finding of the site's suitability for building a geologic permanent repository.[102] The cost of this extensive study is also enormous, totaling approximately fifteen billion dollars.[103] Yucca mountain area possesses several ideal characteristics that would make it an suitable site to store the waste: a very dry climate, layers of volcanic tuff that further reduce moisture, 600 feet of dry rock above the repository tunnels through which water can only move very slowly, and rock beds that contain minerals called zeolites that slowly absorb radionuclides.[104]

After decades of research and billions spent, the whole project was virtually dead. From the start, the project was challenged by parties on all fronts, particularly from the State of Nevada and concerned local communities.[105] Because the NWPA allocates administrative power to a cabinet-level department, policies are highly susceptible to political changes with changing administrations.[106]

1. The Inherent Weakness of the NWPA

In 2002, the DOE published its recommendation that Yucca Mountain serve as the first permanent SNF repository in a publication highlighting fifteen years of scientific research.[107]

Nevada was intensely opposed to the recommendation of Yucca Mountain and submitted a Notice of disapproval to veto the project.[108] Despite support garnered by Nevada, majorities in the House and Senate supported a congressional resolution supporting the Yucca Mountain project.[109] The resolution, combined with the signature of President Bush, allowed the DOE to proceed with the license application.[110] The DOE filed its application for Yucca Mountain on June 3, 2008.[111] Optimism for the project's success was perhaps most warranted when Secretary of Energy Samuel Bodman indicated that the project had entered a 'new phase' with the application."[112]

Yet, the inherent political susceptibility in the allocation of authority under the NWPA soon showed its face. As the DOE submitted its license application in the summer of 2008, Barack Obama secured the Democratic nomination to run for president.[113] As part of his campaign pledge to secure the state of Nevada's delegates, Obama, in alliance with Senate Majority Leader Harry Reid (D-Nevada), promised to terminate the Yucca Mountain project.[114]

After Obama became president, he began to fulfill his campaign promise through his appointment power. He first nominated a Secretary of Energy that was unenthusiastic

95. 42 U.S.C. § 10141(b) (2012).
96. 42 U.S.C. § 10131(a)(4) (2012).
97. *See* Cong. Research Serv., R42513, U.S. Spent Nuclear Fuel Storage 7 (2012), https://www.everycrsreport.com/files/20120201_R40996_93f6823638899e01f58a5d516cf987886823672a.pdf [https://perma.cc/V4SZ-TZM2].
98. 42 U.S.C.§ 10222(a)(5) (2012).
99. Easley, *supra* note 13, at 668.
100. *See* James H. Flynn et al., State of Nevada Agency for Nuclear Projects/Nuclear Waste Project Office, *Evaluations of Yucca Mountain Survey Findings About the Attitudes, Opinions, and Evaluations of Nuclear Waste Disposal and Yucca Mountain, Nevada* (1990), http://www.state.nv.us/nucwaste/library/se-029-90.pdf [https://perma.cc/4TUD-4L5Z].
101. 42 U.S.C. § 10172(a) (2012).
102. *See BRC Report*, *supra* note 54, at 23; *see also* Staff of S. Comm. on Env't and Pub. Works, 109th Cong., Yucca Mountain: the Most Studied Real Estate on the Planet 5, 17 (2006), https://www.epw.senate.gov/repwhitepapers/YuccaMountainEPWReport.pdf [https://perma.cc/W6FP-392W].
103. *Cf.* U.S. Gov't Accountability Off., GAO-11-229, Commercial Nuclear Waste: Effects of a Termination of the Yucca Mountain Repository Program and Lessons Learned 27 (2011).
104. *See* Staff of S. Comm. on Env't and Pub. Works, 109th Cong., Yucca Mountain: the Most Studied Real Estate on the Planet 16 (Comm. Print 2006) [https://perma.cc/9T3N-QEMQ].
105. *See generally* Marta Adams, *Yucca Mountain—Nevada's Perspective*, 46 Idaho L. Rev. 423 (2010).
106. *See* Easley, *supra* note 13, at 672-73.
107. Dep't of Energy, Recommendation by the Secretary of Energy Regarding the Suitability of Yucca Mountain Site for a Repository Under the Nuclear Waste Policy Act of 1982 3 (2002).
108. *BRC Report*, *supra* note 54, at 23.
109. Richard Burleson Stewart & Jane Bloom Stewart, Fuel Cycle to Nowhere: U.S. Law and Policy on Nuclear Waste 223 (2011).
110. *BRC Report*, *supra* note 54, at 23.
111. Easley, *supra* note 13, at 672.
112. *DOE Files Yucca Mountain Nuclear Waste Repository Application*, American Physics Soc'y (June 11, 2008), https://www.aps.org/units/fps/newsletters/200807/yucca.cfm [https://perma.cc/6PFF-7Z7V].
113. Adam Zoll & Steve Layton, *A Historic Race: How the Nomination Was Won*, Chi. Trib. (June 4, 2008), http://articles.chicagotribune.com/2008-06-04/news/0806040006_1_obama-campaign-ohio-and-texas-michelle-obama [https://perma.cc/A9V8-R9EM].
114. *See The Democratic Debate in Las Vegas*, N.Y. Times (Jan. 15, 2008), http://www.nytimes.com/2008/01/15/us/politics/15demdebate-transcript.html [https://perma.cc/J4WD-NPUC].

about the Yucca Mountain Project.[115] Then, Obama nominated Allison Macfarlane, a vocal opponent of the Yucca Mountain Project.[116] In 2010, the Obama administration directed the DOE to establish a commission called the Blue Ribbon Commission on America's Nuclear Future to find an alternative to the Yucca Mountain Project.[117] In a written statement before the Committee on the Budget, the Secretary of Energy, Steven Chu, stated, "[b]oth the President and I have made clear that Yucca Mountain is not a workable option. . . ."[118]

Accordingly, the DOE announced in fiscal year 2010 that "[a]ll funding for development of the Yucca Mountain facility would be eliminated, such as further land acquisition, transportation access, and additional engineering."[119] DOE did not request any funding for Yucca in its budgets from 2011 to 2013.[120] The new administration's clear indifference to the Yucca Mountain Project starkly contrasts with the Bush administration's strong interest in the Project, as evidenced by the fiscal year 2005 budget request.[121] This Yucca Mountain policy shift culminated in the DOE formally withdrawing its license application for construction at Yucca Mountain.[122] The NRC rejected the DOE's move to withdraw. The D.C. Circuit heard a case challenging the withdrawal that the court rejected for lack of ripeness because both the license application and review of the NRC's rejection were still under consideration within the agency.[123]

115. *Where Does It All Go?*, N.Y. Times (Dec. 20, 2008), http://www.nytimes.com/2008/12/20/opinion/20sat2.html [https://perma.cc/3MR9-W3HD].
116. Matthew L. Wald, *N.R.C. Nomination Shines Spotlight on Waste-Disposal Issue*, N.Y. Times (June 10, 2012), http://www.nytimes.com/2012/06/11/science/earth/allison-macfarlane-nuclear-regulatory-commission-hearing-may-focus-on-waste.html [https://perma.cc/3MR9-W3HD].
117. *Cf.* Memorandum on the Blue Ribbon Commission on America's Nuclear Future, 2010 Daily Comp. Pres. Doc. 1 (Jan. 29, 2010) (". . . the Commission should consider a broad range of technological and policy alternatives . . ."), https://obamawhitehouse.archives.gov/the-press-office/presidential-memorandum-blue-ribbon-commission-americas-nuclear-future, [https://perma.cc/8RPR-YGH6].
118. *Statement of Steven Chu Secretary of Energy Before the Committee on the Budget*, Dep't of Energy (Mar. 11, 2009), https://www.energy.gov/articles/statement-steven-chu-secretary-energy-committee-budget [https://perma.cc/4Z9K-W5ZT] ("[B]oth the President and I have made clear that Yucca Mountain is not a workable option . . .").
119. Office of Chief Fin. Officer, U.S. Dep't of Energy, DOE/CF-039, 5 FY 2010 Congressional Budget Request 504 (2009), https://energy.gov/sites/prod/files/FY10Volume5.pdf [https://perma.cc/KP6S-2EJX].
120. Todd Garvey, Cong. Research Serv., R41675, Closing Yucca Mountain: Litigation Associated With Attempts to Abandon the Planned Nuclear Waste Repository 3 (2012).
121. Office of Mgmt., Budget and Evaluation, U.S. Dep't of Energy, DOE/ME-0039, FY 2005 Congressional Budget Request: Budget Highlights 7 (2004), https://energy.gov/sites/prod/files/FY05highlights.pdf [https://perma.cc/KP6S-2EJX] ("One of the most significant and long-standing commitments addressed in this budget is funding to establish a permanent nuclear waste repository. [T]he FY 2005 budget requests $907.5 million, $303 million above the FY 2004 enacted level. The majority of the request, $880 million, is for finalizing the license application for construction of the permanent repository and activities associated with developing a transportation system to transport the nuclear waste to Yucca Mountain, Nevada . . .").
122. The DOE went so far as to request the dismissal of its application "with prejudice." Only the Board and NRC can make such a decision. That the DOE made the request at all indicated its firm commitment to never pursue construction at Yucca Mountain. Todd Garvey, Cong. Research Serv., R41675, Closing Yucca Mountain: Litigation Associated With Attempts to Abandon the Planned Nuclear Waste Repository 7-8 (2012).
123. In re Aiken County, 645 F.3d 428, 434-36 (D.C. Cir. 2011).

2. Legal Challenges on All Fronts

Various parties have challenged the Yucca Mountain Project and its underlying statute NWPAA throughout the years.[124] The 2012 Blue Ribbon Commission Report to the Secretary of Energy stated that the failure of the Yucca Mountain Project was the result of the NWPA's repository development process's "inflexibility and prescriptiveness. This made it difficult to adapt or respond to new developments, whether in the form of new scientific information, technological advances, or (just as important) the expressed concerns of potentially affected publics and their representatives."[125] Academics have criticized the DOE for conducting its operations in a culture of secrecy and arrogance,[126] and have also criticized that the approach in the site selection is administered in a top-down commandeering fashion with no consent from the local community.[127] Opposition from local communities and states was the most vehement. Such discontent was epitomized by the local name of the Nuclear Waste Policy Act Amendment ("NWPAA"): the "Screw Nevada Bill."[128] The State of Nevada and the local communities have fought persistently, using every legal means available, for over twenty years.[129] In 2004, The State of Nevada initiated a major consolidated legal challenge against the federal government in response to the green light on the development of the Yucca Mountain project.[130]

a. Challenges From Nevada

In 2004, the Court of Appeals for the District of Columbia heard a lawsuit brought by "the State of Nevada, local communities, several environmental organizations, and the nuclear energy industry" that challenged the EPA safety standard, the constitutionality of the Yucca Mountain Development Act ("YMDA"), and the Presidential and DOE approval of the Yucca Mountain Project.[131] The D.C. Circuit Court rejected the challenge to the constitutionality of the YMDA.[132] The Court determined that the congressional resolution that selected the Yucca mountain area for the development of the repository is an appropriate exercise of

124. *See* Easley, *supra* note 13, at 668-70.
125. *BRC Report*, *supra* note 54, at 23.
126. *See, e.g.*, Len Ackland, Making a Real Killing: Rocky Flats and the Nuclear West 222 (1999) ("[A]fter just a year in command of the Department of Energy, Watkins found himself caught between two dilemmas . . . The other involved the challenge of changing DOE's values, its intransigent 'culture' of secrecy, unaccountability, and arrogance."); Stewart, *supra* note 10, at 811.
127. *BRC Report*, *supra* note 54, at 35.
128. *See* Thomas W. Lippman, *Nevada's Objections Stall Plan for Nuclear Waste Repository*, Wash. Post (Oct. 3, 1989), https://www.washingtonpost.com/archive/politics/1989/10/03/nevadas-objections-stall-plan-for-nuclear-waste-repository/62c77a9d-c83e-42b6-b29e-ac820c951ad5/?utm_term=.ba9f6d5aaf6c [https://perma.cc/6URZ-KLZ7].
129. *See Timeline: 1954-2016*, Eureka County Yucca Mountain Information Office, http://www.yuccamountain.org/time.htm [https://perma.cc/7995-N73Q] (last updated July 12, 2017).
130. *See Nuclear Energy Inst., Inc. v. EPA*, 373 F.3d 1251, 1261-62 (D.C. Cir. 2004) (overviewing the lawsuits now consolidated before the court).
131. *See id.* at 1304; *see also The Major Yucca Mountain Lawsuits*, Eureka County Yucca Mountain Information Office, http://www.yuccamountain.org/court/case.htm [https://perma.cc/2K5Y-TT92] (last updated Sept. 2004).
132. *Id.*

Congress's Article IV section 3 constitutional authority over federal property.[133] The Court stated that Yucca Mountain is located on federal land, hence Congress has the authority under the Property Clause to designate the area for developing a repository and "[i]n exercising its Property Clause power to enact the Resolution, Congress has not regulated Nevada's activities so as to infringe upon State sovereignty interests of the type recognized under the Tenth Amendment."[134]

The only challenge that was successful was the one in which Nevada challenges EPA's adoption of a 10,000-year compliance period.[135] The Court stated that the EPA is required by Energy Policy of 1992 to develop radiation safety standards that were "based upon and consistent with" the National Academy of Sciences' recommendations.[136] "The court rejected the 10,000 year compliance period because the NAS had expressly rejected it and explained that such a standard "might be inconsistent with protection of public health."[137] NAS also explained that such standard "might be inconsistent with protection of public health," EPA's 10,000-year compliance period was vacated by the court under the backdrop of NAS's recommendation of one-million year standard.[138]

Although multiple lawsuits launched by the State of Nevada and its local communities failed to terminate the Yucca Mountain Project, the efforts successfully caused setbacks and serious delays.[139] The lack of local support, and the non-consensual nature of the process contributed partially to the ultimate failure of the Project.[140]

b. Challenges From Utility Companies

While the federal agencies, especially the DOE, are caught between a federal government whose political objectives fluctuate with changes in administration, and a state government that fights vigorously to delay the project, the utility companies have filed their own lawsuits seeking damages as a result of delays in constructing the repository.[141] In 1996, the utility companies had their early victory based on the DOE's contractual on ligation to build a repository before 1998.[142] In *Indiana Michigan Power v. DOE*, several utilities and state commissions that had paid fees into the NWF, a fund designed to finance the research and construction of the repository, asked the court to review the DOE's 1995 order.[143] The order stated that the Agency did not have a contractual obligation to dispose of SNF if no operational repository were in place by the deadline.[144] The D.C. Circuit Court disagreed and found that Congress had expressly spoken to the question at hand, and as a result, the DOE's obligation to accept and take title to the waste was independent from whether there was a permanent repository available.[145] Thus, the court found that DOE had an obligation to start taking the title of the waste by the statutorily defined deadline.[146]

In subsequent cases with claims similar to the one above, the court determined that the administrative relief would not be adequate to compensate the utility companies.[147] Since that decision, the utility companies can pursue judicial relief in the Court of Federal Claims and seek monetary damages.[148] As of 2012, seventy-two such cases against the DOE have been filed,[149] and billions of dollars have been paid in damages.[150] The result of such high damages is that waste producers now have a disincentive to find a better method of waste disposal.[151]

c. Challenges to Compel Agencies to Take Action: The Discord Between the Judiciary Branches and the Executive Branches in Solving the Question

Amidst the Obama administration's shift of support away from Yucca Mountain project, the DOE filed its motion with the NRC to withdraw the license with prejudice in 2010. Subsequently, the question of whether the Yucca Mountain Project is dead is left in limbo as the NRC refuses to take final agency action regarding the withdrawal.[152] After the Atomic Safety and Licensing Board Panel, (a trial level adjudicatory body within the NRC; its task is to rule on the DOE's motion to withdraw), denied the DOE's motion to withdraw in 2010,[153] various parties filed legal challenges, such as seeking a writ of mandamus, of which the court discusses as an "extraordinary remedy," to call for the judiciary to force the executive branch to decide the question.[154] However, judicial intervention proves to be unsuccessful. The court is unable to compel an agency action when Congress intentionally grants insufficient funds for the continuance of the Yucca Mountain project.[155] The ability of Congress to reverse course and

133. *Nuclear Energy Inst., Inc.*, 373 F.3d at 1302.
134. *Id.*
135. *Id.*
136. *Id.* at 1262.
137. *Id.* at 1271.
138. *Id.* at 1257.
139. *Cf.* Easley, *supra* note 13, at 669.
140. *BRC Report*, *supra* note 54, at 23.
141. *See* Flint, *supra* note 53, at 165.
142. *Id.* at 164.
143. Indiana Mich. Power Co. v. Dep't of Energy, 88 F.3d 1272, 1273 (D.C. Cir. 1996).
144. *Id.* at 1274, 1277.
145. *Id.* at 1276.
146. *Id.* at 1277.
147. *See* Me. Yankee Atomic Power Co. v. United States, 225 F.3d 1336, 1342 (Fed. Cir. 2000).
148. Easley *supra* note 13, at 670.
149. *Id.*
150. *Budget Implications of Closing Yucca Mountain: Hearing Before the H. Comm. on the Budget*, 111th Cong. 11-12 (2010).
151. Jack Spencer, *A Free-Market Approach to Managing Used Nuclear Fuel*, The Heritage Found. (June 23, 2008), http://www.heritage.org/research/reports/2008/06/a-free-market-approach-to-managing-used-nuclear-fuel [https://perma.cc/B4QR-ZDYG].
152. *See id.* at 435-36.
153. *U.S. Dep't of Energy (High Level Waste Repository)*, Docket No. 63-001-HLW, ASLBP No. 09-892-HLW-CAB04 (United States Nuclear Regulatory Commission) (Sept. 30, 2011), https://www.nrc.gov/docs/ML1127/ML11273A041.pdf [https://perma.cc/8LGE-NDQJ].
154. *See* In re Aiken County, 725 F.3d 255, 258 (D.C. Cir. 2013).
155. *Id.* at 270 (Garland, J., dissenting) ("In short, given the limited funds that remain available, issuing a writ of mandamus amounts to little more than ordering the Commission to spend part of those funds unpacking its boxes, and the remainder packing them up again.").

starve the agency program to death demonstrates the defects of the current regulatory mode.

i. Compel Action on the NRC

In 2012, the Petitioners filed a suit to petition for judicial review of the DOE's attempt to withdraw its application to the NRC for the license to construct the Yucca Mountain repository and its apparent gesture to discard the development projection.[156] The Petitioners sought a writ of mandamus to compel the NRC, in accord with the statutory mandate, to act on DOE's long pending license application to store nuclear waste at Yucca Mountain.[157] The NRC was required by statute to give a final decision to approve or disapprove the DOE's license application within three years of the submission of the application.[158] Judge Kavanaugh, in turn, argued on the ground that the NRC "does not have sufficient appropriated funds to complete action on the license application. . . ."[159]

Considering these circumstances unusual, the court decided to put the petition on hold until congress made appropriations.[160] It was the court's hope that appropriations would moot the issue.[161] The court also stated that if the funds appropriated by Congress were not enough, then "mandamus likely would have to be granted," because "[a]n executive or independent agency generally has no authority to disregard a statute that mandates or prohibits specific agency actions, at least so long as there is some appropriated funding available."[162]

ii. Second Challenge, the Inability of the Judicial Branch to Compel Actions

When no funding was available for the review, the D.C. Circuit of Appeals concluded that the Commission's inaction violates the Nuclear Waste Policy Act and granted the petition for a writ of mandamus.[163] Despite NRC's resistance, however, the Court concluded that appropriation for a certain agency action often came "on a step-by-step basis," which means that the NRC may not "ignore statutory mandates simply because Congress has not yet appropriated all of the money necessary to complete a project."[164] Also, the Court did not agree with the contention from the NRC that no appropriation will likely be granted in the future and stated that regardless of whether such inference is correct, "an agency may not rely on political guesswork about future congressional appropriations as a basis for violating existing legal mandates."[165] The Court refused to infer the congressional intent to suspend or abandon a statutory mandate simply because the pattern of recent congressional appropriation on that mandate.[166]

However, Chief Judge Garland dissented and argued that granting Petitioners' writ of mandamus would cause the NRC "to do 'a useless thing.'"[167] He argued that because the agency has only $11 million to the licensing process and "[n]o one disputes that $11 million is wholly insufficient to complete the processing of the application," granting the writ of mandamus with insufficient fund available would force "Commission to spend part of those funds unpacking its boxes, and the remainder packing them up again."[168]

V. Proposal: A Sweeping Legislative Change

As the previous sections demonstrated, the current conundrum of permanent disposal of SNF is caused by the inherent weaknesses of the NWPA. The flaws of the statute which prevents it to carry out its original purpose are demonstrated throughout years since its inception in 1982. Several major defects, which are discussed in length in the previous section have contributed a lion's share of the failure of building a permanent SNF repository. In response to those defects in the NWPA, this Note makes legislative proposals to bypass the legislative mechanism entirely to mitigate the defects demonstrated in the legal and political challenges surrounding the Yucca Mountain Project. Some of the recommendations in my proposal are derived from the successful stories from the EU countries, namely, Sweden and Norway.

A. Introducing the Free Market Concept to Replace the Current "Take Title" Approach

The ossification of the entire license application process under the current mode needs a complete overhaul to solve the difficulties facing the permanent SNF storage problem. The option should provide strong incentives to motivate private utilities companies operating nuclear power plants to find timely and effective solutions for the permanent disposal of SNF. This would be in stark contrast to the current scheme administered by the DOE, which is subject to the unpredictable and bureaucratic congressional budget process.

This Note proposes legislation that completely abandons the current "take title" approach, and replaces it with an industry-driven and market-oriented approach where the commercial nuclear industry will assume the responsibility as well as the cost thereof to find a solution to dispose of the SNF they themselves produced.

1. A Market-Oriented Approach: Let the Waste Producers Manage Their Own Waste

The current mode of waste management, which involves the utilities companies sign a standard contract with the DOE

156. In re Aiken County, No. 11-1271, 2012 WL 3140360, at *1 (D.C. Cir. 2012) [hereinafter In re Aiken County II].
157. *Id.*
158. 42 U.S.C. § 10134(d) (2012).
159. *In re Aiken County II*, 2012 WL 3140360, at *1.
160. *Id.*
161. *Id.*
162. *Id.*
163. In re Aiken County, 725 F.3d 255, 257 (D.C. Cir. 2013).
164. *Id.* at 259.
165. *Id.* at 260.
166. *Id.*
167. *Id.* at 268-69.
168. *Id.* at 269-70.

and let a large federal agency take care of the site selection and construction removed any incentive for the producers to consider ways to dispose of the SNF, which are produced in their power plant every day. In fact, the current arrangement creates a disincentive for the utility companies and the whole industry,[169] which would benefit the most from efficient disposal of the SNF, to pursue a sustainable and efficient waste management strategy.

a. The Successes of Finland and Sweden in Dealing With the SNF Problem

Finland and Sweden have garnered the most success in managing the storage of SNF, by adapting an industry-oriented approach.[170]

Finland's permanent storage program started in 1983.[171] In 1995, the Posiva Oy, a separate company owned and operated by the two Finnish utilities operators Teollisuuden Voima Oyj and Fortum Power & Heat Oy, was set up and charged with responsibility of finding solution for final disposal of spent nuclear fuel produced by the owners[172] The permanent SNF repository, near Olkiluoto, was granted a construction license in 2015[173] and will become operational in the 2020s.[174]

Even though Finland only has four nuclear power plants—with a fifth under construction[175]—Finland has made significant strides towards solving the problem of permanently disposing of spent nuclear fuel.[176] This success for Finland is owed primarily to effective planning by the independent, industry-operated siting body—which managed the permanent SNF disposal problem—and the industry's effort in getting local communities involved on a consensual basis.[177]

In 1987, the Finnish Parliament passed the Nuclear Energy Act, which serves a similar function as the NWPA in the United States.[178] The Nuclear Energy Act establishes a legal framework, and includes a licensing mechanism for the disposal of SNF.[179] A major difference between the Finnish and American approaches is that the Finnish Act provides that a licensee whose operations generate nuclear waste is responsible for all waste management and costs.[180] Under the authority conferred under the Act, the Finnish Ministry of Trade and Industry issued the Nuclear Energy Decree in which each nuclear power plant operator is required to submit a plan on nuclear waste management on an annual basis.[181] The two nuclear power plant operators formed Posiva Oy: "an expert organization responsible for the final disposal of spent nuclear fuel."[182]

Within a decade, this industry operated joint venture completed the environmental impact assessment, filed a timely application for Eurajoki to be the location of the final SNP reposition, and received approval from the parliament.[183] The intense public campaign carried out by the Posiva Oy, which emphasizes local consensus, public participation, and education,[184] generated favorable results. In 2000, the local Council of Eurajoki approved the repository by a twenty to seven vote.[185] The construction license application for the repository was submitted in 2012 by Posiva Oy, and the construction started in late 2016.[186]

Sweden took a strikingly similar approach to solve the SNF disposal problem. Sweden engaged with the local community while conducting site selection process. The party that is responsible for the finance and disposal of the SNF in Sweden is also an independent body owned by the commercial nuclear industry.[187] This industry-owned siting body is the Swedish Nuclear Fuel and Waste Management Company ("SKB"), which is owned by four companies operating commercial nuclear power plants in Sweden.[188] The Swedish Parliament passed the Waste Legislation ("Stipulation Act") in 1977 to establish a mechanism for the management and disposal of the nuclear waste.[189] The act similarly provides that approval for a license to operate is conditioned on the

169. Spencer, *supra* note 151.
170. *National Policies and Funding: Radioactive Waste Management Appendix 2*, World Nuclear Ass'n, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/appendices/radioactive-waste-management-appendix-3-national-p.aspx [https://perma.cc/BHL9-MNML] (last updated Apr. 2017).
171. Henry Fountain, *On Nuclear Waste, Finland Shows U.S. How It Can Be Done*, N.Y. Times (June 9, 2017), https://www.nytimes.com/2017/06/09/science/nuclear-reactor-waste-finland.html [https://perma.cc/V8B7-WFPS].
172. *Posiva Is an Expert in Nuclear Waste Management*, Posiva, http://www.posiva.fi/en/posiva#.WImae31qvAQ [https://perma.cc/PEX7-DHTV] (last visited Jan. 26, 2017).
173. *Onkalo*, Posiva, http://www.posiva.fi/en/final_disposal/onkalo#.WrBtmmaZPow [https://perma.cc/B3RA-PG73] (last visited June 2, 2018).
174. *Final Disposal*, Posiva, http://www.posiva.fi/en/final_disposal#.WrBtMGaZPow [https://perma.cc/4JUD-UBP2] (last visited June 2, 2018).
175. *Nuclear Power in Finland*, World Nuclear Ass'n, http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/finland.aspx [https://perma.cc/SZ79-6LFT] (last updated Apr. 2018).
176. *See id.*
177. *See* Charles de Saillan, *Disposal of Spent Nuclear Fuel in the United States and Europe: A Persistent Environmental Problem*, 34 Harv. Envtl. L. Rev. 461, 504-05 (2010).
178. *See* de Saillan, *supra* note 177, at 505.
179. *Id.* at 505.
180. *See* Chapter 3, § 9 Ydinenergialaki [Nuclear Energy Act] (Suomen säädöskokoelma [SDK] 990/1987) (Fin.), http://www.finlex.fi/en/laki/kaannokset/1987/en19870990.pdf [https://perma.cc/97C3-PML2].
181. *See* Chapter 12 § 74 Ydinenergia-asetus [Nuclear Energy Decree] (SDK 161/1988) (Fin.), http://www.finlex.fi/en/laki/kaannokset/1988/en19880161.pdf [https://perma.cc/N4HM-QRKE].
182. *Posiva Is an Expert in Nuclear Waste Management*, Posiva, http://www.posiva.fi/en/posiva#.WImae31qvAQ [https://perma.cc/KG3K-48FM] (last visited Jan. 26, 2017).
183. *See Nuclear Power in Finland*, *supra* note 175 ("Four locations were investigated by Posiva in some detail—all were technically suitable, and were covered in Posiva's environmental impact statement for the final repository. In 1999, Posiva applied for a decision in principle for the final disposal facility to be sited at Eurajoki. The decision in principle was issued by the Government at the end of 2000 and ratified by Parliament by a 159 to 3 vote in May 2001.").
184. *See* Antti Leskinen & Markku Turtiainen, Posiva Oy, Interactive Planning in the EIA of the Final Disposal Facility for Spent Nuclear Fuel in Finland: Working Report 18 (2002), http://www.posiva.fi/files/2164/POSIVA-2002-45_Working-report_web.pdf [https://perma.cc/6Q45-3NX9].
185. *See* de Saillan, *supra* note 177, at 506.
186. Press Release, Posiva, *First Excavation Works for Posiva's Final Disposal Facility to Begin—YIT as Contractor* (Nov. 29, 2016), http://www.posiva.fi/en/media/press_releases/first_excavation_works_for_posivas_final_disposal_facility_to_begin_-_yit_as_contractor.3300.news#.WImfE31qvAQ [https://perma.cc/X742-UBJT].
187. *Nuclear Power in Sweden*, World Nuclear Ass'n, http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/sweden.aspx [https://perma.cc/LJ3A-E4QY] (last updated Jan. 2018).
188. *Id.*
189. *Id.*

plan from the applicant's side which indicates the method and location the SNF could be stored in accordance with the approved safety standard.[190]

SKB, in searching for location for a permanent SNF repository, engaged in extensive interactions with the local community. It invited all Swedish municipalities to participate in the site selection project and encouraged municipalities that are interested in the project to participate in the *feasibility studies* for constructing the waste *repository.*[191] In 2002, two municipalities—Oskarshamn and Osthammar, approved further site investigations.[192] Since 2002, the SKB has held more than thirty separate consultations on the candidate sites as required in the environmental code regarding the consultations.[193] The consultations encompassed a wide range of events, including public meetings, meetings with citizens groups and local officials, all of which stimulated the public discussion of the project.[194] In 2009, the Osthammar site was selected for repository and it is likely to open in 2028.[195]

b. How the United States Could Replicate the Success in Sweden and Finland in the Long Run

For the United States to succeed on a private industry-led, market-oriented approach similar to that of Finland and Sweden, it needs to implement radical changes on its current mode of waste management. This involves two primary changes.

First, this Note proposes the structural reorganization under which the whole permeant SNF waste management scheme operates. The current scheme, under the statutory authority of the NWPA and other subsequent legislation, is akin to a three-legged stool—(1) the DOE, "is responsible for designing, constructing, operating, and decommissioning a permanent disposal facility for HLW, under NRC licensing and regulation;"[196] (2) EPA "is responsible for developing site-specific environmental standards for use in evaluating the safety of a geologic repository;"[197] and (3) "[t]he NRC is responsible for developing regulations to implement the EPA's safety standards, and for licensing and overseeing the construction and operation of the repository."[198] My proposal is a legislative change which will replace one leg of the current arrangement to make the whole scheme more efficient and effective. Congress should enact legislation which takes DOE's power of site selection and construction out of the hands of the federal government. Instead, such power should be granted to a completely new private company owned and operated by the industry. Such shift in power will produce a strong incentive for the private sector to find a way to dispose its new wastes in compliance with the safety standard that is still issued by the EPA, and oversight and final approval of the license application still provided by the NRC.

This reorganization serves several benefits. First, it will provide enough incentives for the commercial nuclear power industry to seek a timely solution because it is now fully in charge of managing its own wastes. Risks associated with those toxic radioactive wastes will now be tied to the private sector, not to the federal government. Every minute the private nuclear power plants operators remain idle on the issue of SNF disposal, the amount of waste produced in their plants will get larger and the risks related to the stockpile of SNF will become more likely. Second, a private organization which represents the industry and its own interest will be adequately protected from the political battle in Washington, which is one of the primary reasons why the Yucca Mountain Project was dragged for decades and finally derailed under the Obama Administration. Third, without the enormous coercive power upon which the federal government often operates on large projects like this, the private organization must cooperate closely with the local government in a consensual manner because it cannot use tools to compel the local government to cooperate. The strong state and local opposition is another main reason why the Yucca Mountain Project is stalled.

The second change involves revisions on the conduit through which the repository project gets its funding. The current "take title" approach works as follow: (1) the power plants are levied a flat fee based on their power production and such fee will be used and managed by the federal government; (2) in turn, the federal government, through its agency, will assume the title of the waste produced; (3) the federal government will store the nuclear wastes in the repository that it is contracted to build and operate.[199] Such a system, however, now in suspension due to a court order,[200] has major drawbacks. The plant owners will be able to continue to produce waste with no impediment and no concern about whether there will be a place for them to permanently store the wastes—because that is the concern for the government. Because of the constant delays resulting from the breach of the standard contract signed by the operators and the DOE in accord with NWPA, the industry will continue to sue the DOE demanding monetary damages.

From private section's prospect, they will be able to producing nuclear wastes with minimal regard to the problem of permanent SNF disposal and at the same time, collecting money damage from the federal government. The same absence of interest to speed up the project is equally felt on the federal government's side. The mounting money damage

190. *Id.*
191. *See* de Saillan, *supra* note 177, at 502.
192. *See id.*
193. *See id.* at 503.
194. *Id.*
195. *See* Temiz, Fatih, Nuclear Power, Its Waste in the World and In Turkey, (August, 2017), *available at* http://dergipark.gov.tr/download/issue-file/6545 [https://perma.cc/X24U-LNBF] (Östhammar site selected for repository (volunteered location), likely to open in 2028).
196. *What We Regulate*, U.S. Nuclear Regulatory Comm'n, https://www.nrc.gov/waste/hlw-disposal/what-we-regulate.html [https://perma.cc/VHL8-TBLX] (last updated Feb. 12, 2018).
197. *Id.*
198. *Id.*
199. 42 U.S. Code § 10222(a)(5) (2012).
200. *See* Nat'l Ass'n of Regulatory Util. Comm'rs v. Dep't of Energy, 736 F.3d 517, 521 (D.C. Cir. 2013).

itself would not substantially hurt the DOE. DOE is a federal agency that ran on taxpayers' money and will not to go bankrupt like private businesses. The current system is both irrational and inefficient.

Therefore, instead of levying a flat fee as set out by the government, each nuclear operator would contribute a percentage of their operating income as they see fit based on their own assessment (including factors such as the urgency of their SNF disposal, the total amount of the SNF, and the revenue they generated) to the management company to fund the research of the geologic site and the construction of the repository. Their contribution will be pooled together and each contribution will be linked *pro rata* to the total capacity of the proposed permanent nuclear repository. For instance, if the total capacity of the proposed location is 10 thousand tons, the operator whose contribution amounts to 10% of the total funds contributed to the project will receive 10% of that capacity, namely a one-thousand-ton allowance, to store its SNF when the repository is completed.

Since any repository has a limited capacity,[201] each private nuclear power company who has participated in the management company will be fully incentivized into investing the research and construction of the repository as they want to gain an option to store a greater amount of SNF they produced in the limited space of the permanent repository. On the other side, the competition between companies from the private sector would guarantee an adequate funding for the management company. Unlike the current mode where the daily operation of the DOE is subject to the mercy of the congressional appropriation, which makes the DOE highly susceptible to partisan battle, the self-funding nature of this private management company will be completely isolated from the political influence and remain solely to the task it is statutorily assigned to do.

Since the problem of permanent disposal of SNF has been haunting the United States for more than thirty years, many scholars and think tanks have been trying to create innovative ways to resolve the deadlock. However, their solutions are either insufficient to resolve the inherent defects of the NWPA, or will take too long to realize, which will make the current SNF problem even worse.

Some legal scholars have called for the creation of a federal independent agency to replace the DOE's role in site selection and construction.[202] However, such a suggestion would not alleviate the two major defects that are plaguing the current mode. Granted, an independent federal agency with the sole purpose of repository site selection, construction, and operation would be more resilient to the political battle between the two major parties. However, since it is still an agency under the federal government, its commission's members will still be appointed by the President, subject to the confirmation of Congress.[203] This is exactly what happened to the NRC board when the Obama administration replaced the commission members with the help of Congress, which at the time was also controlled by the Democratic Party.[204] Also, such independent agency will still be operated under either congressional appropriation or flat fee contributions from the private sector.[205] Even the agency itself can withhold the political pressure from the President, it will still be able to be starved should Congress decide to cut the funding of the agency.[206]

Other scholars have proposed a similar change involving the creation of a "a privately-held corporation" to ensure efficiency and flexibility.[207] However, the suggestion brought by Professor Charles de Saillan never addresses the method through which such a corporation gets its operating funds, which is essential to an effective solution to the permanent disposal of the SNF. Other researchers working for conservative think tanks, including Jack Spencer for the Heritage Foundation, advocated for a free market approach through a private management body which will sell the space of the permanent SNF repository it develops to the nuclear power plant operators.[208] His approach, however, does not provide enough market incentive for the operators to invest and involves too many uncertainties. His approach recognizes that the limited space in the repository should be treated as a commodity, and bought and sold between operators, and the money raised would be the funding for that private management body. Unlike the bright-line *pro rata* method proposed in this Note, which operates purely on the competitional basis, the criteria upon which the space is priced in his report is determined by a set complex and vague factors, including "heat content of the waste, predicted production of used fuel, repository capacity, and lifetime operation costs. . . ."[209] Each of these variables "would help to determine the price of placing a given volume of waste in Yucca at any specific time."[210] This shortcoming of Spencer's approach is that the factors of determining the price of the space will be, again, a major litigation topic among corporate participants. Also, the scientific uncertainty in regard of price determination will severely slow down the whole process and affect the amount of money that the management body could raise through the marketplace.

201. *See* 42 U.S.C. § 10134(d) (2012) ("The Commission decision approving the first such application shall prohibit the emplacement in the first repository of a quantity of spent fuel containing in excess of 70,000 metric tons . . .").

202. *See* Stewart & Stewart, *supra* note 67, at 117-26 (calling for the establishment of a single purpose federal agency dedicating solely to the development of the permanent SNF repository. The advantage of arrangement would be its independence from the political battle). Stewart, *supra* note 10, at 811-15 ("A solution to these difficulties is to create a new, separate entity whose sole function would be to manage nuclear waste. It would not site new storage facilities or repositories, but would be responsible for waste storage, treatment, and transportation . . . Continuity of funding could be assured by making a nuclear generation fee payable directly to the entity, or establishing contractual arrangement for utility funding. Alternatively, funding by Congress could be accomplished through long term appropriations, possibly including a revolving fund separate from the unified federal budget.").

203. *See* Richard Pierce Jr. et al., Administrative Law and Process 101-02 (5th ed. 2008).

204. *See* discussion *infra* Section IV.C.ii.

205. *Cf.* Stewart, *supra* note 10, at 813.

206. *Id.*

207. *See* de Saillan, *supra* note 177, at 509-11.

208. *See, e.g.*, Spencer, *supra* note 151.

209. *Id.*

210. *Id.*

c. How to Tackle the Immediate Pressure of Rapidly Growing Volume of the SNF in the United States

This Note proposes that the private-sector lead a free-market approach in the previous section, aiming in the long run to build a permanent repository in a suitable geologic location. The whole process could take up to several decades to complete, considering that Finland's process, which is the fastest among countries that have similar projects, takes more than one decade from start to finish.[211] Given the enormous amount of existing SNF and the likely growth in the near future, should the general trend of growth continue,[212] the first repository would like be unable to handle all the existing waste, let alone the wastes that will be produced in the near future. To ensure that the long-term goal of developing permanent SNF repository would not be overwhelmed by the rapid growth of SNF produced in the next few decades, this Note proposes a supplementary short-term solution aiming at reducing the rate at which the amount of SNF will be produced in the near future by tightening up the application requirements for the operating license.

The most urgent changes should be focused on those nuclear plants that are near their original forty-year operating license. Most reactors now operating in the United States were built between the 1970s and 1990s.[213] As a result, roughly one-third of nuclear power plants will exhaust their original forty-year operating license and must file a renewal application to the NRC in order to continue to operate.[214] Besides continuing to operate under the assumption that the take title approach will be repealed and replaced, the current law regarding the continuous storage of nuclear waste upon license renewal holds an overly optimistic view of the availability of permanent repositories.[215] It also places minimal emphasis on long-term on-site storage of the SNFs.[216] This means that the operators who wish to renew their operating license from the NRC will not be as concerned about the safety of medium to long-term on-site storage in their Environmental Impact Statement as they are to the safety of short-term on-site storage when they try to get their license renewed.

The law this Note proposes calls for stricter regulations in the current operating license renewal process. The regulatory changes will place a heavier emphasis on the medium to long-term on-site storage plans. Also, the new regulatory changes will make it mandatory for the applicants seeking renewal to participate in the private management company discussed in the previous section. More stringent license renewal standards, combined with mandatory participation for the industry-run management company will ensure that the aging plants not suitable for continuous operation will not be granted licenses, which will reduce the rate of growth of nuclear waste. Conversely, those plants that are suitable for license renewal will claim responsibility of permanent deposal of the SNF they produced under the renewed license, which will further motivate those operators to invest more in the permanent repository program.

VI. Conclusion

The saga of the Yucca Mountain Project is a failure that led to a huge waste of human resources and taxpayers' money. The dysfunction of the NWPA is multi-faceted. The proposals of this Note signal an overhaul of the current broken system. By abandoning the current mode of operation and embracing an industry-driven and market-oriented mechanism on the question of permanent SNF disposal, especially the site selection and construction, the pressure is shifted from the federal government to the private sector, which values the bottom line more than anything else. This proposal would likely to speed up the time required to have a viable permanent repository project. Whether the federal government is willing to relinquish the power to the private sector, however, is a question that will remain to be seen.

---

211. *See* discussion *infra* Section V.A.i.1.
212. *See* Seth Shulman, *The Growing Threat of Nuclear Waste*, Catalyst (2013), https://www.ucsusa.org/publications/catalyst/su-13-the-growing-threat-of-nuclear-waste.html#.WrFELmaZPow [https://perma.cc/2ER9-PKP9].
213. *See* discussion *infra* Section III.A.
214. *See* Matthew Wald, *Due Up for License Renewal: The Future of Nuclear Power*, N.Y. Times (June 24, 1991), http://www.nytimes.com/1991/06/24/us/due-up-for-license-renewal-the-future-of-nuclear-power.html?pagewanted=all [https://perma.cc/5R9C-X9PH] ("Over the next 25 years, more than half the nuclear plants in the United States will turn 40 . . .").
215. *See* 10 C.F.R § 51.30(b) (2014) ("As stated in § 51.23, the generic impact determinations regarding the continued storage of spent fuel in NUREG-2157 shall be considered in the environmental assessment, if the impacts of continued storage of spent fuel are relevant to the proposed action.").
216. U.S. Nuclear Regulatory Comm'n, NRC-2012-0246, Continued Storage of Spent Nuclear Fuel 25-26 (2013), https://www.nrc.gov/docs/ML1417/ML14177A477.pdf [https://perma.cc/26WW-PC3G] ("The first timeframe is the short-term timeframe, which analyzes 60 years of continued storage after the end of a reactor's licensed life for operation. The NRC considers the short-term timeframe to be the most likely scenario for continued storage; and the GEIS assumes that a repository would become available by the end of the short-term timeframe.").