[University of Richmond Law Review](https://scholarship.richmond.edu/lawreview)

Volume 49 | Issue 4 Article 10

5-1-2015

What's Worse, Nuclear Waste or the United States' Failed Policy For Its Disposal?

Christopher M. Keegan
University of Richmond School of Law

WHAT'S WORSE, NUCLEAR WASTE OR THE UNITED STATES' FAILED POLICY FOR ITS DISPOSAL?

INTRODUCTION

The United States of America is a nuclear nation. Despite individuals and organizations opposed to nuclear energy,[1] the reality is that nuclear power is an integral part of our nation and world.[2] In the United States specifically, nuclear power plays a vital role. Just less than 20% of the electricity produced in the United States comes from nuclear power.[3] Sixty-one commercial nuclear power plants currently operate in thirty states.[4] Furthermore, nuclear power is the most abundant clean energy source, accounting for roughly 60% of the non-fossil fuel electricity generated in the United States.[5] Additionally, the United States Navy is built around nuclear energy. As of 2009, approximately 45% of the Navy's ships were nuclear powered, with 103 reactors powering eleven aircraft carriers and seventy-one submarines.[6]

Whether or not the United States continues to use nuclear power into the future, the country will be left with the remnants

---

1. *See generally* Karl S. Coplan, *The Externalities of Nuclear Power: First, Assume We Have a Can Opener . . .* , 35 ECOLOGY L. CURRENTS 17 (2008) (arguing that the benefits of nuclear power are not worth the long term impacts of nuclear energy production).

2. *See* Alex Funk & Benjamin K. Sovacool, *Wasted Opportunities: Resolving the Impasse in United States Nuclear Waste Policy*, 34 ENERGY L.J. 113, 114 (2013) (stating that nuclear power accounts for 13.5% of the world's electricity).

3. *Nuclear Explained*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/energyexplained/index.cfm?page=nuclear_home#tab2 (last updated Sept. 8, 2014).

4. *How Many Nuclear Power Plants Are in the United States, and Where Are They Located?*, *Frequently Asked Questions*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/tools/faqs/faq/cfm?id=207&t=3 (last updated Jan. 22, 2015); *see also Nuclear Power in the USA*, WORLD NUCLEAR ASS'N, http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/USA-Nuclear--Power/ (last updated Feb. 2015).

5. *See What Is U.S. Electricity Generation by Energy Source?*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3 (last updated June 13, 2014) (stating that 67% of electricity in the United States is generated by fossil fuels and 19% by nuclear; therefore, nuclear energy accounts for 57% of the remaining 33% of energy not generated by fossil fuels).

6. U.S. DEP'T OF ENERGY & U.S. DEP'T OF THE NAVY, THE UNITED STATES NAVAL NUCLEAR PROPULSION PROGRAM 1 (2009).

of its past nuclear usage for generations to come. After a certain period of time, the uranium fuel inside a nuclear reactor is no longer capable of fission.[7] When this point is reached, the reactor must be refueled, which involves removing the old uranium—spent nuclear fuel ("SNF")—and replacing it with new uranium.[8] SNF is highly radioactive and can be hazardous to humans for tens of thousands of years.[9] There are currently about 72,000 metric tons of SNF being stored on site at commercial nuclear power plants across the country.[10] However, this figure does not include the 13,000 metric tons of SNF and other radioactive waste generated as a byproduct of the defense industry and in the custody of the United States Department of Energy ("DOE") at various locations around the country.[11]

So, what is the government's plan for all of this highly hazardous nuclear waste? Well, currently there is no real plan.[12] As a result of overly restrictive legislation and political fighting, the United States has been unable to devise a solution to the problem of where to safely store the ever-increasing stockpile of nuclear waste.[13] The status quo of leaving SNF sitting on-site at nuclear power plants raises safety concerns and questions about the ability to use those locations for some other purpose in the future. Critics have raised concerns about SNF stored at power plants being susceptible to terrorism and natural disasters.[14] Additionally, under the current scheme, SNF remains in place even after its

---

7. *See* U.S. NUCLEAR REGULATORY COMM'N, NUREG/BR-0216, REV. 2, RADIOACTIVE WASTE: PRODUCTION, STORAGE, DISPOSAL 7 (2002), *available at* http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0216/r2/br0216r2.pdf.

8. *Id.*

9. Funk & Sovacool, *supra* note 2, at 117.

10. *U.S. State by State Used Fuel and Payments to the Nuclear Waste Fund*, NUCLEAR ENERGY INST., http://www.nei.org/Knowledge-Center/Nuclear-Statistics/On-Site-Storage-of-Nuclear-Waste/US-State-by-State-Used-Fuel-and-Payments-to-the-Nu (last updated May 2014).

11. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-11-230, DOE NUCLEAR WASTE: BETTER INFORMATION NEEDED ON WASTE STORAGE AT DOE SITES AS A RESULT OF YUCCA MOUNTAIN SHUTDOWN 1–2, 29 (2011); *Disposal of High-Level Nuclear Waste*, U.S. GOV'T ACCOUNTABILITY OFFICE, http://www.gao.gov/key_issues/disposal_of_highlevel_nuclear_waste/issue_summary (last visited Apr. 3, 2015).

12. *See* Funk & Sovacool, *supra* note 2, at 115 (using the term "Achilles Heel" to describe the waste disposal problem, which has plagued the nuclear industry for sixty years).

13. *See id.* at 115–16.

14. *See* Richard B. Stewart & Jane B. Stewart, *Solving the Spent Nuclear Fuel Impasse*, 21 N.Y.U. ENVTL. L.J. 1, 4 (2014) (indicating that there is a growing concern for safety over at-reactor SNF storage).

associated nuclear power plant has been shut down and thus prevents the land on which it sits from being used for other purposes.[15]

This comment will analyze the SNF problem in the United States and offer recommendations for how to move forward. First, Part I will summarize the path that has led to this impasse. Part II offers recommended solutions on how the United States can develop a workable SNF solution that includes a permanent repository, consolidated intermediate storage, and reprocessing. Finally, this comment will offer its conclusion that the United States should begin the process of establishing a permanent geologic repository for SNF at a location other than Yucca Mountain, create a system of consolidated interim storage to temporarily house SNF, and establish a program to reprocess SNF.

I. THE SNF PROBLEM

The path that led to the current SNF situation is full of many political and legal complications. It is, however, critical to understanding the current condition of the SNF problem and is worth summarizing here.

A. *The Nuclear Fuel Cycle*

The nuclear fuel cycle is a term used to refer to "the series of industrial processes used to produce electricity from uranium in a nuclear reactor."[16] Broken down into three major parts, the cycle consists first of a "front end," the mining and preparation of uranium to be used as nuclear fuel; second, the fuel is used in a nuclear reactor to create electrical energy; and third, the "back end," when the SNF is removed from the reactor and stored for ultimate disposal.[17]

During the second part of the nuclear fuel cycle, when the uranium is being used as fuel in an operating reactor, neutrons collide with uranium atoms resulting in fission—the splitting of the

---

15. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, REPORT TO THE SECRETARY OF ENERGY 9, 35 (2012) (explaining that SNF left on-site at shutdown power plants prevents the land from other economically beneficial uses).

16. *Id.* at 9.

17. *Id.*

uranium atoms.[18] The splitting of a uranium atom creates fission fragments, each about half the mass of the original atom, and a number of additional neutrons.[19] These neutrons will go on to collide with other uranium atoms, continuing the chain reaction.[20] The splitting of uranium atoms into fission fragments creates kinetic energy, which is in turn converted to heat and then electricity.[21] The fission fragments created in the nuclear reaction are highly radioactive, and they remain in the SNF after it is removed from the reactor.[22]

When the nuclear fuel can no longer efficiently produce energy, it is removed from the reactor.[23] At the point of initial removal from the reactor, the SNF has a high temperature and emits large amounts of radiation; it is therefore considered a High-Level Waste ("HLW").[24] Immediately after coming out of the reactor, SNF is kept in "wet storage" by submerging it in deep, water-filled pools.[25] The SNF is typically kept in these pools for around five years in order to keep it cool and help dissipate the radiation that it emits.[26] After the SNF has cooled down sufficiently in wet storage, it can be safely moved to "dry storage."[27] Dry storage is typically accomplished by placing the SNF inside casks comprised of an inner steel container surrounded by an outer concrete and steel container.[28] The SNF inside the dry casks can still have relatively high temperatures, but is cooled through natural circulation of air.[29]

---

18. *See How a Nuclear Reactor Makes Electricity*, WORLD NUCLEAR ASS'N, http://www.world-nuclear.org/nuclear-basics/how-does-a-nuclear-reactor-make-electricity-/ (last visited Apr. 3, 2015); *Physics of Uranium and Nuclear Energy*, WORLD NUCLEAR ASS'N, http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Introduction/Physics-of-Nuclear-Energy/ (last updated Sept. 2014).

19. *Physics of Uranium and Nuclear Energy*, *supra* note 18.

20. *Id.*

21. *See id.*

22. *See id.*; BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 11.

23. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 10.

24. *See id.* at 10–11; *High-Level Waste*, U.S. NUCLEAR REGULATORY COMM'N, http://www.nrc.gov/waste/high-level-waste.html (last updated Apr. 6, 2012) (identifying SNF as one form of HLW).

25. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 11.

26. *Id.*

27. *Id.*

28. *See id.*

29. Stewart & Stewart, *supra* note 14, at 27.

B. *Early SNF Policy*

Civilian nuclear power was first developed commercially in the United States in the 1950s with the understanding that the resulting SNF would be reprocessed for our nation's nuclear weapons program.[30] Under this early policy, SNF was only to be stored on site at nuclear power plants temporarily until it would be transported to reprocessing facilities so that the unused uranium and plutonium in the SNF could be separated and reused.[31] However, even after the reprocessing of SNF, there is still a portion of the radioactive waste that requires disposal.[32] So, in 1957 the National Academy of Sciences ("NAS") determined that underground burial would be the best solution for HLW disposal.[33] Furthermore, in the 1970s, concerns about nuclear weapons proliferation effectively ended the United States' policy of commercial SNF reprocessing.[34] In 1978, with reprocessing of SNF no longer considered an option, an Interagency Review Group recommended that the federal government become responsible for the disposal of commercial SNF and that it be disposed in a geologic repository.[35]

C. *Nuclear Waste Policy Act of 1982*

Subsequent to shifting from a policy that included SNF reprocessing to one that was solely focused on geologic burial, Congress passed the Nuclear Waste Policy Act of 1982 ("NWPA").[36] The NWPA established that the federal government would take custody of commercial SNF and required the DOE to recommend at least five sites for a potential location for a geologic repository for its indefinite burial.[37] The NWPA also authorized the development of "monitored retrievable storage" facilities, which would act as centralized locations for the interim storage of SNF while a re-

30. *See* Funk & Sovacool, *supra* note 2, at 117–18; Stewart & Stewart, *supra* note 14, at 8–9.

31. Funk & Sovacool, *supra* note 2, at 118.

32. *Id.* at 140.

33. Debra J. Carfora, *Building a Sustainable Energy Future: Offering a Solution to the Nuclear Waste Disposal Problem Through Reprocessing and the Rebirth of Yucca Mountain*, 8 TEX. J. OIL GAS & ENERGY L. 143, 153 (2012).

34. Stewart & Stewart, *supra* note 14, at 9.

35. Carfora, *supra* note 33, at 153; Funk & Sovacool, *supra* note 2, at 119.

36. Nuclear Waste Policy Act of 1982, 42 U.S.C. §§ 10101–10270 (2012).

37. Carfora, *supra* note 33, at 154.

pository was being constructed.[38] Until a geologic repository or centralized interim storage was developed, electric utilities were to continue storing their SNF on-site at nuclear power plants.[39]

The NWPA also established the Nuclear Waste Fund ("NWF") to finance the disposal of SNF.[40] In exchange for the federal government's eventual assumption of custody of the United States' commercial SNF, nuclear utilities were required to make annual contributions to the NWF, which would pay for the eventual disposal of the SNF.[41] The Standard Contracts the utilities entered into with the DOE stated that the DOE would begin to dispose of the SNF no later than January 31, 1998.[42]

The DOE encountered significant political resistance from local communities in its efforts to choose locations for a geologic repository and consolidated interim storage facilities.[43] Therefore, in order to speed up the process of establishing those locations, Congress amended the NWPA in 1987.[44] These amendments to the NWPA established that the sole candidate for a SNF geologic repository in the United States would be located at Yucca Mountain in Nevada.[45] Additionally, in an effort to ensure that a repository would actually be established, the 1987 NWPA amendments also prohibited the DOE from constructing any consolidated interim storage facility for commercial SNF until a license has been granted for the geologic repository.[46]

D. *Yucca Mountain*

Yucca Mountain, located about ninety miles northwest of Las Vegas, Nevada, is the only legally possible site for a commercial

38. 42 U.S.C. § 10161; *see also* Funk & Sovacool, *supra* note 2, at 120.
39. 42 U.S.C. § 10151; *see also* Funk & Sovacool, *supra* note 2, at 120.
40. 42 U.S.C. § 10222(c); *see also* Funk & Sovacool, *supra* note 2, at 120.
41. 42 U.S.C. § 10222(a)(5); *see also* Funk & Sovacool, *supra* note 2, at 121.
42. 42 U.S.C. § 10222(a)(B); *see also* Funk & Sovacool, *supra* note 2, at 121.
43. Stewart & Stewart, *supra* note 14, at 9.
44. 42 U.S.C. § 10172(b); *see also* Stewart & Stewart, *supra* note 14, at 9.
45. *See* 42 U.S.C. § 10172(a); Carfora, *supra* note 33, at 155.
46. 42 U.S.C. §§ 10165(b), 10168(d)(1); *see also* Funk & Sovacool, *supra* note 2, at 120; Stewart & Stewart, *supra* note 14, at 67 (explaining that the restrictions that the 1987 amendments to the NWPA placed on consolidated interim storage facilities were based on a concern that their establishment would undermine the development of a geologic repository).

SNF repository in the United States.[47] The site, which is owned by the federal government, has been determined by the DOE to be a "'stable geologic environment,' unlikely to be disturbed by seismic or volcanic forces."[48]

Since the passage of the NWPA, Yucca Mountain has been extensively studied and prepared to house the United States' SNF repository.[49] The DOE has assessed Yucca Mountain as a "promising site for a geologic repository."[50] So, in 2002, after spending $7.1 billion studying the suitability of Yucca Mountain, President Bush signed the Yucca Mountain Development Act (YMDA) into law, which began the licensing process for Yucca Mountain as a SNF geologic repository.[51]

The State of Nevada has been opposed to the establishment of a SNF repository at Yucca Mountain since passage of the NWPA Amendments in 1987.[52] In addition to submitting a formal "Notice of Disapproval" to Congress before the passage of the YMDA,[53] the State of Nevada, Natural Resources Defense Council, and the Nuclear Energy Institute filed thirteen lawsuits in an attempt to prevent the repository from moving forward.[54] Their efforts did not completely derail Yucca Mountain, but did result in considerable delay. In 2004, the United States Court of Appeals for the District of Columbia held that, in evaluating radiation protection, a 1,000,000-year safety standard should have been used—based on NAS findings—instead of the 10,000-year safety standard that

---

47. Funk & Sovacool, *supra* note 2, at 121.

48. *Id.*

49. *Id.* at 121–22. This includes the excavation of "a five mile tunnel through the mountain to function as an Exploratory Study Facility." *Id.* at 122.

50. OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, DOE/RW-0508, VIABILITY ASSESSMENT OF A REPOSITORY AT YUCCA MOUNTAIN, OVERVIEW 2 (1998).

51. *See* Carfora, *supra* note 33, at 157; Funk & Sovacool, *supra* note 2, at 124.

52. *See* Joseph A. Cohen, *What to Do with America's Nuclear Defense Waste: The Hanford Effect*, 6 KY. J. EQUINE, AGRIC., & NAT. RESOURCES L. 1, 8–9 (2014) (stating that the 1987 NWPA, dubbed the "Screw Nevada bill," has seen significant local resistance); Stewart & Stewart, *supra* note 14, at 9 (noting Nevada's resistance to the Yucca Mountain project).

53. Funk & Sovacool, *supra* note 2, at 123.

54. Carfora, *supra* note 33, at 157.

was used.[55] Therefore, four additional years of research were required by the Environmental Protection Agency to comply with the court's ruling.[56]

In 2008, after twenty years and $12 billion to establish Yucca Mountain as the repository location, the DOE submitted a licensing application to the Nuclear Regulatory Commission ("NRC") to begin the three-year licensing process.[57] But, in 2009, with the start of the Obama administration, came a shift in policy against Yucca Mountain.[58] First, President Obama requested that Congress discontinue funding the Yucca Mountain project in an attempt to stop its progress.[59] The next year, in 2010, the DOE filed a motion to withdraw the Yucca Mountain licensing application with prejudice, meaning that the application could never be refiled.[60] Although the NRC's Atomic Safety and Licensing Board denied the DOE's petition to withdraw the Yucca Mountain application,[61] the licensing proceeding was nonetheless suspended.[62] States and municipalities that are home to nuclear power plants then brought legal action before the NRC and D.C. Circuit to force the NRC to continue with the licensing procedure.[63] As a result, in August 2013, the D.C. Circuit issued mandamus requiring the NRC to process the Yucca Mountain licensing application.[64] The NRC has since resumed licensing proceedings.[65]

E. *Recent Litigation*

In addition to political and legal issues surrounding the establishment of a geologic repository for SNF, there has also been re-

55. *See* Nuclear Energy Inst. v. Envtl. Prot. Agency, 373 F.3d 1251, 1267, 1273 (D.C. Cir. 2004).

56. Carfora, *supra* note 33, at 158.

57. Cohen, *supra* note 52, at 9.

58. *See id.* According to Cohen, the policy shift against Yucca Mountain was a political decision by President Obama, influenced by Senate Majority Leader Harry Reid (D-Nevada) and tied to a campaign promise Obama made in the 2008 presidential election. *Id.* at 9–10.

59. Carfora, *supra* note 33, at 159.

60. *Id.*; *In re* U.S. Dep't of Energy (High-Level Waste Repository), 71 N.R.C. 609, 615–16, 2010 WL 9105479 at *5 (N.R.C. 2010).

61. *In re U.S. Dep't of Energy*, 71 N.R.C. at 629.

62. Stewart & Stewart, *supra* note 14, at 13.

63. Carfora, *supra* note 33, at 159.

64. *In re* Aiken County, 725 F.3d 255, 267 (D.C. Cir. 2013).

65. Stewart & Stewart, *supra* note 14, at 14.

cent litigation regarding the NWF and licensing and relicensing of commercial nuclear power plants.

In November 2013, the D.C. Circuit held that "[b]ecause the Secretary [of Energy] is apparently unable to conduct a legally adequate fee assessment, the Secretary is ordered to submit to Congress a proposal to change the fee to zero."[66] This has effectively stopped the DOE from collecting money for the NWF.[67]

The uncertainty surrounding the Yucca Mountain SNF repository has also led to problems with the licensing of nuclear power plants. After multiple states filed suit regarding the licensing of nuclear power plants, the D.C. Circuit suspended the licensing process because the NRC had not adequately addressed the possibility of leaks or fires occurring in SNF storage pools, nor had it considered the possibility that a geologic repository might never be built.[68] However, in September 2014, the NRC issued a new "Waste Confidence Rule" which addressed the court's concerns.[69] This has led the NRC to resume issuing licenses for commercial nuclear power plants.[70] However, despite the NRC's new Waste Confidence Rule, recent petitions have been filed to again stop the licensing and relicensing of nuclear power plants.[71] With this continued litigation, it appears that there will not be any resolution to the SNF problem soon.

---

66. Nat'l Ass'n of Regulatory Util. Comm'rs v. U.S. Dep't of Energy, 736 F.3d 517, 521 (D.C. Cir. 2013).

67. *See* Stewart & Stewart, *supra* note 14, at 4 n.3.

68. New York v. Nuclear Regulatory Comm'n, 681 F.3d 471, 478–79 (D.C. Cir. 2012).

69. Continued Storage of Spent Nuclear Fuel, 79 Fed. Reg. 56,238 (Sept. 19, 2014) (to be codified at 10 C.F.R. pt. 51); *see also* Sonal Patel, *NRC Issues Final Rule to Replace Waste Confidence Decision, Ends Licensing Suspension*, POWER (Aug. 26, 2014), http://www.powermag.com/nrc-issues-final-rule-to-replace-waste-confidence-decision-ends-licensing-suspension/. This new waste confidence rule concludes that SNF can be safely stored on-site at nuclear power plants indefinitely. *Id.*

70. Nancy Slater-Thompson, *NRC Resumes License Renewals for Nuclear Power Plants*, PENNENERGY (Oct. 31, 2014), http://www.pennenergy.com/articles/pennenergy/2014/10/nrc-resumes-license-renewals-for-nuclear-power-plants.html.

71. *See* Danielle Killey, *Tribe Appeals NRC's Waste Storage Rule30*, REPUBLICAN EAGLE (Oct. 31, 2014, 5:07 PM), http://www.republican-eagle.com/content/tribe-appeals-nrcs-waste-storage-rule30; *Activists File Petition to Stop Licensing of U.S. Nuclear Plants*, LONGVIEW NEWS-JOURNAL (Sept. 29, 2014), http://www.news-journal.com/news/nation/activists-file-petition-to-stop-licensing-ofu-s-nuclear-plants/article_42987d7f-f0e4-54c6-8c07-d3a90beba077.html.

F. *Current SNF Strategy*

While attempting to take Yucca Mountain off the table as the location for a permanent geologic repository for SNF, President Obama, in January 2010, had the DOE establish a Blue Ribbon Commission to develop a solution to the SNF disposal problem.[72] In January 2012, the Blue Ribbon Commission issued its final report, which included recommendations for SNF disposal.[73] Although the Blue Ribbon Commission's report highlighted the need for a geologic repository, it did not address the suitability of Yucca Mountain as a location for that repository or the controversy over the DOE attempting to withdraw the Yucca Mountain licensing application.[74]

In response to the Blue Ribbon Commission's report, in January 2013, the DOE published the administration's Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste.[75] This document essentially parallels the Blue Ribbon Commission's recommendations, and it also fails to provide a specific plan for how the location of a permanent repository will be determined.[76] In fact, the DOE's strategy does not mention Yucca Mountain at all, not even in an historical context.[77]

However, this recent anti-Yucca Mountain policy shift is in direct conflict with the existing statutory scheme created by the NWPA.[78] As a result, there is currently no real plan to solve the SNF problem. Serious work still needs to be done in order to develop a workable solution. Applying the following recommendations would be a step in that direction.

---

72. Funk & Sovacool, *supra* note 2, at 116; *see also* Carfora, *supra* note 33, at 159 (describing how the Blue Ribbon Commission was part of the President's plan to terminate the Yucca Mountain project).

73. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at vii; Cohen, *supra* note 52, at 10–11.

74. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at vii–viii.

75. U.S. DEP'T OF ENERGY, STRATEGY FOR THE MANAGEMENT AND DISPOSAL OF USED NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE 1 (2013) [hereinafter DOE STRATEGY], *available at* http://www.energy.gov/downloads/strategy-management-and-disposal-used-nuclear-fuel-and-high-level-radioactive-waste; Cohen, *supra* note 52, at 11–12.

76. *See* Cohen, *supra* note 52, at 12.

77. *See* DOE STRATEGY, *supra* note 75.

78. *See supra* note 45 and accompanying text.

II. RECOMMENDED SOLUTIONS

Despite the systemic problems with the United States' SNF policy, there are steps that can and should be taken in order to provide a solution. Specifically, the United States should immediately begin the process of developing one or more consolidated interim storage facilities in addition to a geologic repository in a location other than Yucca Mountain. Additionally, the United States should initiate a commercial SNF reprocessing program in order to reduce the volume of waste that will require permanent disposal.

A. *Permanent Geologic Repository and Consolidated Interim Storage*

Any solution to the SNF disposal problem must include establishing a physical location for our country's SNF to reside. As discussed below, although reprocessing of SNF can reduce the volume of waste to be disposed of, portions of the SNF cannot be recycled and must be disposed in some other way.[79] And, although some creative SNF disposal solutions have been proposed, because of safety concerns or international treaties, the only realistic option is permanent disposal in an underground repository.[80] Regardless of how the Yucca Mountain situation is resolved, the United States should immediately start to consider additional repository locations. In the meantime, due to the significant amount of time required to establish a geologic repository, one or more intermediate storage facilities should be established for temporary storage of our country's commercial SNF.[81]

79. Funk & Sovacool, *supra* note 2, at 140 ("[R]eprocessing does not eliminate the disposal issue. Reprocessing still generates a significant volume of highly radioactive waste.").

80. Carfora, *supra* note 33, at 163–64. Some of the locations that have been considered for SNF disposal include outer space, ocean bottom, and within the polar ice. *Id.* at 163. Unfortunately, launching SNF into space is considered too dangerous because of the risk of nuclear contaminated debris being sprinkled across the globe in the event of a rocket malfunction. *Id.* Similarly, international agreements ban the disposal of SNF at sea or within polar ice sheets. *Id.* at 163–64.

81. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 35 ("The Commission concludes that there are several compelling reasons to move as quickly as possible to develop safe, consolidated storage capacity on a regional or national basis.").

1. Geologic Repository

As part of the solution to the SNF problem, the United States should continue to move towards establishing geologic repositories for the eventual permanent disposal of SNF. This plan should include, but not be completely dependent on, Yucca Mountain for a repository location.

SNF requires disposal because it contains a large concentration of unstable isotopes that undergo radioactive decay and in doing so emit high levels of radiation.[82] Exposure to the radiation from SNF can be dangerous to humans because the radiation has the ability to alter the molecular structure of tissue.[83] The harm that results from radiation exposure can lead to cancer, genetic defects, and death.[84] Because of the extremely long half-lives of some of the radioactive isotopes in SNF, it can remain hazardous for thousands of years.[85] Therefore, as the Blue Ribbon Commission stated in its report, "deep geological disposal is the most promising and accepted method currently available for safely isolating [SNF] and high-level radioactive wastes from the environment for very long periods of time."[86]

The development of a repository at Yucca Mountain is clearly at an impasse.[87] Furthermore, the Obama administration has no intention of going forward with the Yucca Mountain project.[88] However, completely abandoning Yucca Mountain would be a mistake.[89]

Yucca Mountain is a prime location to develop an SNF repository.[90] As stated to the chairman of the U.S. Senate Committee on Environment and Public Works:

---

82. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 12.

83. *Id.*

84. *Id.* at 14.

85. *Id.*

86. *Id.* at 29.

87. *See supra* notes 52–78 and accompanying text.

88. *See* Carfora, *supra* note 33, at 159, 162 (discussing how, under the Obama administration, the Department of Energy attempted to withdraw the licensing application for Yucca Mountain, and the Blue Ribbon Commission made no recommendations for Yucca Mountain).

89. *Id.* at 168 ("[P]olicymakers should move forward with Yucca Mountain.").

90. STAFF OF S. COMM. ON ENV'T & PUB. WORKS, 109th Cong., YUCCA MOUNTAIN: THE MOST STUDIED REAL ESTATE ON THE PLANET 23 (2006).

> More is known about Yucca Mountain than any other parcel of real estate on the planet. . . . It has been confirmed in the laboratory, reviewed by independent experts, and validated against information from analogous sites around the world. . . . There is certainly no reason in science not to move forward directly with this project.[91]

This has been determined after investing more than three decades and billions of dollars into researching Yucca Mountain.[92] However, the Obama administration has decided to put the brakes on Yucca Mountain, not because of any technical or safety issues, but rather solely for policy reasons.[93] But despite the administration's policy shift against Yucca Mountain, the amount of research, time, and money that has already been invested into developing the repository makes the abandonment of Yucca Mountain the wrong decision.[94] Otherwise, the last three decades of SNF policy will have "left the country with no waste disposal solution in sight and taxpayers with a $10 billion bill for a tunnel in the middle of the desert that leads nowhere."[95]

Deciding to keep Yucca Mountain as part of the United States' SNF plan is easier said than done. The "not-in-my-backyard" politics that have all but terminated Yucca Mountain are not likely to go away.[96] However, it is possible that a compromise could be made to prevent a complete loss of the investment that the United States taxpayers have made in Yucca Mountain. Even if it is not used as a repository for SNF, Yucca Mountain could still potentially be developed as a repository for low-level radioactive waste.[97] The United States should keep Yucca Mountain as part of the solution to the SNF problem, even if it is not as a permanent SNF repository.

---

91. *Id.*

92. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-11-229, COMMERCIAL NUCLEAR WASTE: EFFECTS OF A TERMINATION OF THE YUCCA MOUNTAIN REPOSITORY PROGRAM AND LESSONS LEARNED 10 (2011) [hereinafter COMMERCIAL NUCLEAR WASTE].

93. *Id.* at 11.

94. *See* Carfora, *supra* note 33, at 167–68.

95. *Id.* at 166.

96. *See id.* at 150 (describing how "not-in-my-backyard" politics have prevented Yucca Mountain from coming to fruition); *see also* Funk & Sovacool, *supra* note 2, at 144 (recommending that the current Yucca Mountain project be set aside due to local political opposition).

97. Aaron Szabo, *Reprocessing: The Future of Nuclear Waste*, 29 TEMP. J. SCI. TECH. & ENVTL. L. 231, 234, 241 (2010).

Regardless of whether Yucca Mountain ever actually becomes a permanent SNF repository, policymakers should immediately begin to consider other locations for housing another repository.[98] The amount of SNF that is currently being stored on-site at nuclear power plants across the country already exceeds 70,000 metric tons, the legal capacity that Yucca Mountain could hold.[99] Therefore, even if Yucca Mountain were to become a repository for SNF, it would not have the capacity to hold all of our current SNF, not to mention the additional SNF that will be generated in the future.[100] This means, "under current law, the United States will need to find a new repository site even if Yucca Mountain were to go forward."[101]

The search for a new repository site must begin now because, as history has shown, the process of establishing an SNF repository is long and complicated. The United States' quest to establish a repository at Yucca Mountain has taken over thirty years and $15 billion.[102] And after that significant investment, the future of Yucca Mountain is still uncertain.

In conclusion, the plan for the United States' commercial SNF must incorporate at least one geologic repository. That plan should include, but not be completely dependent on, Yucca Mountain as a repository site. Therefore, if Yucca Mountain never materializes—a distinct possibility—there will still be some other location where SNF can be safely disposed of.

2. Consolidated Interim Storage

Because there is no indication that a permanent geological repository for SNF will be established any time soon,[103] in the mean-

98. Stewart & Stewart, *supra* note 14, at 8.

99. Funk & Sovacool, *supra* note 2, at 143.

100. *Id.* at 144 ("The current stockpile of commercial and defense nuclear waste destined for Yucca Mountain already exceeds [the capacity of Yucca Mountain], and the amount of waste continues to increase.").

101. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 48.

102. COMMERCIAL NUCLEAR WASTE, *supra* note 92, at 10.

103. The Government Accountability Office has estimated that even if the licensing process for Yucca Mountain were to resume, it would still take until at least 2027 before it would be open as a repository. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-12-797, SPENT NUCLEAR FUEL: ACCUMULATING QUANTITIES AT COMMERCIAL REACTORS PRESENT STORAGE AND OTHER CHALLENGES 23 (2012). It has also been estimated that a new repository could take up to forty years to develop. Funk & Sovacool, *supra* note 2, at 145.

time, the United States should establish one or more intermediate storage facilities to assume custody of the SNF that is building up at nuclear power plants across the country. There are currently 72,000 metric tons of SNF in storage at seventy-five sites in thirty-three states.[104] This SNF is expected to continue to accumulate at a rate of 2200 metric tons per year.[105] Assuming that the United States does not license any new commercial nuclear power plants,[106] in the year 2067, after the last currently operating reactor shuts down, the amount of SNF needing to be disposed of will be 139,000 metric tons.[107]

Of the seventy-five sites in the United States currently holding SNF, ten of them are storing "stranded SNF."[108] This means that the reactor itself is shut down and has either been removed or is currently being removed.[109] The stranded SNF presents unique challenges due to the lack of an operating reactor on site.

First, because there is no longer an operational nuclear power plant, there are higher costs associated with stranded SNF than with SNF kept at an active plant.[110] Specifically, because operating nuclear power plants already maintain robust systems for security and maintenance there are relatively low incremental costs for maintaining the SNF on site.[111] Conversely, sites keeping stranded SNF must absorb all the security and maintenance costs

---

104. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-15-141, SPENT NUCLEAR FUEL MANAGEMENT: OUTREACH NEEDED TO HELP GAIN PUBLIC ACCEPTANCE FOR FEDERAL ACTIVITIES THAT ADDRESS LIABILITY 1 (2014) [hereinafter SPENT NUCLEAR FUEL MANAGEMENT].

105. *Id.* at 11.

106. This is probably a bad assumption considering the United States currently gets about twenty percent of its electricity from nuclear power. *Nuclear Explained*, *supra* note 3.

107. SPENT NUCLEAR FUEL MANAGEMENT, *supra* note 104, at 14.

108. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 35–36 (noting that as of January 2012 ten plants—Big Rock Point (Michigan), Haddam Neck (Connecticut), Hamboldt Bay (California), LaCrosse (Wisconsin), Maine Yankee (Maine), Rancho Seco (California), Trojan (Oregon), Yankee Rowe (Massachusetts), Zion 1 & 2 (Illinois), and Fort St. Vrain (Colorado)—all contain stranded SNF. Additionally, Vermont Yankee shut down in December 2014, creating the newest stranded SNF. *See* Zoë Schlanger, *Vermont Yankee Nuclear Power Plant Just Shut Down; U.S. Still Has No System for Disposing of Nuclear Waste*, NEWSWEEK (Dec. 31, 2014), http://www.newsweek.com/vermont-yankee-nuclear-plant-just-shut-down-us-still-has-no-system-disposing-295775.

109. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 35.

110. Stewart & Stewart, *supra* note 14, at 57.

111. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 35.

for the singular purpose of holding SNF.[112] This can be particularly burdensome considering the fact that the site is no longer generating any revenue from electricity production to offset those costs.[113]

The other challenge unique to stranded SNF is that it prevents the site from being used for some other purpose.[114] The local community is forced to deal with the fact that the stranded SNF is there and the land that it sits on cannot be put to some more productive use.[115] This can be especially aggravating for the community because they never consented to the SNF being stored indefinitely nor do they receive any benefits for hosting this material.[116]

All SNF, but stranded SNF in particular, would be much better suited if it were moved from the several sites where it is currently located to one or more consolidated interim storage facilities while a geologic repository is being constructed.[117] Consolidated interim storage of SNF also has the support of the DOE and the Blue Ribbon Commission.[118] There are major benefits of moving the commercial SNF to a consolidated interim storage facility. Interim storage facilities are considered safer and more cost effective than on-site storage and would allow the DOE to meet its obligation of taking custody of the commercial SNF sooner than it would if it had to wait for a permanent geologic repository.[119]

The federal government contends that the current system of storing SNF on site at commercial nuclear power plants is safe.[120] In fact, in September 2014, the NRC issued a new rule adopting

---

112. *See id.* ("[T]he operation and maintenance costs for spent fuel storage at shutdown sites range from $4.5 million to $8 million per year, compared to an incremental $1 million per year or less when the reactor is still in operation.").

113. Stewart & Stewart, *supra* note 14, at 57.

114. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 35.

115. *Id.*

116. *See id.* (discussing the impact of spent fuel on communities in the area).

117. *See* Funk & Sovacool, *supra* note 2, at 144 (advocating the simultaneous development of "both centralized interim storage and permanent geological disposal facilities"); *see also* Stewart & Stewart, *supra* note 14, at 59 ("[T]he considerations invoked by BRC and the Hamal Report also justify development of consolidated storage facilities for SNF that now resides at reactor sites.").

118. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 35; DOE STRATEGY, *supra* note 75, at 2.

119. Funk & Sovacool, *supra* note 2, at 138.

120. *See* Stewart & Stewart, *supra* note 14, at 10–11.

the findings from a generic environmental impact statement ("GEIS").[121] The GEIS evaluated the safety of storing SNF on site at nuclear power plants over three separate timeframes: short-term (sixty years beyond licensed life of the reactor), long-term (100 years beyond the licensed life of the reactor), and indefinite storage (assuming no geologic repository ever becomes available).[122] The GEIS concluded that commercial SNF can be safely stored at reactor sites indefinitely.[123] However, despite the government's confidence that SNF can be safely stored on-site at power plants, the Fukushima incident in 2011 has led some to question how safe that policy actually is.[124] Multiple consolidated interim storage facilities for SNF could help protect the United States against a Fukushima-like disaster.[125] By having consolidated interim storage facilities that include wet storage, SNF could be moved from pools at nuclear power plant sites in the event of an emergency requiring those pools to be cleared.[126]

Besides safety concerns, proponents of consolidated interim storage for commercial SNF argue that those facilities can "achieve significant scale economies in operating and maintaining security, yielding very significant operating cost savings relative to the costs of providing security for the numerous storage facilities at nuclear power plants dispersed across the country."[127] These cost savings will be most significant for the country's stranded SNF, where the cost for storage ranges from $4.5 million to $8 million per year.[128] According to the Blue Ribbon Commission, the

121. Continued Storage of Spent Nuclear Fuel, 79 Fed. Reg. 56,238 (Sept. 19, 2014) (to be codified at 10 C.F.R. pt. 51).

122. U.S. NUCLEAR REGULATORY COMM'N, NUREG-2157, GENERIC ENVIRONMENTAL IMPACT STATEMENT FOR CONTINUED STORAGE OF SPENT NUCLEAR FUEL, at xxx fig.ES-1 (2014) [hereinafter GEIS], *available at* http://pbadupws.nrc.gov/docs/ML1419/ML14196A105.pdf.

123. Patel, *supra* note 69. *See generally* GEIS, *supra* note 122, at xlvii–xlviii tbl.ES-3 (indicating that even with indefinite at-reactor storage of commercial SNF, environmental impacts would be generally small for all of the study's resource areas).

124. *See* Funk & Sovacool, *supra* note 2, at 136; *see also* Stewart & Stewart, *supra* note 14, at 29. The Fukushima Daiichi nuclear power complex was struck by an earthquake and tsunami that caused significant damage. *Id.* at 24. The most serious problems at Fukushima involved the SNF located in cooling pools that experienced cooling system failures due to the loss of electrical power. *Id.* at 24–25. This dangerous condition can lead to a release of radiation. *Id.*

125. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 37–38.

126. Stewart & Stewart, *supra* note 14, at 49.

127. *Id.* at 52.

128. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 35.

savings associated with moving the stranded SNF to a consolidated interim storage facility would be enough to pay for that facility.[129]

Establishing one or more consolidated interim storage facilities would also allow the federal government to begin meeting its waste acceptance obligations sooner than it otherwise would if it waited for a geologic repository.[130] Pursuant to the NWPA, the DOE entered into Standard Contracts with utilities for the removal of SNF from their reactor sites starting in 1998.[131] In return for the federal government taking custody of the SNF, the utilities have made annual contributions to the NWF, which would finance the eventual disposal of the SNF.[132] The fee that the utilities pay was initially set at 1 mill (0.1 cents) per kilowatt-hour of nuclear electricity produced.[133] The NWF currently has an unspent balance of $27 billion.[134]

However, due to the delays in establishing a geologic repository at Yucca Mountain, the federal government has not yet taken custody of any commercial SNF.[135] As of March 2014, over ninety lawsuits have been filed against the DOE for this breach of contract.[136] By 2012, the federal government had paid $2 billion in damages as a result of these lawsuits.[137] The DOE estimates that its future liability will be $21.4 billion through 2071.[138]

Congressional budget rules have resulted in the NWF money becoming essentially inaccessible.[139] As a result, the damages that the federal government has been paying to the utilities for its breach of contract do not come from the NWF; instead, they come from the federal Judgment Fund.[140] "Because payments from the

---

129. *Id.*

130. *See id.* at 36 ("Developing consolidated storage capacity would enable the U.S. government to begin fulfilling its legal obligations . . . with respect to the acceptance and removal of SNF from commercial reactor sites.").

131. Funk & Sovacool, *supra* note 2, at 120–21; *see supra* Part I.C.

132. Funk & Sovacool, *supra* note 2, at 120–21; *see supra* Part I.C.

133. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 70.

134. *Id.* at 71.

135. Funk & Sovacool, *supra* note 2, at 121.

136. SPENT NUCLEAR FUEL MANAGEMENT, *supra* note 104, at 2.

137. Schlanger, *supra* note 108.

138. SPENT NUCLEAR FUEL MANAGEMENT, *supra* note 104, at 2.

139. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 72.

140. Stewart & Stewart, *supra* note 14, at 102.

Judgment Fund come out of the general federal Treasury, rather than the NWF, taxpayers are ultimately paying for the cost of SNF storage" instead of the nuclear utility ratepayers who have, by extension, been paying into the NWF.[141] By establishing consolidated interim storage facilities, taxpayers will finally be off the hook for the federal government's breach of contract.[142]

Opponents of establishing consolidated interim storage facilities argue that there will be too much political opposition from local communities where the federal government attempts to establish such facilities.[143] Another downside to interim storage is that the SNF would often have to be transported twice—from the nuclear power plant to the interim storage facility and then from the interim storage facility to an eventual geologic repository—adding unneeded additional risk.[144] Additionally, it is estimated that an interim storage facility for SNF would take nineteen years to develop at a cost ranging from $23 billion to $81 billion.[145]

The significant time associated with establishing a system of consolidated interim storage is precisely why the United States should act now to implement such a system as part of the solution to the SNF problem. Had the NWPA not put all its eggs in the Yucca Mountain basket, but rather allowed an SNF disposal system that included interim storage, the United States might not be facing this problem today. Therefore, "[f]rom the viewpoint of SNF safety and costs, it would be desirable to include SNF from operating reactors as well as from decommissioned reactors in consolidated storage sooner rather than later."[146]

3. Choosing Intermediate Storage and Repository Locations

In order to implement a plan for SNF that includes a repository at a non-Yucca Mountain location and consolidated interim storage, the NWPA will have to be repealed or amended. The NWPA, as amended in 1987, prohibits the construction of an interim

141. *Id.* at 20, 102.

142. *See* BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 36–37.

143. Funk & Sovacool, *supra* note 2, at 138.

144. *Id.*

145. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-11-731T, NUCLEAR WASTE: DISPOSAL CHALLENGES AND LESSONS LEARNED FROM YUCCA MOUNTAIN 12 (2011).

146. Stewart & Stewart, *supra* note 14, at 59–60.

storage facility until a geological repository is licensed.[147] Additionally, by law, Yucca Mountain is the only site that can be considered for a geologic repository.[148] Therefore, Congress must amend or repeal the NWPA to clear the way for the implementation of a workable SNF plan that includes developing a non-Yucca Mountain geologic repository and a consolidated interim storage facility.[149]

In changing the NWPA to restructure the United States' approach to managing SNF, policymakers should adopt a consent-based approach to finding locations for a new geologic repository and one or more consolidated interim storage facilities.[150] Yucca Mountain has not worked as a geologic repository site because the project has been driven solely by politicians in Washington, D.C., and has not had the support of the local community.[151] Given this opposition, "[t]he federal government must accordingly abandon the 'top-down' prescriptions embraced in NWPA and its 1987 amendments, and the dysfunctional approach to their implementation."[152] It is a positive sign that the Blue Ribbon Commission and the DOE both support a consent-based approach for determining future SNF storage and repository locations.[153]

In using a consent-based approach to establish future SNF storage and repository sites, the federal government should tie economic incentives to localities that are willing to host a consolidated interim storage facility or geologic repository.[154] A vigorous incentive package is also something that the Blue Ribbon Commission identified as necessary in finding suitable locations for SNF disposal.[155] Specifically, the United States' SNF plan should

147. Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100-203, sec. 5021, § 148(d)(1), 101 Stat. 1330–227, 1330–236 (codified as amended at 42 U.S.C. 10168 (2012)).

148. Sec. 5011, §160, 101 Stat. 227, 228.

149. *See* Funk & Sovacool, *supra* note 2, at 146–47.

150. *See id.* at 145.

151. *See, e.g., id.* at 123–24 (describing how Nevada submitted a formal Notice of Disapproval in response to President Bush's approval of the Yucca Mountain repository and subsequently filed multiple lawsuits after Congress and the President overrode Nevada's disapproval).

152. Stewart & Stewart, *supra* note 14, at 75.

153. *See* BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 47; DOE STRATEGY, *supra* note 75, at 1–2.

154. Funk & Sovacool, *supra* note 2, at 145.

155. *See* BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 58–59.

tie storage and repository sites to research, development, and implementation of SNF reprocessing.[156]

B. *SNF Reprocessing*

Nuclear power technology has only existed for sixty years.[157] It would be extremely shortsighted to think that this technology will not continue to grow through advances in science and innovation. Therefore, the Unites States should not focus exclusively on a million-year solution to the SNF problem—burial in a geologic repository—when emerging technology, such as reprocessing, can be part of the answer. In order to solve its SNF problem, the United States should change its policy to include the reprocessing of SNF instead of solely focusing on permanent disposal.

When a nuclear reactor reaches the point where it can no longer efficiently maintain its chain reaction to produce energy, it must be either decommissioned or refueled.[158] However, despite the fact that the SNF can no longer be used efficiently in the reactor, the SNF still contains a large quantity of uranium that can be used for fission.[159] Reprocessing is the process of removing the unused uranium from the SNF so that it can be reused as nuclear fuel in the future.[160] Even though reprocessing technology presently exists,[161] the United States currently has no commercial SNF reprocessing plants.[162] However, by implementing repro-

156. The Blue Ribbon Commission recommends that a potential host site be "co-located [with] research and demonstration facilities" but does not go far enough to explicitly encourage establishing a commercial SNF reprocessing program. *Id.* at 59.

157. Stewart & Stewart, *supra* note 14, at 8–9.

158. Decommissioning is the process of removing a nuclear power plant from service. *See Backgrounder on Decommissioning Nuclear Power Plants*, U.S. NUCLEAR REGULATORY COMM'N, *available at* http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/decommissioning.html (last updated Dec. 12, 2014). As an alternative to decommissioning, nuclear power plants can be refueled by replacing the SNF with fresh fuel. *See* U.S. NUCLEAR REGULATORY COMM'N, *supra* note 7, at 7.

159. *See Recycling Used Fuel from Reactors*, AREVA, http://www.areva.com/EN/operations-1092/areva-la-hague-recycling-used-fuel.html (last visited Apr. 3, 2015) (stating that 95% of the SNF removed from commercial nuclear reactors is uranium that can be recycled).

160. *Fuel Reprocessing (Recycling)*, U.S. NUCLEAR REGULATORY COMM'N, http://www.nrc.Gov/reading-rm/basic-ref/glossary/fuel-reprocessing-recycling.html (last updated Feb. 18, 2015).

161. *See* Carfora, *supra* note 33, at 169 (stating that France, Japan, the United Kingdom, Russia, India, and China have all instituted SNF reprocessing programs).

162. *See* Szabo, *supra* note 97, at 236 (stating that the only U.S. commercial SNF re-

cessing as part of the solution to the SNF problem, the United States will be able to take advantage of increased efficiency in its nuclear power plants while at the same time minimizing the volume of SNF that will require permanent disposal.[163]

1. History of SNF Reprocessing in the United States

SNF reprocessing technology has existed since the early 1940s when it was used by the United States for the development of nuclear weapons.[164] Reprocessing continued for military purposes from the time of World War II until the Cold War, with the objective of creating greater numbers of nuclear weapons and developing more advanced nuclear weapon technology.[165] The only commercial SNF reprocessing plant in the United States operated in West Valley, New York from 1966 until 1976, when it shut down due to high costs and burdensome regulatory requirements.[166]

In 1977, because of policy changes stemming from nuclear weapons proliferation concerns, President Carter indefinitely deferred the commercial reprocessing of SNF.[167] However, in 1981, President Reagan lifted the ban on commercial SNF reprocessing, stating that the government had "failed in meeting its responsibility to work with industry to develop an acceptable system for commercial waste disposal" and that he was "lifting the indefinite ban which previous administrations placed on commercial reprocessing activities in the United States."[168] However, despite the

---

processing plant operated in West Valley, New York, for six years starting in 1966).

163. *See* Carfora, *supra* note 33, at 169–70.

164. Szabo, *supra* note 97, at 235.

165. *Id.* at 235–36.

166. *Id.* at 236; *West Valley Demonstration Project Nuclear Timeline*, U.S. DEP'T OF ENERGY W. VALLEY DEMONSTRATION PROJECT, http://www.wv.doe.gov/Site_History.html (last visited Apr. 3, 2015).

167. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 20. President Carter stated that "a serious risk is involved in the handling of nuclear fuels—the risk that component parts of this power process will be turned to providing explosives or atomic weapons" and that the United States would "defer indefinitely the commercial reprocessing and recycling of the plutonium produced in U.S. nuclear power programs." Nuclear Power Policy: Remarks and a Question-and-Answer Session with Reporters on Decisions Following a Review of U.S. Policy, 1 PUB. PAPERS 581, 582 (Apr. 7, 1977).

168. Statement Announcing a Series of Policy Initiatives on Nuclear Energy, PUB. PAPERS 903, 904 (Oct. 8, 1981).

reversal of the Carter policy by President Reagan, commercial reprocessing never resumed in the United States.[169]

As expressed by the DOE, the current policy of the United States under the Obama administration remains opposed to reprocessing. In January 2013, in response to the Blue Ribbon Commission's report, the DOE issued a strategy for the disposal of SNF.[170] The strategy appears on the surface to be open to reprocessing: "DOE will continue to conduct research on advanced fuel cycles to inform decisions on new technologies that may contribute to meeting the nation's future energy demands."[171] However, by dismissing the need for the ability to retrieve SNF from a future repository and stating that any future governmental organization charged with managing commercial SNF should not be authorized to research, fund, or conduct SNF reprocessing, the DOE is effectively promoting an anti-reprocessing policy.[172]

2. Potential Benefits of SNF Reprocessing

Despite the current policy of not reprocessing its SNF, the United States should change that policy and implement SNF reprocessing as a part of the solution to the SNF disposal problem. Reprocessing SNF provides more efficient use of our natural resources and minimizes the amount of SNF that must be disposed of in a geological repository.[173]

If nuclear fuel is only used in a reactor once—meaning it is never reprocessed—then only about 5% of the available energy from the fuel is actually consumed.[174] Ninety-five percent of the SNF is unused uranium and 1% is plutonium.[175] The uranium and plutonium—energy materials—can be physically separated from the 4% of the SNF that is waste.[176] Once separated from the waste, the energy materials can be recycled by turning them into

169. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 20.
170. DOE STRATEGY, *supra* note 75, at 1.
171. *See id.* at 8.
172. *See id.* at 7, 10.
173. *See* Carfora, *supra* note 33, at 169–70.
174. *Id.* at 169.
175. *Recycling Used Fuel from Reactors*, AREVA, http://www.areva.com/EN/operations-1092/areva-la-hague-recycling-used-fuel.html (last visited Apr. 3, 2015).
176. *Id.*

new fuels for nuclear power plants.[177] The waste can then be stabilized through a vitrification process.[178] When the reprocessing is complete, the SNF needing to be disposed of in a permanent repository has been reduced to one-fifth of its original volume.[179] So, in addition to using up to 30% less newly-mined uranium to refuel nuclear reactors,[180] the volume of waste needing disposal in a repository would also be significantly reduced.[181]

3. Arguments Against Reprocessing

Despite the benefits of reprocessing SNF, opponents of reprocessing argue that the practice is not justified because of economics and the risk of nuclear weapons proliferation.[182]

a. Expense of Reprocessing

One of the main arguments against SNF reprocessing is that it is expensive.[183] Accordingly, "the Congressional Budget Office concluded that reprocessing would cost at least $5 billion more than direct disposal over the life of a reprocessing plant, some 25% greater in cost than direct disposal."[184] With current reprocessing technology, the cost of nuclear fuel would have to increase from its current value of $40/kilogram-Uranium (kgU) to $140/kgU for reprocessing to be an economical alternative to disposal.[185]

However, just because reprocessing is currently more expensive than permanent disposal in a repository does not mean that this

---

177. *Id.*

178. *Id.*

179. *Id.*

180. Funk & Sovacool, *supra* note 2, at 140.

181. *See* Carfora, *supra* note 33, at 170; *see also Recycling Used Fuel from Reactors*, *supra* note 175 ("Thanks to recycling and vitrification, the volume of highly radioactive waste is reduced fivefold.").

182. *See* Carfora, *supra* note 33, at 171–72.

183. Funk & Sovacool, *supra* note 2, at 141.

184. *Id.* (citing *Costs of Reprocessing Versus Directly Disposing of Spent Nuclear Fuel*, 110th Cong. 1 (2007) (statement of Peter R. Orszag, Director, Congressional Budget Office)).

185. Szabo, *supra* note 97, at 247. "With the significant costs of building a reprocessing plant, the cost of reprocessing spent fuel would need to be significantly less than the cost of mining, fabricating and storing new nuclear fuel." *Id.* at 246–47.

will always be the case. By "using efficiency-increasing practices, improving reprocessing technologies, and the potential for demand of uranium to increase, the cost per kgU of reprocessed fuel could significantly decrease the cost of reprocessing fuel, making it economical relative to the status quo."[186] A logical conclusion can be drawn that more advanced SNF reprocessing technology will not be developed if reprocessing is not researched and used. If the United States continues to sit idly by, waiting for reprocessing technology to become more economically viable without actually developing it, that viability will never occur.

Additionally, the economic analysis of reprocessing as opposed to direct disposal does not take into account the increased volume of radioactive material and additional real estate of repository space needed if reprocessing does not occur.[187] These are certainly valid concerns especially when considering how difficult it can be to actually establish repository space. Therefore, despite the economic cost associated with SNF reprocessing, it should still be part of the United States' SNF strategy going forward.

b. Nuclear Weapons Proliferation

Another major concern with SNF reprocessing, and the reason that commercial reprocessing was banned in the United States from 1977 to 1981, is the threat of nuclear weapons proliferation.[188] SNF reprocessing, by design, requires the separation of various elements contained within the SNF.[189] As a result of this

186. *Id.* at 247.

187. *See* Carfora, *supra* note 33, at 168–69 ("Removing the heated short-lived components of the SNF could reduce the amount of space needed in the repository by eliminating the large gaps between casks."). *See generally Costs of Reprocessing Versus Directly Disposing of Spent Nuclear Fuel*, 110th Cong. 1 (2007) (statement of Peter R. Orszag, Director, Congressional Budget Office) ("Policymakers weighing the merits of reprocessing and direct disposal may have other concerns besides cost—such as extending U.S. uranium resources . . . or lessening the demand for long-term storage space. Judging whether those goals justify the added costs of reprocessing is ultimately a decision for policymakers.").

188. RADIOACTIVE WASTE MANAGEMENT AND CONTAMINATED SITE CLEAN-UP, PROCESSES, TECHNOLOGIES AND INTERNATIONAL EXPERIENCE 148 (William E. Lee, et al. eds., 2013) ("A *de facto* moratorium was placed on reprocessing of commercial spent nuclear fuel in the US in 1977; this ban was lifted in 1981 . . . ."); Carfora, *supra* note 33, at 172 ("Many critics oppose reprocessing on grounds that it could lead to nuclear weapons proliferation."); BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 20 (stating that the presidential directive deferring commercial reprocessing of SNF was in response to concerns of nuclear weapons proliferation).

189. *Recycling Used Fuel from Reactors*, *supra* note 175.

process, pure plutonium is generated.[190] Plutonium, because of the type of radiation that it emits, can be more easily used to create a nuclear weapon than other radioactive elements.[191].

However, the fact that SNF reprocessing generates plutonium should not prevent commercial SNF reprocessing because commercial SNF reprocessing does not produce the quality of plutonium ideal for weapons.[192] Plutonium from commercial SNF reprocessing is considered "reactor-grade plutonium."[193] SNF from commercial nuclear power plants has been used as fuel in the reactor for as long as economically feasible, which allows the power plant to get as much energy out of the fuel as possible.[194] This lengthy time in the reactor, however, also results in a high concentration of neutrons in the SNF.[195] These neutrons make the plutonium, from commercial SNF less explosive and therefore ill-suited for making weapons.[196]

"Weapons-grade plutonium," which has fewer neutrons, would have to be extracted from SNF that has only been powering a commercial nuclear reactor for a short period of time.[197] Additionally, reactors specifically designed to produce weapons-grade plutonium are less expensive and less technologically complex than commercial power reactors.[198] Because weapons-grade plutonium is better suited for building nuclear weapons than reactor-grade plutonium, and it is easier to obtain from a plutonium reactor than from a commercial power reactor, it is unlikely that commercial SNF reprocessing would result in nuclear weapons proliferation.[199]

Additionally, there are emerging SNF reprocessing technologies that do not result in plutonium being isolated from the rest of the SNF.[200] These new reprocessing techniques keep uranium

---

190. Funk & Sovacool, *supra* note 2, at 141.

191. *Id.* at 141–42.

192. Carfora, *supra* note 33, at 172.

193. *Id.*

194. *See id.* (indicating that it would be economically impractical to remove the fuel rods during the right time frame to create weapons grade plutonium).

195. *Id.*

196. *Id.*

197. *Id.*

198. *Id.*

199. *Id.* at 173.

200. Szabo, *supra* note 97, at 238; *see also* Funk & Sovacool, *supra* note 2, at 140.

and plutonium together but separate them from the waste.[201] This type of reprocessing does not generate pure plutonium and, therefore, is less likely to result in weapons proliferation.[202] Because the reprocessing of SNF from commercial power plants results in a low threat of nuclear weapons proliferation, reprocessing of commercial SNF should be implemented as part of the United States' plan for managing the SNF disposal problem.

In summary, reprocessing SNF will result in greater efficiency in the nuclear fuel cycle and a lower volume of waste that will eventually need to be disposed in a repository.[203] The risk of nuclear weapons proliferation and the high cost of reprocessing are both factors that should be considered when developing an SNF reprocessing scheme, but, as discussed above, they should not prevent the United States from using SNF reprocessing as part of its SNF solution. Therefore, in addition to storage and disposal, reprocessing of commercial SNF should become part of the United States' solution to the SNF problem.

CONCLUSION

The United States' system of disposing SNF is broken because it is nonexistent.[204] Progress can be made, however, if policymakers implement these recommendations: (1) begin the process of establishing a permanent geologic repository at a location other than Yucca Mountain, while at the same time working to keep Yucca Mountain as a potential repository site; (2) while waiting for the other repository to be developed, create a system of consolidated interim storage to temporarily house SNF; and (3) establish a program to reprocess SNF.

All three of these steps should be interrelated. The SNF plan should use a consent-based approach to determine the locations for future repository and interim storage sites. Part of the process for establishing these locations should involve providing incentives to communities that agree to host the sites. This should include granting priority for funding SNF reprocessing research

201. Funk & Sovacool, *supra* note 2, at 140.
202. *Id.*
203. *See* Carfora, *supra* note 33, at 169–70.
204. *See supra* notes 72–78 and accompanying text.

and development.[205] By tying disposal and storage locations with reprocessing, the United States could more easily implement a multifaceted approach to solving the SNF problem.

The last three decades of failed SNF policy prove that a singular-focused, top-down approach will not work.[206] Instead of boxing the nuclear industry into an all-or-nothing plan, the United States' SNF policy should take a flexible, iterative approach.[207] The Blue Ribbon Commission has identified the need for this change,[208] but in order to implement it there must be a significant bipartisan political effort coupled with a focus on sound science.

The United States cannot afford to keep ignoring its nuclear waste problem. Regardless of individual opinions about the wisdom of nuclear power, SNF is here to stay.[209] The United States should move towards a solution by adopting a multidimensional approach including reprocessing, consolidated interim storage, and eventual permanent SNF disposal.

Christopher M. Keegan *

205. *See* Stewart & Stewart, *supra* note 14, at 47.

206. *See id.* at 78–79 ("NWPA imposed a blueprint for Yucca that defined the key elements of the repository project at the outset and prescribed a rigid timetable for implementation.").

207. *See id.* (discussing how the Waste Isolation Pilot Program in New Mexico was successful because it involved a flexible iterative process).

208. BLUE RIBBON COMM'N ON AM.'S NUCLEAR FUTURE, *supra* note 15, at 31 ("Flexibility . . . is needed because implementing a disposal program will take at least several generations, during which technology and values are sure to evolve . . . .").

209. *See supra* text accompanying note 9.

* J.D. Candidate, 2015, University of Richmond School of Law. M.E.M., 2013, Old Dominion University; B.S., 2007, United States Naval Academy. I must express my extreme gratitude to Casey, for years of listening to me talk about nuclear power. Thank you also to the *University of Richmond Law Review's* editors and staff whose tireless and thankless work has made this comment possible.