Pace Environmental Law Review

Volume 18
Issue 2 *Summer 2001*

Article 8

June 2001

Financing for Eternity the Storage of Spent Nuclear Fuel: A Crisis of Law and Policy Precipitated by Electric Deregulation Will Face New President

Michael A. Mullett

Financing for Eternity the Storage of Spent Nuclear Fuel: A Crisis of Law and Policy Precipitated by Electric Deregulation Will Face New President

MICHAEL A. MULLETT*

* Managing Attorney, Mullett & Associates, Indianapolis, Indiana; LL.M., Northwestern School of Law at Lewis & Clark College, Portland, Oregon, 1999; J.D., *magna cum laude,* Indiana University School of Law, Indianapolis, Indiana, 1982; B.A. Political Science, *magna cum laude*, University of Michigan, 1966, M.A. Public Policy and Administration, with honors, University of Michigan, 1973. In his law practice, Mr. Mullett serves as Special Counsel for Energy, Environment and Utilities to the Citizens Action Coalition of Indiana, a non-profit citizen advocacy organization which, since its inception in 1974, has frequently litigated on behalf of its members both economic and environmental issues associated with commercial nuclear power. He also serves as an adjunct member of the faculty at the Indiana University School of Law at Indianapolis, teaching a seminar in public utility regulation and deregulation.

I. Abstract

This article[1] will present a concise legal history tracing the development of United States national policy and law relating to the generation, transportation, storage and disposal of the high-level nuclear waste commonly known as "spent nuclear fuel" since the authorization of commercial nuclear power by the Atomic Energy Act of 1954. It will identify and discuss the principal outstanding issues of law and policy associated with spent nuclear fuel as the nation undertakes the disaggregation and deregulation of the electric utility industry. The article will describe the princi-

1. This article is based on the thesis which the author submitted in partial satisfaction of the requirements for his LL.M. degree from Northwestern School of Law at Lewis and Clark College. It could not have been completed without the steadfast support and timely help of Janice Weis, Director of the Environmental and Natural Resources Law Program at Lewis & Clark. While retaining complete responsibility for any errors or omissions, the author is also grateful for the thoughtful and instructive comments and suggestions on earlier drafts of this article by Bill Funk, Craig Johnston and Jack Bogdanski of the Northwestern School of Law. He also wishes to express his appreciation for numerous corrections and changes, especially on technical matters, suggested by David Lochbaum, Senior Nuclear Safety Engineer for the Union of Concerned Scientists.

pal elements of the nation's transition from an electric utility industry of vertically integrated, regulated monopolies to an industry in which generation is disaggregated from transmission and distribution and its price is determined by market forces rather than regulatory processes. The article will then evaluate the implications of this transition for the future development of law and policy relating to commercial spent fuel. As its thesis, the article will demonstrate that the emergence of a competitive, deregulated market for electric generation in conjunction with projected increases in the cost of transportation, storage and disposal of spent fuel will precipitate a financing crisis for high-level nuclear waste law and policy as currently conceived. The article will then conclude with policy proposals to resolve this crisis.

II. Nuclear Waste: A Brief Overview

Essentially all radioactive wastes start with one substance: uranium ore. Virtually all man-made radioactive wastes come from two sources: the production of nuclear weapons and the generation of electricity by nuclear power plants.[2] In one year, a typical nuclear power plant will generate seven billion kilowatt hours of electricity.[3] To produce that amount of electricity, the plant will fission only approximately one ton of uranium and convert less than two pounds of matter to energy.[4] However, approximately 125,000 tons of uranium ore must be mined to supply the 175 tons of uranium, which will be required to fuel the plant[5] (the accumulated mill tailings produced by the refining of uranium ore total more than 230 million tons).[6] Moreover, the plant will generate per year as much as forty-five tons of high-level radioactive waste in the form of spent nuclear fuel and approximately 500 tons of low-level radioactive waste of several different types.[7] Additionally, by the end of its useful life, typically anticipated to be forty years but often significantly shorter in actuality, the plant itself will have become radioactive and have to be decommissioned. This will generate wastes containing approximately one hundred times

2. All other sources, such as medical laboratories and industrial facilities, account for only a negligible fraction of radioactive waste. *See* Michael B. Gerrard, *Fear and Loathing in the Siting of Hazardous and Radioactive Waste Facilities: A Comprehensive Approach to a Misperceived Crisis*, 68 TUL. L. REV. 1047, 1074 (1994).

3. *See id.*

4. *See id.*

5. *See id.*

6. *See id.* at 1087.

7. *See* Gerrard, *supra* note 2, at 1074.

the radioactivity of all the other low-level radioactive waste produced during the plant's operating life.[8]

A. High-Level Commercial Waste Distinguished from Defense Waste

A distinction is made in the United States between high-level waste (HLW) classified as "commercial" and that classified as "defense," according to whether the material is generated in commercial electricity production or in nuclear weapons production and naval propulsion reactors.[9] The principal commercial HLW is spent nuclear fuel from the reactors of nuclear power plants.[10] The primary defense HLW is the residue, mainly liquid, from the manufacture of plutonium for nuclear bombs and warheads.[11]

B. High-Level Waste Distinguished from Other Commercial Nuclear Waste

In the United States, commercial HLW means (1) spent nuclear fuel, (2) liquid wastes resulting from the reprocessing of spent nuclear fuel, and (3) solid wastes into which liquid reprocessing wastes have been converted.[12] Transuranic waste (TRU) means radioactive waste which contains material, such as plutonium, having an atomic number greater than that of uranium.[13] Uranium mill tailings are the residue remaining after the extraction of fissionable uranium from mined uranium ore.[14] Low-level wastes (LLW) are defined to mean all radioactive wastes that are not high-level wastes, transuranic wastes, or uranium mill tailings.[15]

C. Spent Nuclear Fuel Distinguished from Other High-Level Waste

When uranium fuel assemblies (containing 50 to 300 separate rods) are initially loaded into the reactor of a commercial nuclear

8. *See id.* at 2086-87.

9. *See* John P. Holdren, *Radioactive-Waste Mgmt. in the United States: Evolving Policy Prospects and Dilemmas*, 17 ANN. REV. ENERGY & ENV'T 235, 240 (1992).

10. *See* Gerrard, *supra* note 2, at 1075.

11. *See id.*

12. *See* 10 C.F.R. § 60.2 (1997).

13. *See* 42 U.S.C. § 2014(ee) (1994 & Supp. 1997).

14. *See* Gerrard, *supra* note 2, at 1087; *see also* Holdren, *supra* note 9, at 241.

15. *See* Gerrard, *supra* note 2, at 1087; *see also* Holdren, *supra* note 9, at 240.

power plant, they are only mildly radioactive.[16] But, the fuel assemblies are gradually irradiated during the fission process[17] by which nuclear power is produced. After several years, the fuel rods become too spent and embrittled to support the fission process efficiently.[18] The irradiated rods are then removed and replaced, becoming "spent nuclear fuel." The typical commercial reactor discharges about thirty metric tons of spent nuclear fuel per year.[19] In a few countries other than the United States,[20] this spent nuclear fuel is "reprocessed" to separate the remaining uranium and produced plutonium from the other fission products for subsequent reuse as nuclear fuel.[21] The other fission products remaining following reprocessing are not subject to reuse and are therefore wastes. They are primarily liquid, highly radioactive, and very unstable, being quite prone to fire and explosion. To improve their stability and safety, these high-level wastes are sometimes changed into solid forms.[22] However, no commercially

16. "Radioactivity" is the distinguishing characteristic of the atoms of certain elements, known as radionuclides, which undergo spontaneous decay over time, emitting energy in several forms (known as alpha, beta and gamma) which is sufficient to "ionize," i.e. dislodge, electrons from other atoms. The rate of radioactive decay is measured in half-lives, the time it takes for half of the radioactive atoms in a particular radionuclide to decay into another form. *See* THE LEAGUE OF WOMEN VOTERS EDUC. FUND, THE NUCLEAR WASTE PRIMER: A HANDBOOK FOR CITIZENS 13 (1993) [hereinafter LEAGUE OF WOMEN VOTERS].

17. "Fission" is the process by which the nucleus of an atom of a radionuclide is split into two smaller nuclei either spontaneously or by the addition of neutrons. This splitting releases neutrons, gamma radiation, and heat. The released neutrons strike other nearby atoms, causing them to split also. If enough fissionable material is present and contained, an ongoing chain reaction can begin. This chain reaction, if caused quickly in a large quantity of fissionable material, can be explosive, as in the case of nuclear weapons. By contrast, the nuclear chain reaction in a power plant is controlled, with a smaller, slower and steadier release of energy, primarily in the form of heat. This heat is then used to create steam to drive a generator and produce electricity. Only certain radionuclides, known as "fissile" nuclides, are subject to fission. Uranium-235 is the only fissile nuclide that occurs naturally to any significant extent. Other fissile nuclides are man-made. The principal man-made fissile radionuclide is plutonium-239, which is produced when uranium-238 absorbs a neutron. *See id.* at 13-14.

18. *See id.* at 37-38.

19. *See* NICHOLAS LENSSEN, WORLDWATCH INST., NUCLEAR WASTE: THE PROBLEM THAT WON'T GO AWAY 9 (1991).

20. Great Britain and France still do commercial reprocessing. Until its collapse, so did the former Soviet Union. *See* Gerrard, *supra* note 2, at 1076 n.190.

21. *See* LEAGUE OF WOMEN VOTERS, *supra* note 16, at 38 (1993).

22. *See id.* at 38-39. *See also* Gerrard, *supra* note 2, at 1075.

generated spent fuel has been reprocessed in the United States since 1976.[23]

III. Spent Nuclear Fuel in the United States: Its Sources and Characteristics

A. Commercial Nuclear Power Plants: The Sources of Spent Nuclear Fuel

1. Brief History

The first five commercial nuclear power plants were ordered in 1955. The first commercial plant began operation in 1960.[24] There were fifteen operating plants in the United States by 1970, and seventy-two by 1980. The number of operating commercial nuclear plants in the United States peaked at 112 in 1990, remaining at that level until 1992.[25] Those plants were located at seventy sites in thirty-three states.[26] Since 1992, eight commercial nuclear plants have permanently closed in the United States.[27] Only one new plant has opened.[28] While there are three previously ordered plants, which at this writing technically still

23. While originally expected to be the solution to the accumulation of spent fuel from nuclear power plants, commercial reprocessing proved both economically unattractive and environmentally disastrous in the United States. Of the three reprocessing plants constructed in the United States, one (West Valley, N.Y.) operated for six years but left a legacy of contamination, fires, and accidents; the second (Morris, Ill.) was completed but never opened because it did not work; and the third (Barnwell, S.C.) was never finished because of massive cost overruns. *See* Gerrard, *supra* note 2, at 1075-76 n.190.

24. *See* James Quirk & Katsuaki Terasawa, *Nuclear Regulation: An Historical Perspective*, 21 NAT. RES. J. 833, 836 (1981). The first commercial plant in operation was Commonwealth Edison's Dresden 1, which permanently closed in 1978. *Compare id.* at tbl. 1, *with* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, SPENT FUEL STORAGE REQUIREMENTS 1994-2042 A.3 (1995) [hereinafter SPENT FUEL STORAGE REQUIREMENTS].

25. *See* K.S. SCHRADER-FRECHETTE, BURYING UNCERTAINTY 11 (1993). Throughout the world, there were 418 commercial nuclear power plants operating in twenty-six nations to start in 1992.

26. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, LOCATIONS OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE ULTIMATELY DESTINED FOR GEOLOGIC DISPOSAL (1994) [hereinafter LOCATIONS OF SPENT NUCLEAR FUEL]. This count reflects only the states and sites, which had operating reactors at the beginning of 1992; there was one additional state (Colorado) and there were three additional sites with closed reactors at that time.

27. San Onofre 1, Yankee Rowe, Trojan, Big Rock Point, Haddam Neck (a/k/a Connecticut Yankee), Maine Yankee, and, most recently, Zion 1 and 2.

28. The Tennessee Valley Authority's Watts Bar 1, in 1996.

have Nuclear Regulatory Commission construction permits,[29] it is highly doubtful they ever will be completed.[30]

The first fifteen plants ordered between 1955 and 1962 all included small prototype reactors funded by the Atomic Energy Commission under the Power Reactor Demonstration Program.[31] Commercial sales of reactors began in 1963, but many of the plants ordered between 1963 and 1966 were "turnkey" projects built under fixed price contracts by the two major domestic reactor manufacturers, General Electric and Westinghouse.[32] Following 1966, with only one or two exceptions, nuclear plants have been ordered on strictly commercial terms.[33] The number of new plants ordered peaked at thirty-six in 1973.[34] No new commercial power plants have been ordered in the United States since 1978; none of the plants ordered after 1973 were completed.[35]

2. Current Status

At present, there are 104 operational commercial nuclear plants in the United States with a combined generating capacity of approximately 100,000 megawatts. Nuclear power accounted for approximately twenty percent of the nation's electricity production in 1997, compared to almost twenty-two percent in 1996.[36]

All operating commercial nuclear plants in the United States use light-water reactors to produce steam. The steam drives a turbine-generator, which produces electricity. Commercial plants use two types of light-water reactors: boiling water and pressurized water reactors. In both types, water is circulated through the reactor core to absorb heat and to moderate the fission process. In a boiling-water reactor, water is boiled and steam is produced inside the reactor vessel. In a pressurized-water reactor, water in the reactor vessel is pressurized to prevent it from boiling. Instead, the pressurized, super-heated water is circulated to

---

29. The Tennessee Valley Authority's Watts Bar 2 and Bellefonte 1 and 2.

30. *See* PLAN. INFO. CORP., THOMPSON PROF. GROUP, & DECISION RES. INST., NUCLEAR WASTE PROJECTS OFFICE, STATE OF NEVADA, AN INDEP. COST ASSESSMENT OF THE NATION'S HIGH-LEVEL NUCLEAR WASTE PROGRAM 26 (1998) [hereinafter INDEP. COST ASSESSMENT].

31. *See* Quirk & Terasawa, *supra* note 24, at 835.

32. *See id.* at 836.

33. *See id.*

34. *See id.*

35. *See* Dan M. Berkovitz, *Pariahs and Prophets: Nuclear Energy, Global Warming, and Intergenerational Justice*, 17 COLUM. J. ENVTL. L. 245, 247 (1992).

36. *See* Barnaby J. Feder, *Nation's Biggest Atomic Utility to Shut 2 Units*, N.Y. TIMES, Jan. 16, 1998, at A10.

another vessel, called a steam generator, where steam is produced.[37]

3. Projected Future Status Pending Electric Utility Disaggregation and Deregulation

Based on official Department of Energy (DOE) projections,[38] there will be still be 104 operating reactors at year-end 2000, a number which will decline to eighty-nine at year-end 2010, forty-three at year-end 2020, and only two at year-end 2030.[39] The last U.S. commercial nuclear plant is projected to close by year-end 2035.[40]

In 2000, nuclear plants are expected to account for twenty percent of electricity production in the United States.[41] By 2010, nuclear power is projected to represent only fifteen percent of the nation's electricity.[42] By 2020, it is expected to decline to approximately nine percent.[43] By 2030, it is forecast to be negligible.[44]

B. Spent Nuclear Fuel: Its Characteristics and Amounts

1. Constituent Elements

There are more than thirty elements which are produced by the fission process in a nuclear reactor and found in spent nuclear fuel. These elements are products of both the nuclear fuel and the cladding in which it is contained.[45]

---

37. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, OCWRM TRANSP. REP. 1 (1995) [hereinafter TRANSP. REP.].

38. *See id.* These projections were adjusted to eliminate TVA's hypothetically planned but effectively cancelled Watts Bar 2 and Bellefonte 1 and 2 plants.

39. *See* SPENT FUEL STORAGE REQUIREMENTS, *supra* note 24, at tbl. A-1. These projections assume no new plants are ordered and existing plants operate for their license periods, without early closures or license extensions.

40. Tennessee Valley Authority's Watts Bar 1, in 1996. *See* SPENT FUEL STORAGE REQUIREMENTS, *supra* note 24, at tbl. A-1.

41. *See* ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ANNUAL ENERGY OUTLOOK 1998 PROJECTIONS, app. tbl. 8 (1997).

42. *See id.*

43. *See id.*

44. *See* SPENT FUEL STORAGE REQUIREMENTS, *supra* note 24, at tbl. A-1.

45. Nuclear fuel products created by the fissioning of uranium-235 include radioactive isotopes of strontium, cesium, promethium, krypton, curium, ruthenium, zirconium, barium, iodine and xenon. Products of the fissioning of uranium-238 include radioactive isotopes of the transuranic elements of plutonium, neptunium, americium, curium, berkelium, and californium. The fission process also produces from the fuel cladding radioactive isotopes of a number of other elements, including zirconium, chromium, tin, iron and nickel, along with much smaller quantities of manganese, silicon, phosphorus, carbon, sulfur, selenium. Also produced from the fuel cladding are small amounts of niobium, tantalum and molybdenum, and trace

2. Physical characteristics

Nuclear fuel is packaged in long, thin, metal-clad rods, which are then bundled in assemblies. While there is considerable variation in individual assemblies, a typical fuel assembly is about fourteen to fifteen feet long, about nine inches square in a pressurized-water reactor, and about five inches square in a boiling-water reactor.[46] In a boiling-water reactor, there are typically sixty-three fuel rods per fuel assembly, with each assembly weighing 320 kg (705 lbs), having a nominal volume of 0.0864 m^3 (3.05 ft^3) containing 0.183 metric tons of uranium (MTU).[47] In a pressurized-water reactor, there are typically 264 fuel rods per assembly, with each assembly weighing 658 kg (1451 lbs), having a nominal volume of 0.1860 m^3 (6.57 ft^3) and containing 0.461 MTU.[48]

3. Radioactive Characteristics

Spent nuclear fuel is highly radioactive and thermally very hot. At discharge, each metric ton initially produces nearly 180 million curies of radioactivity and generates 1.6 megawatts of heat.[49] By comparison, it has been estimated that, ten days after the initial explosion, the nuclear reactor accident at Chernobyl released 50 million curies.[50] Because many of the radioactive isotopes in spent fuel decay quickly, its level of radioactivity falls to 693,000 curies and its thermal output to 12,500 watts per ton a year after removal from the reactor.[51] However, even after 10,000 years, each ton of spent fuel still emits hazardous levels (470 curies) of radioactivity and measurable amounts (fourteen watts) of heat.[52]

---

amounts of cobalt, titanium, and aluminum. *See* Richard Ausness, *High-Level Radioactive Waste Mgmt.: The Nuclear Dilemma*, 1979 WIS. L. REV. 707, 727-30 (1979).

46. *See* TRANSP. REP., *supra* note 37, at 1.

47. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, CIVILIAN RADIOACTIVE WASTE MGMT. SYSTEM: TOTAL SYSTEM DESCRIPTION 6 (1997), *available at* http://www.rw.doe.gov (last visited Nov. 28, 2000) [hereinafter TOTAL SYSTEM DESCRIPTION].

48. *See id.*

49. *See* LENSSEN, *supra* note 19, at 9.

50. *See id.*

51. *See id.* at 9-10.

52. *See id.* at 10.

4. Threats to Human Health and the Environment

Spent nuclear fuel is perhaps the most dangerous radioactive waste of all in terms of its threat to human health and the environment.[53] Even though it accounts for less than one percent of the volume of all radioactive waste in the United States, it contains ninety-five percent of the radioactivity from all civilian and military sources combined.[54] Each radioactive isotope in spent fuel has its own characteristic duration and level of radioactivity, emitting varying levels of alpha and beta particles and gamma rays for varying lengths of time.[55] It is these particles and rays that cause harm to living tissue and threat to the environment.[56] Typically, the level of radiation at a point in time is measured in curies and duration of radioactivity over time is measured in

53. *See id.* at 9.

54. *See* LENSSEN, *supra* note 19, at 9.

55. *See id.* at 8-9.

56. Radiation causes damage to living tissue at the cellular level by transferring energy by means of ionization. Although they have little penetrating power, alpha particles cause intense ionization along their paths. As a result, internal exposure to alpha radiation is generally much more harmful than external exposure. Beta particles ionize less intensely, but penetrate more deeply than alpha particles. Gamma rays penetrate very deeply into tissues at the cellular level and ionize uniformly along their paths. External exposure to high-level gamma radiation can be very dangerous. The amount of energy transferred by ionization can be measured. The rad is the unit of absorbed energy in tissue; the roentgen is the unit of transmitted energy in air. The rem measures the relative biological damage caused by multiplying the absorbed dose in rads by a relative effectiveness factor. One rad of beta or gamma radiation is equal to one rem, while one rad of alpha radiation is equivalent to ten rems. As far as external exposure is concerned, the most immediate and dramatic biologic effects are produced by whole-body exposure to high doses of penetrating radiation. Doses over 600 rems usually cause death within a few weeks, while doses of between 150 and 600 rems may be fatal but also provide some chance of recovery. Radiation sickness may be caused by doses as low as 100 rems. External exposure to high but non-lethal levels of radiation may have serious human health effects. For example, sub-lethal levels of total body irradiation can cause leukemia and exposure to gamma radiation can cause cataracts and thyroid cancer. Exposure to even low levels of ionizing radiation, particularly where it is chronic, can also cause genetic changes in living organisms. This effect can be particularly significant where small doses of radiation are received by large numbers of individuals in a particular population through which radiation may introduce as many mutant genes as would large doses into small numbers of individuals. Even very low levels of radiation exposure can be dangerous when radioactive substances are ingested, inhaled or injected. This is because the radiation can diffuse throughout the entire body or concentrate in particular organs or tissue, depending on the substance. For example, radium, strontium and barium, which are chemically similar to calcium, are absorbed in bone, often causing bone cancer. Plutonium also accumulates in bone, while radioactive iodine accumulates in the thyroid gland, posing strong cancer risks. Inhaled plutonium is extremely dangerous, both in terms of short-term toxicity and long-term cancer risks. All these substances are present in spent nuclear fuel. *See* Ausness, *supra* note 45, at 713-15.

"half-lives," where a half-life is the amount of time it takes for fifty percent of the isotope's current level of radioactivity to decay.[57] Generally, the radioactive isotopes in spent fuel are considered dangerous to human health and the environment for at least ten and, in some cases, as many as twenty half-lives.[58] Thus, shorter-lived fission products, such as strontium-90 and cesium-137 with thirty year half-lives, require isolation from the environment for 600 years before being considered safe.[59] By contrast, long-lived transuranics, such as plutonium-239, remain hazardous for at least 240,000 and perhaps as many as 500,000 years.[60]

5. Current and Projected Amounts of Spent Fuel

At the end of 1997, there were estimated to be between 36,100 and 36,800 MTU of spent fuel from commercial nuclear plants in temporary storage.[61] This equated to approximately 125,000 spent fuel assemblies.[62] Additional spent fuel is currently being generated at the rate of approximately 2,000 MTU and 7,000 assemblies per year.[63] The DOE has projected that by 2030, the cumulative amount of spent fuel discharged by commercial reactors will be 84,100 MTU in 293,000 assemblies.[64] By 2035, the cumulative amount of spent fuel discharged has been projected by a private consultant to reach a maximum of approximately 87,000 MTU in 299,000 assemblies.[65]

6. Current Storage of Spent Fuel

Currently, virtually all commercial spent fuel is being stored at the site of the reactor that generated it.[66] Most commercial spent fuel is being stored in steel-lined, water-filled pools below

57. *See* LENSSEN, *supra* note 19, at 9.

58. *See* Ausness, *supra* note 45, at 746; *see also* LENSSEN, *supra* note 19, at 9.

59. *See* Ausness, *supra* note 45, at 746.

60. *See id.*

61. *See* SPENT FUEL STORAGE REQUIREMENTS, *supra* note 24, at 4.3.

62. *See id.* at B-34.

63. *See id.* at 4.3, B-34.

64. *See* TOTAL SYSTEM DESCRIPTION, *supra* note 47, at 6.

65. *See id.* In addition to civilian spent fuel, DOE will eventually need to dispose of defense wastes totaling approximately 2,700 MTU of spent fuel and 8,000 MTU equivalent of other high-level wastes by 2035. *See* TRANSP. REP., *supra* note 37, at 2.

66. In June 1997, a consortium of nuclear utilities applied to the Nuclear Regulatory Commission for a permit to store spent fuel and other high-level waste in dry casks at the nation's first and only away-from-reactor "independent spent fuel storage installation" (ISFSI) on the Skull Valley Goshute Indian Reservation in Skull Valley, Utah. *See* 62 Fed. Reg. 41,099 (July 31, 1997). This application is still pending at this writing.

ground-level at the site of the generating reactor. However, a small but increasing amount of spent fuel is being stored in heavy, thick-walled metal or concrete casks above-ground at reactor sites.[67] The current locations of storage sites for spent fuel and other high-level wastes are shown in Figure 1, *infra*.[68]

IV. Commercial High-Level Nuclear Waste Policy in the United States: History and Issues

A. History

1. The Atomic Energy Act of 1954 and the Price-Anderson Act of 1957

The Atomic Energy Act of 1946[69] restricted the possession and use of nuclear technology to the federal government and prohibited private ownership of nuclear facilities and materials.[70] This policy was changed by the Atomic Energy Act of 1954,[71] which established a program to encourage widespread private participation in the development and use of nuclear power "to the maximum extent consistent with the common defense and security and with the health and safety of the public."[72] The 1954 Act authorized private industry to own and operate nuclear facilities and use nuclear technology under license from and regulation by the Atomic Energy Commission (AEC).[73]

Private industry was initially reluctant to accept the federal government's invitation to develop commercial nuclear power. Nuclear technology was unproven in commercial use and posed liability risks not associated with other means of generating electricity for commercial use.[74] While both the federal government

67. *See* LOCATIONS OF SPENT NUCLEAR FUEL, *supra* note 26, at 1 (unnumbered). Sites currently using aboveground dry storage include Virginia Power's Surry Plant, Carolina Power & Light's H.B. Robinson Plant, Duke Power's Oconee Nuclear Station, Colorado Public Service Company's closed reactor at Fort St. Vrain, Baltimore Gas & Electric Company's Calvert Cliffs Plant, Wisconsin Electric Power's Point Beach Plant and Michigan's Consumers Power Palisades Plant.

68. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, ANNUAL REPORT TO CONGRESS FISCAL YEAR 1997 12 (1999).

69. Pub. L. No. 79-585, 60 Stat. 755 (superseded by Atomic Energy Act of 1954).

70. *See id.* at §§ 4-5.

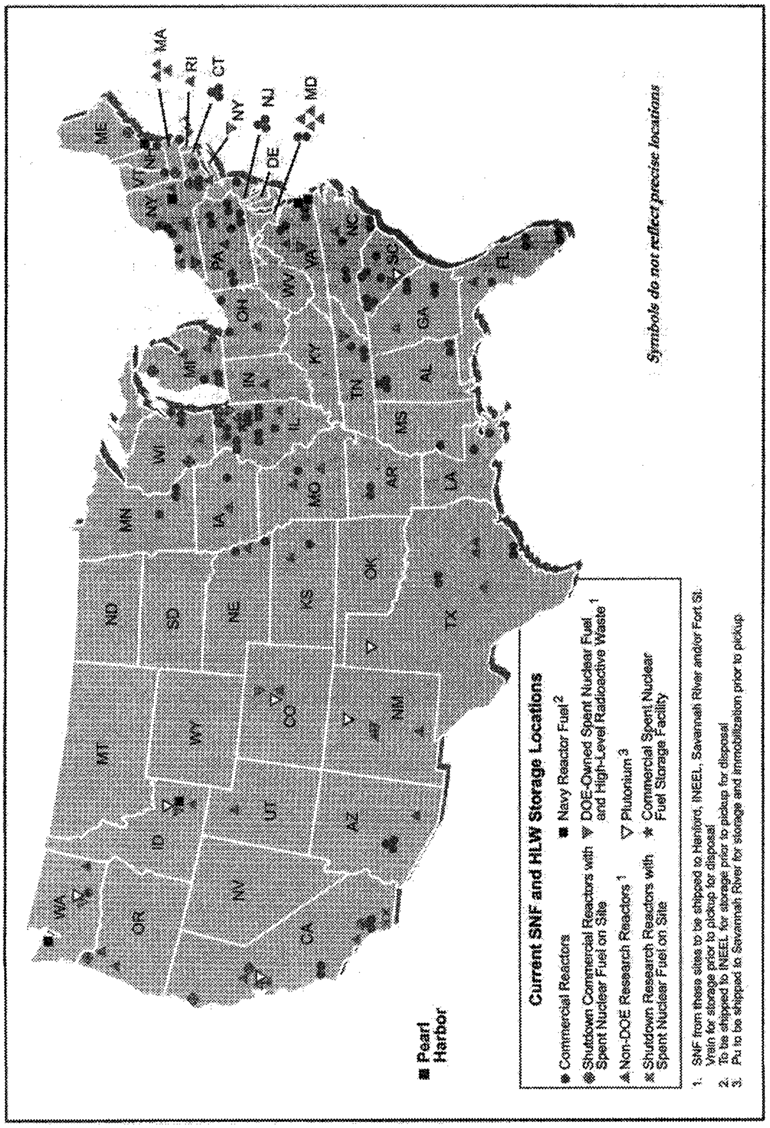
71. Pub. L. No. 703, 68 Stat. 919 (codified as amended at 42 U.S.C. §§ 2011-2283 (1994 & Supp. 1997)). *See* Diane C. Maleson, *The Historical Roots of the Legal System's Response to Nuclear Power*, 55 S. CAL. L. REV. 597, 601-09 (1982).

72. Pub. L. No. 703, § 3(d), 68 Stat. 919, 922 (codified at 42 U.S.C. § 2013(d)).

73. *See id.* at §§ 41, 53, 68 Stat. 919, 928-31 (codified at 42 U.S.C. §§ 2061, 2073).

74. *See*, Daniel W. Meek, Note, *Nuclear Power and the Price-Anderson Act: Promotion over Public Protection*, 30 STAN. L. REV. 393, 393 (1978).

Figure 1



Locations of Spent Nuclear Fuel and High-Level Radioactive Waste Destined for Geologic Disposal

and the utility industry believed such risks were remote, the magnitude of potential damages was so huge that private insurance companies would not underwrite those risks.[75] In response, the Price-Anderson Act[76] was enacted in 1957 to limit the liability of nuclear utilities[77] and remove this obstacle to private investment in nuclear power.[78]

2. Energy Reorganization Act of 1974

The development of commercial nuclear power was supervised by the AEC until 1974. The Energy Reorganization Act of 1974[79] created the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), divided the responsibilities of the AEC between them, and abolished the AEC. This reorganization represented a Congressional response to concerns about the AEC being responsible for both promoting nuclear power as a viable commercial option and regulating nuclear plant safety, by assigning promotional functions to ERDA and safety responsibilities to the NRC.[80] The NRC became responsible for developing procedures for commercial nuclear plants to follow in order to protect the public and the environment from the hazards of spent fuel and other radioactive wastes gener-

75. *See* Maleson, *supra* note 71, at 602.

76. Pub. L. No. 85-256, 71 Stat. 576 (1957).

77. The Price-Anderson Act limits the aggregate liability of nuclear utilities and Department of Energy contractors arising out of "nuclear incidents" at nuclear plants or in the course of transportation of nuclear materials. The term "nuclear incident" means "any occurrence . . . within the United States causing, within or outside the United States, bodily injury, sickness, disease, or death, or loss of or damage to property, or loss of use of property, arising out of or resulting from the radioactive, toxic, explosive or other hazardous properties of source, special nuclear or byproduct material." 42 U.S.C. § 2014(q). Spent nuclear fuel is a "byproduct material" within the meaning of this definition. *See* 42 U.S.C. § 2014(e). Price-Anderson also defines the method by which the financial resources necessary to meet this limited liability will be provided and apportions responsibility for providing them. *See* 42 U.S.C. § 2210(e)(1). The current limit of apportioned liability for an incident at a commercial nuclear plant is $63 million per plant, resulting in an aggregate limit per incident of approximately $7 billion. While the Act clearly limits the liability of the private sector, it does not limit the liability of the federal government, which Congress is to determine for each incident on a case-by-case basis. *See* 42 U.S.C. § 2210(e)(2).

78. *See* James H. Davenport, *The Law of High-Level Nuclear Waste*, 53 TENN. L. REV. 481, 521 (1986).

79. Pub. L. No. 93-438, 88 Stat. 1233, *codified at* 42 U.S.C. §§ 5801-5891 (1994). *See generally* Marcus A. Rowden, *Nuclear Power Regulation in the United States: A Current Domestic and International Perspective*, 17 ATOM. ENERGY L. J. 102 (1975).

80. *See* Maleson, *supra* note 71, at 603 n.35.

ated by commercial reactors. ERDA became part of the Department of Energy when it was established in 1977.

3. Natural Resources Defense Council, Inc. v. U.S. Nuclear Regulatory Commission

The procedures developed by the NRC to consider the environmental and public safety impacts of the radioactive wastes generated by commercial nuclear power plants were soon challenged as violative of the National Environmental Policy Act (NEPA)[81] in *Natural Resources Defense Council, Inc. v. NRC.*[82] Under NEPA, an agency taking a major federal action significantly affecting the environment is required to prepare an Environmental Impact Statement (EIS) evaluating the action's environmental effects.[83] Natural Resources Defense Council (NRDC) contended that NEPA required the NRC to consider the environmental impacts of radioactive waste disposal and spent fuel reprocessing in each commercial reactor licensing proceeding, but the NRC concluded that these issues should be reviewed only during the licensing of waste disposal or reprocessing facilities.[84]

The D.C. Circuit found the NRC's approach to be violative of NEPA for two reasons.[85] First, NEPA had been enacted to assure that all the environmental consequences of an action would be evaluated together before the action, not separately after the action. Second, once a power plant had been licensed and started to operate, the decision to produce waste had been made and the only question was what to do with it. Thus, according to the Court of Appeals, NEPA required the NRC to consider the environmental impacts before the wastes were produced and, absent generic proceedings, individual reactor licensing proceedings were the proper time to consider the impacts.[86]

However, in *Vermont Yankee Nuclear Power Corp. v. NRDC*, the Supreme Court reversed the Court of Appeals, ruling that the appellate tribunal had exceeded its authority and invaded the province of the NRC.[87] The Court reasoned that the legislative

81. 42 U.S.C. §§ 4321-4370(d) (1994).

82. 547 F.2d 633 (D.C. Cir. 1976), *rev'd sub nom.*, Vermont Yankee Nuclear Power v. NRDC, 435 U.S. 519 (1978). *See also* Maleson, *supra* note 71, at 621-24.

83. 42 U.S.C. § 4332(c)(1)-(v).

84. *See Vermont Yankee*, 435 U.S. at 533-35.

85. *See* Natural Resources Defense Council, Inc. v. NRC, 547 F.2d at 640-41.

86. *See id.* at 646-54.

87. *See Vermont Yankee*, 435 U.S. at 556-58; *see also* Maleson, *supra* note 71, at 623-24.

history of the Administrative Procedure Act (APA) showed that Congress intended that administrative agencies have broad discretion with respect to their procedures, discretion which reviewing courts could curtail only when constitutional issues or extremely compelling circumstances were presented.[88] The Court concluded that the unresolved public safety and environmental protection issues associated with nuclear waste had been subsumed in the fundamental policy decision by Congress "to at least try nuclear energy."[89] Because Congress had made this basic policy decision and established a reasonable review process for its implementation by the NRC, the courts were to play only a limited role and the policy was "*not* subject to reexamination in federal courts under the guise of judicial review of agency action."[90] As a result of the *Vermont Yankee* decision, the unresolved public safety and environmental protection issues associated with nuclear waste were defined as policy issues and deferred for future attention by the legislative and executive branches.

4. Presidential Policy Statement of 1980

After the DOE was created in October 1977, the Carter administration began an interagency review to reassess existing policy toward nuclear waste disposal. However, this effort did not culminate in formal policy proposals until the President sent a message to Congress on February 12, 1980.[91] This message outlined a comprehensive national radioactive waste management program, the key elements of which included:

- Federal, state and local government would share responsibility for safe management and disposal of nuclear waste, with siting decisions governed by the principle of "consultation and concurrence";
- Pending reviews required under NEPA, an interim plan was adopted for disposal of high-level and transuranic wastes in "mined geologic repositories," with four or five alternative sites to be evaluated and the initial repository sited by 1985 and operational by the mid-1990s;

88. *See Vermont Yankee*, 435 U.S. at 545-46.

89. *Id.* at 557-58.

90. *Id.* at 558.

91. Presidential Message and Fact Sheet of February 12, 1980, *reprinted in* THE POL. OF NUCLEAR WASTE 220 (E. William Colglazier, Jr. ed., 1982) [hereinafter Presidential Message].

- Until a permanent geologic repository became available, safe interim storage of commercial spent fuel at reactor sites would continue to be the responsibility of the generating utilities, but legislation would be sought to authorize limited away-from-reactor (AFR) facilities for domestic spent fuel which could not be stored on-site and foreign spent fuel when the objectives of U.S. nonproliferation policy would be served;
- The Department of Energy would continue to have the primary responsibility for implementation and integration of the program at the federal level, with the primary planning mechanism to be a comprehensive, interagency "National Plan for Nuclear Waste Management" subject to public input and Congressional review.[92]

The Carter proposal was premised on a number of basic policy principles. First, the technical program would be required to meet all of the relevant radiological protection criteria, as well as other applicable regulatory requirements, with risks "reduced to the lowest level practicable."[93] Second, the responsibility for establishing a nuclear waste management program would be undertaken by the same generation of Americans which had begun producing the waste and not deferred to future generations. Third, the program would include consideration of all aspects of the waste issue, "including safety, environmental, organizational and institutional factors."[94] Fourth, the basic elements of the program should be independent of the number of commercial nuclear reactors and the specific fuel cycle technologies or reactor designs chosen by the nuclear industry.[95] Additionally, the President's message declared, "The principle that will be applied to financing the cost of nuclear waste management and disposal is that the cost should be payed [sic] by the generator of the waste and borne by the beneficiary of the activity generating the waste."[96] Specifically, this principle meant, "utilities will pay the cost of storage and disposal of waste from power plant operations and pass those costs on to their customers. The government will pay the cost of storage and disposal of wastes from defense and government R&D activities and finance it from tax revenues."[97]

92. *Id.* at 221-26.
93. *Id.*
94. *Id.*
95. *See id.* at 227.
96. Presidential Message, *supra* note 91, at 232.
97. *Id.*

5. Nuclear Waste Policy Act of 1982

Congress did not respond to the Carter Administration recommendations until 1982, when it enacted and President Reagan signed the Nuclear Waste Policy Act (NWPA).[98] The NWPA directed DOE to identify suitable sites for, and then to construct and operate two geologic repositories, with the specified search criteria essentially requiring the first to be located in the western United States.[99] In order to provide geographic equity (and political palatability), the NWPA limited the waste disposed at the western repository to 70,000 metric tons of spent fuel and directed that a search be initiated for the site of a second repository according to criteria which virtually assured it would be located in the eastern United States[100] The first repository was to begin receiving spent fuel by January 31, 1998.[101] The civilian share of the costs for siting, constructing and operating the repositories and transporting and managing the wastes disposed there was to be paid through appropriations by Congress from a Nuclear Waste Fund (NWF) financed by a fee of one mill (one tenth of a cent) per kilowatt-hour of electricity generated and sold by commercial nuclear reactors.[102]

The NWPA required DOE to consider various geological, technical and geographical factors to evaluate the suitability of potential repository sites.[103] DOE was directed to identify five sites for preliminary evaluation as the location for the first repository, from which it would recommend three to the President for more detailed evaluation or "characterization" not later than January 1, 1985.[104] Similarly, DOE was charged with identifying five sites for further evaluation and recommending to the President by January 1, 1989 which three should be "characterized" for the second

98. Pub. L. No. 97-425, 96 Stat. 2202 (1983) (codified as amended at 42 U.S.C. §§ 10101-10270 (1994 & Supp. 1997)).

99. *See* 42 U.S.C. § 10132(a), (b)(1)(A), (b)(1)(C) (1982), *amended or repealed by* Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100-202, 101 Stat. 1329-104 and Pub. L. No. 100-203, § 5011(b), 101 Stat. 1330-228.

100. *See* 42 U.S.C. § 10132(b)(1)(C) (1982), *repealed by* Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100-202, 101 Stat. 1329-104 and Pub. L. No. 100-203, § 5011(b), 101 Stat. 1330-228. *See* Berkovitz, *supra* note 35, at 260 n.53.

101. *See* 42 U.S.C. § 10222(a)(5) (1982).

102. *See id.* § 10222(a)(2)-(3).

103. *See id.* § 10132(a).

104. *See id.* § 10132(b)(1)(A)-(B).

repository.[105] The President would then either accept or reject each of DOE's recommendations.[106] After characterizing each site approved by the President, DOE would recommend one to be the location of a repository.[107] If the President approved the recommended site, s/he would formally nominate the site to Congress.[108] An affected state or Indian tribe could veto the President's nomination, in which case the selection would be invalidated unless the veto was overridden by a majority vote of both houses of Congress.[109] An NRC license would be required for the actual construction and operation of the repository at the selected site.[110]

DOE's implementation of the NWPA proved controversial from the outset. While a broad consensus supported the Act in concept, states in which sites under consideration for characterization were located raised numerous objections to DOE's site selection process. As a result, DOE suspended the process for the second repository prior to recommending any sites for characterization in order to shore up political support for continuing the process for the first repository.[111] But, this patent submission to pressure only compounded DOE's political problems regarding the first repository, which were even further exacerbated by program delays and cost increases resulting from technical and management problems.[112]

6. Nuclear Waste Policy Amendments of 1987

Congress responded to the political turmoil surrounding implementation of the NWPA by enacting the Nuclear Waste Policy Amendments Act of 1987 (NWPAA).[113] The NWPAA short-cir-

105. *See id.* § 10132(b)(1)(C), *repealed by* Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100-202, 101 Stat. 1329-104 and Pub. L. No. 100-203, § 5011(b), 101 Stat. 1330-228.

106. *See* 42 U.S.C. § 10132(c) (1994 & Supp. 1997).

107. *See* 42 U.S.C. § 10134(a)(1) (1982), *amended by* Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100-202, 101 Stat. 1329-104 and Pub. L. No. 100-203, § 5011(b), 101 Stat. 1330-228.

108. *See id.*

109. *See* 42 U.S.C. §§ 10136(b), 10138(a), 10135(c) (1994 & Supp. 1997).

110. *See* 42 U.S.C. §§ 10134(b), (d) (1982), *amended by* Nuclear Waste Policy Amendments Act of 1987, Pub. L. No. 100-202, 101 Stat. 1329-104 and Pub. L. No. 100-203, § 5011(b), 101 Stat. 1330-228.

111. *See* Berkovitz, *supra* note 35, at 261.

112. *See id.*

113. Pub. L. No. 100-203, 101 Stat. 1330-227 (1987) (codified at 42 U.S.C. §§ 10101 - 10270 (1994)). *See generally* Jeffrey D. Raeber, Comment, *Federal Nuclear Waste Policy as Defined by the Nuclear Waste Policy Amendments Act of 1987*, 34 ST. LOUIS U. L. J. 111 (1989); *see also* Berkovitz, *supra* note 35, at 261-62 (1992).

cuited the selection process for the first repository and designated Yucca Mountain, Nevada as the only site to be characterized by DOE.[114] However, the 1987 Amendments retained the 1982 Act's provision for state veto power over a site selection decision by the President and its requirement for an NRC license for actual construction of a repository. The NWPAA left unchanged the January 31, 1998 deadline for DOE to begin to accept spent fuel from the commercial nuclear utilities. The Amendments also preserved the NWF with its one mill-per-kilowatt-hour funding mechanism for the Act's commercial waste program.

While the NWPAA was strongly supported by both DOE and the nuclear industry, the new legislation did not solve the political problems associated with repository siting. Predictably, the State of Nevada and its elected officials mounted a concerted attack on the NWPAA's pre-emption of the site selection process contemplated by the 1982 Act. Moreover, the patently political and manifestly unfair nature of that provision were so widely recognized that the 1987 Amendments were commonly characterized on Capitol Hill as the "Screw Nevada bill."[115] Moreover, the unresolved public safety and environmental impact issues associated with nuclear waste disposal, which the Supreme Court's *Vermont Yankee* decision had deferred for future consideration by the policy branches of government, became present problems for policymakers with enactment of the NWPAA.

The NRC had concluded in its "Waste Confidence Decision" of August, 1984 that safe disposal of nuclear wastes in a geologic repository was technically feasible; that at least one repository would be available by 2007-2009; that sufficient repository capacity would be available for all nuclear wastes from commercial reactors within thirty years after the cessation of operations at any reactor; and that wastes could be safely stored at reactor sites, or offsite, for at least thirty years.[116] The NRC reaffirmed this decision in 1990, although it did reflect the delays in the DOE repository program by concluding that at least one repository would be available not by 2007-2009, but "within the first quarter of the

114. *See* 42 U.S.C. § 10133 (1994 & Supp. 1997).

115. *See* Berkovitz, *supra* note 35, at 262; James Flynn & Paul Slovic, *Yucca Mountain: A Crisis for Policy: Prospects for America's High-Level Nuclear Waste Program*, 20 ANN. REV. ENERGY & ENV'T 83, 95 (1995).

116. Waste Confidence Decision, 49 Fed. Reg. 34,658 (Aug. 31, 1984) (codified as amended at 10 C.F.R. § 51.23 (1998)).

twenty-first century," i.e. by 2025.[117] But, these decisions assumed that technical standards could be set which a repository could meet that would provide reasonable assurance of public safety and environmental protection - an assumption which came under increasingly widespread and credible challenge at about the same time the NWPAA was being enacted.

In particular, the First Circuit Court of Appeals invalidated, in July 1987, the environmental standards for a repository which the U.S. Environmental Protection Agency (EPA) had promulgated in 1985,[118] finding both the duration of prescribed protection and the specific limits set for groundwater protection set by the agency to be arbitrary and capricious.[119] Subsequently, in 1990, the Board of Radioactive Waste Management of the National Research Council conducted a symposium of nuclear waste experts and published an influential report of its results entitled "Rethinking High-Level Radioactive Waste Disposal," which challenged the theoretical basis of the EPA standards and criticized

---

117. Waste Confidence Decision Review, 55 Fed. Reg. 38,474 (Sept. 18, 1990) (codified at 10 C.F.R. § 51.23 (1998)). The NRC recently reaffirmed the findings of its 1990 Waste Confidence Review and, absent unexpected events, deferred any further review until after "impending repository development and regulatory activities run their course." *See* Status Report on the Review of the Waste Confidence Decision, 64 Fed. Reg. 68,005, 68,007 (Dec. 6, 1999).

118. The standards issued by EPA in 1985 included four requirements for the long-term disposal of high-level radioactive waste in geologic repositories:

(1) containment requirements, which were intended to limit the total releases of radionuclides over the first 10,000 years of the repository's existence to specified dose levels projected to cause no more than 1,000 premature deaths over the compliance period;

(2) individual protection requirements, designed to protect individuals living in the vicinity of the repository for annual exposures in excess of twenty-five millirems to the whole body or seventy-five millirems to any critical organ for 1,000 years after disposal;

(3) groundwater protection requirements, which limited the concentration of radionuclides in groundwater in the vicinity of the repository to levels somewhat above those specified under the Safe Drinking Water Act for community water systems; and

(4) quality assurance requirements, which established various institutional and procedural requirements for facilities not licensed by the NRC.

Berkovitz, *supra* note 35, at 270-71 (summarizing requirements set in Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, Final Rule, 50 Fed. Reg. 38,066 (Sept. 19, 1985) (codified in 40 C.F.R. Pt. 191)).

119. *See* Natural Resources Defense Council, Inc. v. EPA, 824 F.2d 1258, 1293 (1st Cir. 1987).

the deadline-directed, geology-focused, and detail-oriented approach of the DOE repository program.[120]

7. Title VII, Energy Policy Act of 1992

Responding to the increasing controversy, Congress passed Title VII of the Energy Policy Act of 1992 (EPAct).[121] In EPAct, Congress directed the EPA to contract with the National Academy of Sciences (NAS) to conduct a study to determine and then to recommend, not later than December 31, 1993, the appropriate public health and safety standards for the disposal of high-level nuclear waste at the Yucca Mountain site designated for characterization by the NWPAA.[122] EPA was charged with the responsibility of issuing its public health and safety standards for the Yucca Mountain repository within one year of receiving the NAS study and recommendations.[123] However, the Conference Report accompanying EPAct expressly provided that the EPA was not required to base its new standards on the NAS recommendations.[124] Also, the NRC was required to modify its licensing standards for a Yucca Mountain repository to conform to the EPA standards within one year of their issuance.[125]

Despite the year-end 1993 deadline set by EPAct, the NAS did not complete its study and forward its recommendations regarding Yucca Mountain public health and safety standards until 1995.[126] The standards recommended by the NAS differed in important ways from those originally promulgated by EPA in 1985. In particular, the NAS recommended:

---

120. BD. ON RADIOACTIVE WASTE MGMT., NAT'L RES. COUNCIL, RETHINKING HIGH-LEVEL RADIOACTIVE WASTE DISPOSAL (1990), *reprinted in* NAT'L RES. COUNCIL, RADIOACTIVE WASTE LICENSING, app. A at 21 (1992).

121. Pub. L. No. 102-486, §§ 801-03, 106 Stat. 2921 (1992).

122. *See id.* at § 801(a)(2).

123. *See id.* at § 801(a)(1). These standards would apply *only* to the Yucca Mountain repository; separate standards would apply to all other high-level nuclear waste facilities. Shortly after enacting EPAct, Congress also passed the Waste Isolation Pilot Plant Land Withdrawal Act, Pub. L. No. 102-579, § 8(b)(1), 106 Stat. 4777, 4786 (1992), which directed EPA, within six months, to promulgate standards for all other facilities that would either reinstate or replace those remanded to the agency in Natural Resources Defense Council, Inc. v. EPA, 824 F.2d 1258, 1293 (1st Cir. 1987). *See supra* note 118 and accompanying text.

124. H.R. CONF. REP. NO. 1018, at 391 (1992).

125. *See* Pub. L. No. 102-486, § 801(b), 106 Stat. 2922 (1992).

126. *See* BD. ON RADIOACTIVE WASTE MGMT., NAT'L RES. COUNCIL, TECH. BASES FOR YUCCA MOUNTAIN STANDARDS (1995) [hereinafter YUCCA MOUNTAIN STANDARDS].

> (1) the use of a standard that sets a limit on the risk to individuals of adverse health effects from radioactive releases, rather than the standard adopted by EPA which sets a limit on the dose of radioactivity received by individuals;
>
> (2) that compliance with the standard be measured at the time of peak risk, whenever that occurs, as contrasted with the EPA approach of measuring compliance only for the first 10,000 years of the repository's existence; and
>
> (3) the use of a standard which, unlike EPA's, does not include a risk-based calculation of the adverse effects of human intrusion into the repository but does calculate the consequences of an intrusion to assess the resilience of the repository.[127]

More generally, the NAS concluded that science simply could not resolve all the issues necessary to set the standard, so that it was important that the EPA rulemaking which set the standard allow for "wide-ranging input from all interested parties" with respect to the policy choices necessarily involved.[128] For example, the NAS acknowledged that the level of risk which was acceptable was necessarily a policy decision, with a "reasonable starting point" being in the range of 10^{-5} to 10^{-6} adverse effects per year.[129]

Notwithstanding the EPAct deadline to promulgate new standards within twelve months of receipt of the NAS report, EPA did not issue its proposed Yucca Mountain public health and safety standards until late August 1999–approximately three years late.[130] From EPA's interim status report on the standards-writing process, it would appear that EPA struggled internally with nine principal issues:

---

127. *Id.* at 2.

128. *Id.* at 3. The need for EPA to accommodate a wide range of viewpoints on Yucca Mountain health and safety standards is not an idle concern on the part of the NAS. For example, 65 different individuals and organizations from eighteen states and the District of Columbia submitted a wide range of comments to EPA on the NAS report recommendations. *See* RAYMOND L. CLARK, OFFICE OF RADIATION AND INDOOR AIR, ENVTL. PROT. AGENCY BACKGROUND ON 40 CFR PART 197 ENVTL. RADIATION PROTECTION STANDARDS FOR YUCCA MOUNTAIN (1998). Despite the fact that the NAS report was intended to reduce uncertainty and produce consensus, its recommendations have themselves generated new difficulty, complexity and controversy. *See, e.g.*, K. S. Shrader-Frechette, *Academy Recommendations on the Proposed Yucca Mountain Waste Repository: Overview and Criticisms*, 8 RISK: HEALTH, SAFETY AND ENV'T 25 (1997).

129. *See* YUCCA MOUNTAIN STANDARDS, *supra* note 126, at 49.

130. *See* Envtl. Radiation Protection Standards for Yucca Mountain, Nevada, 64 Fed. Reg. 46,976 (Aug. 27, 1999) (to be codified at 40 C.F.R. pt. 197) [hereinafter Proposed EPA Standards].

(1) the definition of the critical group, i.e., determining which subset of the exposed population would be most exposed;

(2) the form of the protection standard, i.e., dose limits, risk limits, or a combination of the two;

(3) the level of the protection standard, i.e., how high the dose and/or risk limits should be;

(4) how to define the biosphere from which the repository is intended to isolate radionuclides;

(5) whether the level of the protection standard should be set with reference to the concept of "negligible incremental risk," i.e., whether there is a level of individual dose which can, for radiation protection purposes, be dismissed from consideration;

(6) the length of the compliance period, i.e., how long the repository should be required to meet the protection standard;

(7) whether to reflect in the protection standard the risk and consequences of human intrusion into the repository and, if so, how;

(8) whether to include "assurance requirements" such as active and passive institutional controls, monitoring, engineering barriers, and waste retrievability as qualitative conditions on the protection standard; and

(9) whether to include a separate protection standard for ground water.[131]

EPA's proposed rule would resolve most of these issues, although not necessarily in the manner recommended by the NAS.[132] In particular, EPA proposed public health and safety standards based on:

(1) the exposure of the "reasonably maximally exposed individual" rather than the "critical group" recommended by the NAS, which EPA concluded should be an individual engaged in a "rural residential" rather than the "subsistence farming" lifestyle recommended by the NAS;[133]

131. *See* RAYMOND L. CLARK, OFFICE OF RADIATION AND INDOOR AIR, ENVTL. PROT. AGENCY, ENVTL. RADIATION PROTECTION STANDARDS FOR YUCCA MOUNTAIN: CONSIDERATIONS ON ISSUES (1998).

132. EPA determined that, as a matter of law, it was not bound by the NAS recommendations but should use them as a "starting point" for its proposed rule. *See* Proposed EPA Standards, 64 Fed. Reg. 46,981-82 (Aug. 27, 1999).

133. *Id.* at 46,988.

(2) an exposure limit defined in terms of radioactive dose rather than health risk as recommended by the NAS;[134]

(3) a whole-body exposure limit of fifteen millirem per year, which would be within the range recommended by the NAS;[135]

(4) the use of assumptions about the future state of the biosphere that reflect current technologies and living patterns but vary geologic, hydrologic and climactic conditions, as recommended by the NAS;[136]

(5) acceptance of the NAS premise that an individual protection standard will serve to adequately protect both the local and general population, but without adoption of the concept of "negligible incremental risk" for exposure of the general population recommended by the NAS;[137]

(6) a compliance period of 10,000 years, rather than the period of 1,000,000 years suggested by the NAS;[138]

(7) an assumption that human intrusion will occur in accordance with a particular scenario designed to test the "resilience" of the repository, as recommended by the NAS;[139]

(8) no determination regarding whether "assurance requirements" such as active and passive institutional controls, monitoring, engineering barriers, and waste retrievability should be imposed as qualitative conditions, an issue on which EPA invited further comment and deferred decision to its final rule;[140] and

(9) a separate groundwater protection standard set at the same levels for particular radionuclides as established by rule under the Safe Drinking Water Act.[141]

---

134. *See id.* at 46,984. "Dose" is a measure of the amount of radiation received by an individual from exposure to radionuclides, while "risk" is the probability of an individual incurring an adverse health effect from exposure to radiation. *See id.*

135. *See id.* at 46,985. This standard uses a new dose calculation method known as "committed effective dose equivalent" (CEDE). EPA believes that the proposed standard using the new calculation method establishes a risk level that is essentially equivalent to the whole body standard of twenty-five mrem/yr set in other, older regulations, *e.g.* 40 CFR § 191.03(a), applicable to DOE storage and management of SNF. EPA has rulemakings pending to update the older regulations. *See* 64 Fed. Reg. 46,983.

136. *See* 64 Fed. Reg. at 46,993.

137. *Id.* at 46,991.

138. *Id.* at 46,991.

139. *Id.* at 46,998.

140. *Id.* at 46,998.

141. Proposed EPA Standards, 64 Fed. Reg. at 47,000.

8. 1996 OCRWM Program Plan

After enactment of the NWPAA in 1987, "the DOE's civilian radioactive waste management program . . . progressed more slowly than expected."[142] The reasons for the slow progress were several, with their comparative importance subject to heated debate. Certainly, intergovernmental conflict played a role, with official opposition by the State of Nevada increasing substantially in response to the "Screw Nevada bill."[143] Scientific disputes also plagued the program, with controversies developing over the Yucca Mountain site's vulnerability to catastrophic geologic events and human intrusion.[144] There were also many complaints from a variety of sources of DOE management problems, particularly failures to meet program schedules, stay within program budgets, maintain focus on program priorities, and to respond timely and appropriately to program problems and criticisms.[145]

142. NUCLEAR WASTE TECH. REVIEW BD., DISPOSAL AND STORAGE OF SPENT NUCLEAR FUEL–FINDING THE RIGHT BALANCE 7 (1996) [hereinafter RIGHT BALANCE].

143. E.g., Nevada passed a law in 1989 making storage of high-level radioactive waste illegal. It then attempted to exercise its "state veto" in advance of formal selection by the President of the Yucca Mountain site and sued (unsuccessfully) when DOE refused to recognize the premature veto. It also declined to issue environmental permits required from the State for repository development, forcing DOE to file suit and delaying certain site activities for up to three years. DOE has characterized these actions as evidence of a "scorched-earth battle plan" that has substantially delayed site characterization activities. *See* Flynn & Slovic, *supra* note 115, at 95-97.

144. One of DOE's scientists has theorized that Yucca Mountain is subject periodically to upwelling of groundwater, which could flood the repository and possibly cause release of radioactivity into the environment–perhaps explosively. The occurrence on June 29, 1992 of an earthquake measuring 5.6 on the Richter Scale and centered only twelve miles from the repository site highlighted concerns over the site's vulnerability to earthquakes–especially along the Ghost Dance Fault, which cuts directly through the site from south to north. Another scientific issue has been the release of radioactive carbon-14 as a result of the decay of nuclear waste canisters and the escape of the radioactive element in gaseous form. *See id.* at 98-102.

145. In May 1993, the General Accounting Office (GAO) reported that the repository program was behind schedule, over budget, and facing numerous scientific uncertainties. *See* GEN. ACCOUNTING OFFICE, NUCLEAR WASTE: YUCCA MOUNTAIN PROJECT BEHIND SCHEDULE AND FACING MAJOR SCIENTIFIC UNCERTAINTIES (1993). Program costs were projected at more than $6 billion for site characterization alone, three times the per-site estimate in 1987 and 100 times the 1981 estimate. Moreover, the GAO reported that more than sixty percent of allocated funds were being spent on management and administrative activities, and only about twenty-two percent on critical scientific and technical activities at the site. In June 1993, the Nevada Congressional delegation called for an investigation and high-level review of the DOE program, which was echoed a month later by the State's governor. Several public interest groups also asked President Clinton to initiate a comprehensive review of the program in July, 1993. A number of members of Congress also sent letters to the President requesting a review between August and October, 1993. The Nuclear Waste Technical Review Board also suggested a major program review in a letter to

These complaints culminated in Congress slashing fiscal year (FY)1996 program funding and directing that program expenditures and activities be focused on site characterization.[146] In response to these difficulties and criticisms, DOE conducted a comprehensive review of its program and, in May, 1996, significantly revised its Program Plan.[147]

As required by the FY 1996 funding authorization, the revised Program Plan deferred licensing activities and concentrated available resources on the most significant outstanding technical and engineering issues associated with Yucca Mountain site characterization. The primary near-term objectives of the revised Program Plan were: first, to complete a "viability assessment" of the Yucca Mountain site by September 30, 1998;[148] second, to submit the Secretary of Energy's formal site recommendation to the President in 2001; and, third, if the Yucca Mountain site was recommended and selected, to submit a repository license application to

---

the Secretary of Energy in November of 1993. *See* Flynn & Slovic, *supra* note 115, at 103-104. While DOE initiated its own internal review in 1993, the GAO concluded that the review was "too narrow in scope and lack[ed] sufficient objectivity to provide the thoughtful and thorough evaluation of the program that is needed." *Id.* at 104 (citing GEN. ACCT. OFFICE, NUCLEAR WASTE: COMPREHENSIVE REV. OF THE DISPOSAL PROGRAM IS NEEDED (1994)). Additionally, in August 1994, the Nuclear Waste Strategy Coalition, consisting of nuclear utility, state regulatory commission, and state attorney general representatives released a report critical of DOE program management and calling for reassignment of its high-level nuclear waste responsibilities to a federally chartered corporation. *See* Flynn & Slovic, *supra* note 115, at 103 (citing NUCLEAR WASTE STRATEGY COALITION, REDESIGNING THE U.S. HIGH-LEVEL NUCLEAR WASTE DISPOSAL PROGRAM FOR EFFECTIVE MGMT. (1994)).

146. Specifically, the FY 1996 budget was cut from $520 million to $400 million, with $85 million of that amount set aside for future development of an interim storage facility–an effective reduction in repository program funding of approximately forty percent. *See* RIGHT BALANCE, *supra* note 142.

147. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, DRAFT CIVILIAN RADIOACTIVE WASTE MGMT. PROGRAM PLAN, REVISION 1 (1996) [hereinafter REVISION 1].

148. The DOE defined the "viability assessment" to include four components:

> (1) the preliminary design concept for the critical elements for the repository and waste package; (2) a total system performance assessment, based upon the design concept and the scientific data and analysis available by September 30, 1998, describing the probable behavior of the repository in the Yucca Mountain geological setting relative to overall system performance standards; (3) a plan and cost estimate for the remaining work required to complete a license application; and (4) an estimate of the costs to construct and operate the repository in accordance with the design concept.

NUCLEAR WASTE TECH. REV. BD., REP. TO THE U.S. CONGRESS AND THE SECRETARY OF ENERGY — 1996 FINDINGS AND RECOMMENDATIONS 3 (1997) [hereinafter FINDINGS & RECOMMENDATIONS].

the NRC in 2002. These near-term objectives were directed toward the revised Program Plan's primary long-term goal of starting repository emplacement operations in 2010.[149]

In the FY 1997 appropriations bill, the Congress endorsed the "viability assessment" and directed that DOE complete it not later than September 30, 1998.[150] Other elements of the revised Program Plan were more controversial. Both the NWPA and the NWPAA had set a deadline of January 31, 1998, for the federal government to begin to accept spent fuel from the commercial nuclear utilities. However, the plan established a goal of repository operation beginning in 2010, and the Secretary of Energy had submitted Senate testimony in December, 1995, that repository operation would probably not start before 2015.[151] Moreover, the Plan assumed that Congress would not designate a site for a centralized interim storage facility until 1999.[152] Because DOE estimated that about four years would elapse between selection of an interim storage site and the first receipt of commercial spent fuel at the facility,[153] an interim storage facility would not be available to receive commercial spent fuel any sooner than 2003. With the Yucca Mountain repository not available to receive waste before 2015 and an interim facility not available to store spent fuel before 2003, the commercial nuclear utilities were faced with continued at-reactor storage for a much longer period and a much larger volume of waste than contemplated when the NWPA was enacted in 1982, or even when it was amended in 1987.

This possibility became a definite prospect in May, 1995, when DOE issued its Final Interpretation of Nuclear Waste Acceptance Issues, stating that it did not have an unconditional obligation, and would not be able to accept spent fuel by January 31, 1998, in the absence of a repository or interim storage facility constructed under the NWPA.[154] The agency also determined that it had no authority under the NWPA to provide interim storage in the absence of a facility authorized, constructed, and licensed in

149. *See* REVISION 1, *supra* note 147, at §§ 1.3.2-3.

150. *See* Energy and Water Development Appropriations Act, 1997, Pub. L. No. 104-206, Title III, 110 Stat. 2984, 2995-96 (1996).

151. *Hearings on S. 1271 Before the Senate Comm. on Energy and Natural Resources*, 104th Cong. (1995) (Dec. 14, 1995 statement of Hazel R. O'Leary, Secretary, U.S. Dep't of Energy), *cited in* RIGHT BALANCE, *supra* note 146, at 11 n.4 (1996).

152. *See* FINDINGS & RECOMMENDATIONS, *supra* note 148, at 5.

153. *See id.* at 5.

154. *See* 60 Fed. Reg. 21,793, 21,793-94 (May 3, 1995).

accordance with the Act.[155] Finally, DOE ruled that, even if it did have an unconditional obligation to accept waste beginning January 31, 1998, the Delays Clause of its Standard Contract for the Disposal of Spent Nuclear Fuel would provide an administrative remedy for the agency's failure to meet the obligation.[156]

By the end of 1995, approximately 32,000 metric tons of spent fuel had been generated at seventy commercial nuclear reactor sites nationwide.[157] Unless a significant number of reactors closed prior to the expiration of their licenses, spent fuel would continue to be produced at the rate of approximately 2,000 metric tons per year through 2010 and slowly decline to zero by the 2030's absent a material number of operating license extensions.[158] If repository operations did not begin until sometime between 2015 and 2020 and the repository could accept 3,000 metric tons per year as DOE assumed, almost 80,000 metric tons of spent fuel would require storage for some period, and all the spent fuel generated by current reactors during their licensed lives would not be emplaced at the repository until 2050. This estimate stands in marked contrast to the maximum of 40,000 metric tons requiring storage and final emplacement in the mid-2020's that had been assumed in the early 1980's.[159]

While the precise figures are subject to debate and dispute, there is no doubt that at-reactor storage of much larger volumes of spent fuel for much longer periods of time will cost the nuclear utilities significant amounts of money. For example, DOE estimated that the capital cost of developing at-reactor dry cask storage facilities would average $20 to $30 million per plant and a study sponsored by the nuclear utilities projected operating costs for such facilities of approximately $2 million per site per year.[160] Once spent fuel is accepted by DOE for transport to a repository or central interim storage facility, the costs of its emplacement or storage are paid from the Nuclear Waste Fund. But, the costs of at-reactor storage or off-site storage at private facilities are to be paid directly by the nuclear utilities over and above their Nuclear Waste Fund fees.[161] Moreover, with no place to ship on-site spent fuel, the nuclear utilities also face the necessity for delayed

155. *See id.* at 21,797.
156. *See id.*
157. *See* RIGHT BALANCE, *supra* note 142, at 9.
158. *See id.* at 10.
159. *See id.* at 11.
160. *See id.* at 14.
161. *See id.* at 15.

decommissioning of closed plants, with its attendant uncertainties regarding future costs and liabilities.[162]

9. Spent Nuclear Fuel Contract Litigation

A number of nuclear utilities, states, and state public utility commissions sought judicial review of DOE's Final Interpretation of Nuclear Waste Acceptance Issues. In *Indiana Michigan Power Co. v. Department of Energy,*[163] the D. C. Circuit rejected DOE's interpretation of the NWPA and held that the agency did have an unconditional obligation to begin to accept spent fuel no later than January 31, 1998, even in the absence of a repository or interim storage facility authorized, constructed, and licensed under the NWPA.[164] However, the court also ruled that it was premature to determine the appropriate remedy, as DOE had not yet defaulted on its obligation.[165]

The prospect of DOE default on its waste acceptance obligation and indefinite at-reactor storage of spent nuclear fuel became a reality for nuclear utilities in December 1996 when DOE sent letters to all holders of its Standard Contract formally notifying them that the Department would be unable to begin accepting spent nuclear fuel by January 31, 1998.[166] The agency also invited the utilities to share their views as to how the indefinite delay in waste acceptance could best be accommodated. In response, much the same group of utilities, states, and state commissions as had sued in *Indiana Michigan Power Co.* petitioned the D. C. Circuit for a writ of mandamus, seeking to compel DOE to begin to accept spent fuel by the January 31, 1998 deadline. DOE opposed the writ on the grounds that the petitioners had an adequate remedy under the Delays Clause of the Standard Contract. In *Northern States Power Co. v. Department of Energy,*[167] the court denied the writ sought by petitioners, but did issue one to compel DOE to comply with the court's prior mandate in *Indiana Michigan Power Co.*[168] Specifically, the court ordered DOE to proceed with con-

162. *See* RIGHT BALANCE, *supra* note 142, at 9

163. *See* Indian Michigan Power Co. v. Dep't of Energy, 88 F.3d 1272 (D.C. Cir. 1996).

164. *See id.* at 1277.

165. *See id.*

166. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, FISCAL YEAR 1996 ANNUAL REPORT TO CONGRESS SUMMARY 4 (1997).

167. *See* Northern States Power Co. v. Dep't of Energy, 128 F.3d 754 (D.C. Cir. 1997).

168. *See id.* at 759.

tractual remedies in a manner consistent with its unconditional NWPA obligation to begin acceptance of spent nuclear fuel by January 31, 1998, and precluded DOE from concluding that any delay in acceptance was unavoidable "on the ground that it has not yet prepared a permanent repository or that it has no authority to provide storage in the interim."[169] Both the petitioners and DOE sought Supreme Court review of the *Northern States Power* decision, but the Court denied certiorari.[170] The petitioners also sought a "move fuel" order from the D.C. Circuit to implement its mandate in *Northern States Power*, but the court denied that relief on the grounds that the NWPA "requires the DOE to include an unconditional obligation in the Standard Contract, [but] it does not itself require performance," so "[b]reach by DOE does not violate a statutory duty [or] provide a basis for a move-fuel order."[171]

Since the *Northern States Power* decision, eleven utilities have filed suits in the Court of Federal Claims seeking, in the aggregate, more than $4 billion in damages.[172] *The Washington Post* has quoted industry predictions that owners of all of the nation's nuclear plants will eventually sue for damages totaling between $31 billion and $53 billion.[173] However, the results of litigation to date have been mixed. In *Yankee Atomic Power Co. v. United States,* the Court of Federal Claims ruled in favor of a nuclear utility suing for breach of its standard contract and found DOE liable for the breach, with the resulting damages to be determined in subsequent proceedings.[174] But, in *Northern States Power Co. v. U.S.*, a different judge in the same court ruled that the petitioning utility could not seek damages in a civil suit and directed the company to pursue its contract remedies at the agency level.[175]

169. *Id.* at 760.

170. *See* Dep't of Energy v. Northern States Power Co., 525 U.S. 1016 (1998).

171. Northern States Power Co. v. Dep't of Energy, 1998 WL 276581, at *2 (D.C. Cir. 1998).

172. *See* Michael A. Bauser, Comment, *Recent Decisions Concerning the DOE's Commercial Radioactive Waste Disposal Program,* 19 ENERGY L. J. 387, 394 (1998).

173. *See* Michael Grunwald, *Lawsuit Surge May Cost U.S. Billions,* WASH. POST, Aug. 10, 1998, at A1.

174. *See* Yankee Atomic Power Co. v. United States, 42 Fed. Cl. 223, 237 (1998).

175. *See* 43 Fed. Cl. 374, 388 (1999). *See also* Connecticut Yankee Atomic Power Co. v. United States, 42 Fed. Cl. 448 (1998) (reaching an identical result). What remedy, if any, will ultimately be available to the complaining nuclear utilities will apparently be determined as a matter of contract, not statute and by the Federal Circuit, not the D. C. Circuit Court of Appeals. *See* Wisconsin Elec. Power Co. v. Dep't of Energy, 211 F.3d 646, 648 (D. C. Cir. 2000).

10. Recent Legislative Activity

With DOE's breach of its waste acceptance obligation under its standard contracts an accomplished fact, indefinite at-reactor storage the only proffered solution to the growing spent nuclear fuel problem, and the legal remedies for this state of affairs uncertain, the nuclear utilities and their allies turned to Congress for a legislative remedy. In both the 104th Congress (1995-96) and the 105th Congress (1997-98), legislation was introduced in the House and the Senate to require DOE to construct an interim storage facility at the Nevada Test Site near Yucca Mountain and to begin to accept and transport spent fuel to that facility by a date certain, initially set as 1999, but subsequently changed to 2002 and then 2003. Among numerous other provisions, the bills also would have facilitated designation, approval, and licensing of a Yucca Mountain repository by legislatively mandating its public health and safety standards, thereby pre-empting and short-circuiting the highly controversial EPA rulemaking discussed earlier. Additionally, the bills would have redefined the funding formula for the Nuclear Waste Fund to limit strictly the maximum and average fees DOE could assess nuclear utilities for the time period that an interim storage facility and a repository were under construction.

In 1996, S. 1936[176] passed the Senate sixty-three to thirty-seven,[177] but the House did not take up its companion measure, H.R. 1020.[178] In 1997, H.R. 1270[179] passed the House 307 to 120[180] and S. 104[181] passed the Senate sixty-five to thirty-four,[182] but opponents blocked reconciliation of the two bills throughout the 1998 session.[183] The reasons for the failure of legislation in

176. Nuclear Waste Policy Act of 1996, S. 1936, 104th Congress (1996) (passed Senate, July 31, 1996).

177. *See Senate Passes Nuclear Waste Bill, But Fails to Get Veto-Proof Majority*, NUCLEAR WASTE NEWS, Aug. 1, 1996, *available at* 1996 WL 12719539-41.

178. Nuclear Waste Policy Act of 1996, H.R. 1020, 104th Congress (1996).

179. Nuclear Waste Policy Act of 1997, H.R. 1270, 105th Congress (1997).

180. *See House Approves H.R. 1270 with Veto-Proof Margin*, NUCLEAR WASTE NEWS, Nov. 6, 1997, *available at* 1997 WL 13045188.

181. Nuclear Waste Policy Act of 1997, S. 104, 105th Congress (1997) (passed Senate, April 15, 1997).

182. *See Senate Passes Nuclear Waste Bill, But Lacks Veto-Proof Majority*, NUCLEAR WASTE NEWS, April 17, 1997, *available at* 1997 WL 10908310.

183. *See* Helen Dewar, *Senate Stalls Action on Bill to Create Nuclear Dump*, WASH. POST, June 3, 1998, at A10.

both the 104th and 105th Congresses[184] were the same: the explicit promise of a Presidential veto and the absence of the necessary sixty-seven votes in the Senate to override it.[185]

The Clinton Administration threatened a Presidential veto of the legislation for several reasons. First, the Administration opposed the construction of an interim storage facility, contending that it would divert DOE attention and resources from the effort to characterize, evaluate, and if appropriate, designate a permanent repository at Yucca Mountain. Second, the Administration asserted it is illogical to site an interim storage facility at the Nevada Test Site until it is known whether Yucca Mountain will be the site of a permanent repository. Third, the Administration rejected legislative mandating of the public health and safety standards for the repository, adamantly insisting that those standards should be set by the EPA based on the best science available.[186]

As the 106th Congress opened in 1999, the battle lines between the Clinton Administration and the nuclear industry's allies in the House and Senate were still drawn. Bills looking much like their predecessors were introduced in both the House (H.R. 45) and the Senate (S. 608), except their title was now the Nuclear Waste Policy Act Amendments of 1999. Administration officials were still threatening a veto if either bill passed as introduced. However, new Secretary of Energy Bill Richardson suggested that the President would be willing to sign a bill which dispensed with interim storage, preserved EPA's authority to set public health and safety standards for a Yucca Mountain repository, and provided for the DOE to take title to spent fuel at reactor sites.[187] Bill sponsors responded with amendments to the Senate bill addressing some, but not all Administration concerns. As S. 1287, this bill passed both the House and the Senate in early 2000, but

184. Multiple bills relating to nuclear waste policies were introduced in each house during both the 104th and 105th Congresses; however, the bills discussed are the only ones on which significant action was taken.

185. *See* Lori A. Burkhart, *Nuclear Waste Debate Simmers on Capitol Hill*, PUB. UTIL. FORT., June 1, 1997, at 58; Joseph F. Schuler, Jr., *Dodging Suits and Pols, DOE Digs In on Nuclear Waste*, PUB. UTIL. FORT., Mar. 1, 1997, at 38.

186. *See Clinton Will Veto S. 104 as it Stands, Grumbly Tells Senate Committee*, NUCLEAR WASTE NEWS, Feb. 6, 1997, *available at* 1997 WL 10908626; Burkhart, *supra* note 185; *Hearings on H.R.1270 Before the Subcommittee on Energy and Power, Committee on Commerce*, 105th Congress (1997) (Apr. 29, 1997 Statement of Lake H. Barrett, Acting Director, Office of Civilian Radioactive Waste Mgmt., U.S. Dep't of Energy).

187. *See* Joseph F. Schuler, Jr., *Nuclear Waste's Slow Boil*, PUB. UTIL. FORT., June 1, 1999, at 34-35.

President Clinton vetoed it and the President's veto was sustained in a very close but widely expected Senate vote.[188]

11. Private Interim Storage Facility

Because a Yucca Mountain repository would become available, if at all, no sooner than 2010 and a Nevada Test Site interim storage facility has been stalled by the threat of a Presidential veto, the nuclear power industry has actively searched for a location for a privately owned and operated central interim storage facility for the spent fuel accumulating at reactor sites. Described in NRC regulations as an "independent spent fuel storage installation"[189] and frequently referenced by its acronym "ISFSI," a private storage facility would be licensed to receive spent fuel shipped from reactor sites and to store it above ground in dry cask storage systems. In 1996, after several abortive attempts elsewhere, a consortium of nuclear utilities led by Northern States Power leased 840 acres of land for such a facility at the Skull Valley, Utah, reservation of the Goshute Indian tribe.[190] In June, 1997, Private Fuel Storage, a limited liability company formed by the utility consortium, applied to the NRC for a license to construct and operate an ISFSI at the Skull Valley site, initially for a period of twenty years.[191] In 1998, Private Fuel Storage and the Goshutes signed a contract for the construction and operation of the Skull Valley ISFSI.[192] As proposed, the ISFSI would have the capacity to hold approximately 40,000 metric tons of spent fuel, almost half of the total amount projected to be generated by the nation's commercial nuclear plants.[193] However, Utah Governor Michael Leavitt has vowed to block use of the facility by any means available, characterizing plans for the ISFSI as "an over-

188. *See Senate Energy Committee Approves Compromise Nuclear Waste Bill*, NUCLEAR WASTE NEWS, June 17, 1999, *available at* 1999 WL 10309221; *House Sends HLW Bill to the White House; Veto Promised*, NUCLEAR WASTE NEWS, Mar. 23, 2000, *available at* 2000 WL 12745444; *and Senate Fails to Override Clinton's Veto of S. 1287 by Three Votes*, NUCLEAR WASTE NEWS, May 4, 2000, *available at* 2000 WL 12745605.

189. 10 C.F.R. § 72.3 (1998).

190. *See* John J. Fialka, *Goshute Indians' Plan to Store Nuclear Waste for Eight Utilities is Opposed by Utah Governor*, WALL. ST. J., Aug. 26, 1998, at A24; William Claiborne, *Utah Resisting Tribe's Nuclear Dump*, WASH. POST, Mar. 2, 1999, at A3.

191. *See* NRC Notice of Consideration of Issuance of a Materials License for the Storage of Spent Fuel and Notice of an Opportunity for a Hearing, 62 Fed. Reg. 41,099 (Jul. 31, 1997).

192. *See* Claiborne, *supra* note 190.

193. *See* Fialka, *supra* note 190.

my-dead-body issue."[194] At this writing, NRC licensing proceedings were still pending.

B. Major Outstanding Issues Pending Electric Industry Restructuring

As the United States approached the end of the twentieth century, it was clear that certain of the political compromises and policy choices incorporated in the Nuclear Waste Policy Act as enacted in 1982 and amended in 1987 must be re-evaluated in the light of subsequent experience. Others may retain sufficient political and technical support to survive into the new millennium. As the century closed, the status of these compromises and choices appeared to be as follows.

1. Monitored Retrievable Storage versus Permanent Disposal

At this point, American policy remains committed to permanent disposal in a geologic repository as the best long-term solution to the spent fuel and high-level nuclear waste problem. DOE's 1998 "viability assessment" identified "no show-stoppers" for the planned Yucca Mountain repository and work on Yucca Mountain's characterization continues, with a formal recommendation to be made to the President in 2001. However, there are unresolved technical issues with Yucca Mountain and continuing controversy as to whether "permanent" disposal of spent fuel and high level-nuclear waste is even possible. Moreover, there are increasing concerns regarding the ultimate cost of a geologic repository. As a result, there continue to be credible calls for abandonment of the geologic repository approach in favor of monitored retrievable storage.

2. Repository Location and Development

At this juncture, it would appear that if there is to be a geologic repository in the United States, it will be at Yucca Mountain. Given the political dynamics, which resulted in Yucca Mountain's presumptive designation in the 1987 NWPA Amendments, it appears practically impossible that any other sites could realistically be considered if Yucca Mountain proves unsuitable as a repository site. But, it is by no means certain that Yucca Mountain will be

194. *See id.*

designated and approved as the repository site, let alone actually operate as a functional waste disposal facility.

First, there are the nagging questions regarding Yucca Mountain's geologic stability and groundwater permeability. Second, there is the unresolved issue of the appropriate radiation protection standard. Third, there is the increasing concern about the cost of constructing and operating the repository. Fourth, there is the continuing doubt about DOE's ability to construct and operate the repository at all, let alone as planned. Fifth, there is the growing public anxiety about the extended, widespread and frequent transportation of spent fuel to a repository. Finally, in light of these other issues, there is the political issue of whether the Congress would be able to muster the votes needed to override the expected veto by the State of Nevada.

3. Interim Storage and Related Transportation

It would appear that a DOE interim storage facility at the Nevada Test Site will not be authorized, at least for several years. The failure of mandated interim storage legislation in both the 104th and 105th Congresses presaged Congress's failure to override the Clinton veto in the 106th, given the similar political situations. However, in the 107th Congress, the situation could change. There will be a new President and a Yucca Mountain designation decision in 2001. If Yucca Mountain is designated, but its operation projected to be delayed to 2015 or later, a new President could find interim storage politically unstoppable, especially if no agreement has been reached between DOE and the nuclear utilities regarding legal and financial responsibility for on-site storage. At that point, however, the privately-owned and operated Skull Valley ISFSI, if it has been licensed and constructed, could well prove to be both politically and practically preferable to a government-owned and operated facility at the Nevada Test Site. On the other hand, if Yucca Mountain is not designated in 2001, the rationale for the siting of an interim facility at the Nevada Test Site would seem to lose most of its remaining force, both practically and politically. Of course, either a Nevada Test Site or a Skull Valley location for an interim storage facility would still face substantial opposition because of continuing political concerns and public anxieties regarding the costs and risks associated with transportation of 80,000 metric tons of spent fuel across much of the country at the rate of 2,000 to 3,000 MTU per year for thirty years.

4. Public Health and Safety Standards

The 1987 NWPAA decision to characterize only the Yucca Mountain site for a repository has inevitably and inextricably linked the determination of public health and safety standards for *a* high-level waste repository to the viability of *the* site for such a repository. In effect, repository decision-making has become circular: Yucca Mountain should be the site of the repository if and only if it can meet the proper public health and safety standards, but the public health and safety standards are proper if and only if Yucca Mountain can meet them. This circularity is the direct result of the legislative presumption enshrined in the NWPAA that Yucca Mountain is the best site available for a geologic repository.

Of course, there are radioactive protection standards that apply to other facilities posing the risk of exposing human populations and the environment to radionuclides. Because none of these other facilities involve wastes which will be so highly (and lethally) radioactive for so long, it seems logical that the standards applied to a geologic repository should be *at least* as protective as the standards applied to other facilities. There is continuing concern among credible critics that, no matter how it is designed, the Yucca Mountain site can be shown not to meet such standards. But, even more importantly, there is near unanimity at this point that it is simply not scientifically possible to show with any predetermined probability that *any* site, including Yucca Mountain, would meet such standards for any period even remotely approaching the length of time the wastes buried there would be hazardous to human health and the environment. In brief, the time frame of human history is too short and our models of repository behavior too crude to plausibly predict its performance for even a thousand years, let alone ten thousand or a million.

As a result, the political grenade, which the policy-makers tossed to the scientists in the Energy Policy Act of 1992, has returned, still armed and dangerous. How safe is safe *enough* for a geologic repository has once again become a policy, not a scientific issue. As a policy issue, of course, the proper definition of radioactive protection standards has also become a political issue. Recently, the politics of the issue have been reduced to a single divide: who should determine the appropriate standards, Congress by statute or the EPA by rule. And, to date, no compromise formula has been found.

5. Financing

The NWPA requires DOE to estimate periodically the costs of its spent nuclear fuel and high-level waste disposal program and then assess the sufficiency of the Nuclear Waste Fund to cover them.[195] DOE conducted studies of the adequacy of the Nuclear Waste Fee at its current level of one mill per kilowatt-hour to finance the total life-cycle costs of the spent nuclear fuel and high-level waste disposal program in 1990[196] and 1996.[197] Both of these studies projected that the fee was adequate; however, critics of the 1996 study suggested that it showed the current fee was barely adequate, and would be inadequate if some of the questionable assumptions used in the study were changed or permitted to vary. In particular, the State of Nevada commissioned a study by independent consultants which showed that DOE had under-estimated total life-cycle costs by fifty-four percent in its 1996 report.[198] An analysis performed by another independent consultant retained by public interest groups concluded that DOE had also over-estimated its revenues; an error which, if not corrected, produces a Nuclear Waste Fund shortfall of at least $1.9 billion and, when combined with the Nevada consultant's revised cost estimate, yields a Fund shortfall of $46.5 billion (in 1997 dollars in the year 2017).[199]

When DOE issued its Yucca Mountain "viability assessment" in December 1998, the agency also updated its fee adequacy study.[200] This study also concluded that the current fee was adequate under the assumptions made.[201] However, it also recognized that if program costs were more than 20% higher than

---

195. *See* 42 U.S.C. § 10222(a)(4) (1994). While the Act expressly calls for annual reviews of fee adequacy, the DOE has to date only published the results of three reviews–in 1990, 1996 and 1998.

196. *See* Office of Civilian Radioactive Waste Mgmt., U.S. Dep't of Energy, Nuclear Waste Fund Fee Adequacy: An Assessment (1990).

197. *See* Office of Civilian Radioactive Waste Mgmt., U.S. Dep't of Energy, Nuclear Waste Fund Fee Adequacy: An Assessment (1996).

198. *See* Indep. Cost Assessment, *supra* note 30, at 9.

199. *See* Bruce Biewald & David White, Synapse Energy Economics, Inc., Stranded Nuclear Waste: Implications of Electric Industry Deregulation for Nuclear Plant Retirements and Funding for Decommissioning and Spent Fuel 18-19 (1999), *available at* http://www.synapse-energy.com/Downloads/Stranded-Nuclear-Waste.doc.

200. *See* Office of Civilian Radioactive Waste Mgmt., U.S. Dep't of Energy, Nuclear Waste Fund Fee Adequacy: An Assessment (1998).

201. *See id.* at 17.

assumed, or if inflation rates were 15% higher and interest rates 15% lower than assumed, the fee would be inadequate.[202]

V. Electric Industry Restructuring in the United States

A. Origins, Nature and Status

The commercial nuclear waste policy of the United States reflected in the Nuclear Waste Policy Act, as amended, has been premised on the historic structure of the electric utility industry in this country. This structure has been characterized largely by electric utilities which vertically integrate the functions of generation, transmission and distribution, and are franchised by government to provide retail electric service as regulated monopolies within designated geographic service areas.

1. Traditional Paradigm: Government Regulation of Privately-Owned, Vertically Integrated Monopolies

Since the First World War, the electric industry has been dominated by investor-owned utilities. In 1917, for example, utilities produced fifty-nine percent of the electricity generated, and investor-owned utilities were responsible for ninety-six percent of that production.[203] Technological change and economic consolidation resulted in utilities becoming increasingly dominant as producers, accounting for eighty-two percent of generation by 1945.[204] The Depression and the New Deal brought a significant expansion of "public power," electricity produced and sold by government- or cooperatively-owned utilities. By 1945, investor-owned utilities accounted for 66.7%, public power represented 15.3%, and industry supplied eighteen percent of electricity production. Industrial sources steadily declined after World War II. Between 1965 and 1995, investor-owned utilities consistently generated between seventy and seventy-five percent of the electricity produced in the United States.[205] During the same period, government- and cooperatively-owned utilities generated approximately twenty percent, with the balance of electricity produced generated by industrial and other sources.[206]

202. *See id.* at 18.

203. *See* LEONARD S. HYMAN, AMERICA'S ELECTRIC UTILITIES: PAST, PRESENT & FUTURE 97 (5th ed. 1994).

204. *See id.* at 116.

205. *See id.* at 129, 149.

206. *See id.*

Because of economies of scale and scope involved in the production, transmission, and distribution of electricity, electric utilities, whether privately or publicly owned, have traditionally been vertically-integrated monopolies, owning or controlling the generating plants, transmission lines, and distribution systems required to produce electric power and deliver it to all the homes, businesses and factories in a given geographic area. Because they have traditionally and typically been privately-owned monopolies, electric utilities have also been subject to government regulation to assure adequate and non-discriminatory service and fair and reasonable prices to their customers.[207]

Government regulation has typically been performed by appointed or elected commissions which set prices and standards for electric service using "cost of service" pricing. Since the enactment of the Federal Power Act in 1935,[208] prices and standards for "wholesale" service have been regulated by the Federal Energy Regulatory Commission[209] (FERC), while prices and standards for "retail" service have been determined by individual state public utility commissions (PUCs).[210]

The prices, called "rates," are set to permit the utility to generate enough revenue to cover its "operating expenses" (e.g., wages, fuel, maintenance), depreciation, and taxes, and to earn sufficient profit, termed "net operating income," to provide its investors with a fair "rate of return" on the money they have invested in the utility's plant and equipment, which is known as the "rate base." A "rate of return" is "fair" if it is comparable to what the utility's investors could earn at about the same time on an investment of similar risk in an unregulated business.[211]

207. *See id.* at 4-5.

208. Public Utility Act of 1935, Title II, 49 Stat. 803 (1935) (codified as amended at 16 U.S.C. §§ 791a to 828c (1994 & Supp. 1997).

209. The FERC was previously known as the Federal Power Commission. *See generally* Federal Energy Regulatory Commission, *Introduction to the FERC, available at* http://www.ferc.fed.us/intro/intro2.htm (last modified Jan. 19, 2001).

210. While it is intended to be a "bright line," the dividing line drawn by the Federal Power Act between "wholesale" (federal) and "retail" (state) jurisdiction has at times proven to be both elusive and controversial. *See, e.g.,* Federal Power Comm'n v. Southern Cal. Edison Co., 376 U.S. 205 (1964).

211. *See* HYMAN, *supra* note 203, at 4-5. For a more detailed discussion, *see* CHARLES F. PHILLIPS, PUBLIC UTIL. REP., THE REG. OF PUB. UTIL. 171-432 (3d ed. 1993).

2. Recent Developments: Structural Disaggregation and Competition and Deregulation of Generation and Marketing

Recently, the electric utility industry entered a period of dramatic change. This period was presaged by the passage of the Public Utility Regulatory Policy Act (PURPA),[212] in 1978, but really began with the enactment in 1992 of the Energy Policy Act.[213] Because of increasing economic and environmental concerns associated with the generation of electricity by large, coal- and nuclear-fueled central station generating facilities and the technological development of increasingly cost-competitive alternative sources of power, competitive contracting for supplies of electricity has become increasingly prevalent in the industry.[214]

By the early 1990's, a new sector of the electric industry, commonly known as "independent power producers," had developed, with more than fifty major firms and many more smaller producers competing to supply power at wholesale.[215] These independent producers have been offering "purchased power" at contract prices well below the "avoided costs" being quoted for electricity from new generating facilities constructed by traditional electric utilities.[216] Combined with the "open access" to bulk power transmission facilities ordered by FERC in 1996,[217] this low-cost purchased power has put downward pressure on wholesale electricity prices. Moreover, the availability of wholesale "purchased power" at prices substantially below the average cost of utility generation has resulted in increasing political pressure to introduce competition into retail power markets.[218] California became the first state to legislate retail competition for its electric utility industry in 1996;[219] by this writing, an additional twenty-two states had

212. Pub. L. No. 95-617, 92 Stat. 3117 (1978) (codified as amended in scattered sections of 16 and 42 U.S.C.).

213. Pub. L. No. 102-486, 106 Stat. 2776 (1992) (codified in scattered sections of 16 and 42 U.S.C.).

214. *See* Bernard S. Black & Richard J. Pierce, Jr., *The Choice Between Markets and Central Planning in Regulating the U.S. Electric Industry*, 93 COLUM. L. REV. 1339-41, 1346-50 (1993).

215. *See id.* at 1349 (citing Paul L. Joskow, *The Evolution of an Independent Power Sector and Competitive Procurement of New Generating Capacity*, 13 RES. IN L. & ECON. 63, 73-100 (1991)).

216. *See id.*

217. *See* 18 C.F.R. § 35.28 (1996).

218. *See* Black & Pierce, *supra* note 214.

219. *See* CAL. PUB. UTIL. CODE § 330 (West 1999).

authorized retail competition for their electricity markets.[220] However, no federal legislation mandating, authorizing or facilitating retail competition nationally has yet been enacted.[221]

With retail competition, traditional utilities are no longer monopoly suppliers of electricity within their franchised service areas. Customers have the legal right to purchase electricity produced by alternative suppliers at market prices,[222] and the disenfranchised monopoly utilities are legally obligated to "wheel" power from other sources across their transmission and distribution systems.[223] As a competitive power market develops,[224] the generation and marketing of electricity are deregulated, while its transmission and distribution remain regulated by state and federal authorities.[225]

B. Implications for Commercial Nuclear Power

The disaggregation of the electric utility industry and the phased deregulation of its generation and marketing sectors are expected to have significant implications for the commercial production and sale of commercial nuclear power. These implications are both economic and political in character.

220. Through August 1999, twenty-one states had authorized retail competition by legislation, two by regulation. *See Oregon Enacts Restructuring Law*, LEAPLETTER (William A. Spratley & Assoc., Columbus, OH), July-August, 1999, at 1.

221. Numerous federal bills have been introduced in recent sessions by members in both Houses of Congress since 1996. The Clinton Administration also offered successive versions of an Electric Utility Restructuring Act in both 1998 and 1999. To date, none of these bills have even been reported from a full committee in either house.

222. The "power exchange" and "bilateral contracts" models are the two most widely discussed approaches to competitive retail power markets. In the "power exchange" model, a wholesale spot market for electricity serves as the institution for conducting power transactions within a certain geographic area. The power exchange conducts an auction in which electric generators bid their supply amounts and electric distributors submit their demand amounts at incremental points in time (e.g., half-hourly, hourly), with the market price balancing supply and demand. Customers demanding electricity at points in time pay the market price set by the exchange for those times. The "bilateral contracts" model is more decentralized, with individual customers or groups of customers contracting directly with power suppliers for their electricity. In actuality, the evolving power markets in jurisdictions which have authorized retail competition are generally combinations or "hybrids" of these two analytical models. *See* LAWRENCE J. HILL, OAK RIDGE NAT. LABORATORY, ECON. EFFICIENCY CONSIDERATIONS IN RESTRUCTURING ELECTRIC MARKETS 26-31 (1996).

223. *See* Joseph P. Tomain, *Electric Util. Restructuring: A Case Study in Gov't Regulation*, 33 TULSA L. J. 827, 842-43 (1998).

224. *See* PETER FOX-PENNER, ELECTRIC UTIL. RESTRUCTURING 140-141 (1997).

225. *See* HILL, *supra* note 222, at 31-37.

1. Economic Implications

Deregulation of the generation and marketing of electricity, even when that state of affairs has largely been prospective, has resulted in very strong economic pressures on the electric utility industry to reduce its costs of doing business.[226] Deregulation substitutes "unbundled" market pricing of electric generation for "bundled" regulatory pricing of generation, transmission, and distribution combined.[227] As a result, deregulation focuses market pressure on the price and cost of electric generation particularly.

Regulatory pricing under the historic paradigm has been determined by the costs specific to a particular source of electricity.[228] Market pricing, by contrast, is determined by the supply and demand for electricity in a particular market independent of the costs specific to a particular source of electricity. If the restructuring of the industry proceeds as predicted, deregulation will be associated with a significant escalation of competition among generators of electricity.[229] The combination of market pricing and the escalation of competition will provide a compelling economic incentive for electricity generators to avoid or reduce whatever costs they can and to stringently limit increases of other costs.[230] Competitive market pressure will also provide a particularly compelling economic incentive for electricity generators to eliminate costs not incurred by their competitors.[231]

The long-term effects of these market pressures on the generation and marketing of nuclear power are necessarily speculative, especially given the historic level of federal government involvement in regulating and promoting the commercial use of nuclear energy. Moreover, these effects are the subject of considerable disagreement, with electric industry restructuring being viewed as both the death knell and the second coming of commercial nuclear power. However, there does appear to be an emerging consensus

226. *See* Nuclear Regulatory Commission, Final Policy Statement on the Restructuring and Economic Deregulation of the Electric Utility Industry, 10 CFR Part 50 (Aug. 19, 1997), *available at* http://www.nrc.gov/OPA/reports/drgstmt.htm [hereinafter NRC Final Policy Statement]; *See also* JOSEPH P. TOMAIN, NUCLEAR POWER TRANSFORMATION 79-101 (1987).

227. *See* NRC Final Policy Statement, *supra* note 226.

228. *See id. See also* Nicholas S. Reynolds & Robert L. Draper, *The Future of Nuclear Power*, 8 NAT. RESOURCES. & ENV'T 9 (1994).

229. *See* NRC Final Policy Statement, *supra* note 226; *See also* Reynolds & Draper, *supra* note 228.

230. *See* Reynolds & Draper, *supra* note 228.

231. *See id.*

on the likelihood of certain general effects. First, the current de facto moratorium on the construction of new plants is expected to continue, with a focus instead of extending the operating licenses of selected plants with the best safety records and economic performance.[232] Second, existing plants with the worst safety records and economic performance are expected to be permanently closed prior to the expirations of their operating licenses, typically at times when large capital expenditures would be required to replace key components such as steam generators or to correct significant deficiencies in safety-related systems.[233] Third, plants which are kept open will be operated to achieve higher capacity factors and lower costs per unit of generation.[234] Fourth, ownership and/or management of the remaining operating plants will be consolidated among a comparatively small number of companies specializing in that role.[235]

2. Political Implications

Electricity deregulation has also created significant political pressures to change public policies relating to nuclear power.[236] Competition among generators, even prospectively, has engendered strong political pressures for policy-makers to establish and maintain a "level playing field" among the alternative sources of electric generation in terms of the regulations imposed and subsidies provided by government.[237]

---

232. *See id.*

233. *See id. See also* Marsha Burton & Lynne Olver, *Can Nuclear Power Survive Deregulation? The Jury is Still Out*, WALL ST. J., Sept. 14, 1998, at R21.

234. *See* Reynolds & Draper, *supra* note 228.

235. *See* Burton & Olver, *supra* note 233; Reynolds & Draper, *supra* note 228.

236. *See* NRC Final Policy Statement, *supra* note 226; *See also* TOMAIN, *supra* note 226, at 103-34.

237. *See, e.g., Workshop on the Effects of Competition on Fuel Use and Types of Fuel Generation Before the Committee on Energy and Natural Resources*, 105th Congress (1997) (remarks by Samuel K. Skinner, President, Commonwealth Edison Co.), *available at* 1997 WL 10570918:

> [I]t is critical that Congress and the administration take the deliberate steps necessary to achieve the goal of removing barriers to competition within your traditional jurisdiction. While I am realistic enough to believe that no business is on a truly "level playing field," this must be the ideal. . . . The federal government must acknowledge its obligation to begin taking used nuclear fuel in 1998 to a central, interim storage facility - - - and get on with it. . . . I cannot overemphasize the need for passage of legislation this year to reform the government's nuclear waste management program. . . . [T]his nation cannot continue to avoid dealing with the issues of nuclear waste disposal, nor can it afford to block further use of nuclear energy simply because of that inaction. I also want to note that

The commitment by the federal government since enactment of the Atomic Energy Act in 1954 to protect public health and the environment from the risks of nuclear power has resulted in significant regulation of nuclear generators. On the other hand, the long-standing federal commitment to promote the development of commercial nuclear power has also resulted in significant subsidies to nuclear generators.[238] The transition from regulatory to market pricing and the escalation of competition will thus result in significant political pressures to reduce both government subsidies to and government regulation of nuclear power.[239]

These political pressures will focus on a number of public policy issues of significance to the future of commercial nuclear power. First, there is the issue of the recovery of so-called "stranded costs"[240] associated with closure of plants prior to the expiration of their operating licenses. Second, the responsibility for the costs of decommissioning plants constructed under traditional regulation but closed after deregulation is quite significant. Third, the stringency of public health and safety standards and the methods used by the NRC to set and enforce those standards have become a focus of concern for the industry and its critics. Fourth, the continuation of the accident liability limitations cur-

---

> most of the uncertainties about the cost estimates for future cleanup of nuclear plant sites stem from uncertainties related to waste disposal - - - where it will go - - - and how much it will cost. . . .We are not seeking any special preferences as a result of restructuring. However, we believe there are actions, which we have discussed in this testimony, that the federal government should consider to ensure that the benefits of nuclear energy continue. . . .

Id.

238. *See* Meek, *supra* note 74, at 393-4. Nuclear power is not alone in securing public policy-derived subsidies, of course. For example, environmental groups, pollution regulators, and nuclear and gas generators have been particularly concerned during the restructuring debate about the significant subsidy which results from unregulated air emissions from coal generators. *See, e.g.*, Rudy Perkins, *Electricity Deregulation, Environmental Externalities and the Limitations of Price*, 39 B.C. L. REV. 993, 1032-34 (1998).

239. *See* Reynolds & Draper, *supra* note 228; TOMAIN, *supra* note 226, at 161-72.

240. "Stranded costs" refer to the previously incurred costs of a utility which would be recoverable in prices charged by a monopoly under traditional cost-of-service regulation but would not be recoverable in the prices set by a competitive market. The types of costs that may become stranded fall into three major categories: (1) the costs of generating facilities built in the past which were a lot more expensive to construct and operate than plants currently being constructed; (2) the costs of purchased power and/or fuel supply contracts executed in the past with significantly higher prices than those being negotiated today; and (3) the remaining balances of regulatory assets set up by regulators to defer to the future recovery of costs incurred in the past. *See* FOX-PENNER, *supra* note 224, at 385-86.

rently imposed by the Price-Anderson Act is a looming controversy.

But, perhaps the most significant public policy issue for the future of commercial nuclear power in the United States is high-level nuclear waste policy. According to a spokesman for the Nuclear Energy Institute, the principal legislative and regulatory affairs representative for the nuclear utilities, "'We're well positioned economically to make the move to a competitive market. The only problem we have is waste disposal.'"[241] According to the Vice President of Nuclear Operations for Northern States Power Company, one of the leading nuclear utilities, the high-level waste issue could prove to be the "Achilles heel" of commercial nuclear power.[242]

VI. Implications of Electric Industry Restructuring for High-Level Nuclear Waste Policy

A. Effects on Nuclear Waste Generation

Electric utility industry restructuring is expected to have a significant role in determining how many U.S. nuclear plants will operate for how long at what capacity factor. The number of operating plants, the lengths of their remaining operating lives, and their capacity factors during their remaining operating lives will all be variables that affect the volume of spent nuclear fuel discharged by American nuclear utilities. While the Department of Energy prepares periodic forecasts of the volumes of spent fuel to be discharged in the future, it has not attempted to assess the effects of competition and deregulation in the electric utility industry. Indeed, until recently, it has used the simplifying assumption that, absent announced plans to close a particular reactor, operating plants would continue to operate for the balance of their license periods (i.e., forty years).[243] In effect, this "reference case" assumes that the number and duration of operating life extensions will more or less offset the number and length of nuclear plant early retirements, whatever the cause. Under this assumption, DOE's January, 1998 projection of the total volume of spent fuel to be discharged by 2035 when the last existing commercial reactor completes its licensed operating life was approximately

241. Burton & Olver, *supra* note 233.

242. *See id.*

243. *See* SPENT FUEL STORAGE REQUIREMENTS, *supra* note 24, at 4.1.

87,000 MTU.[244] In its 1998 projection, however, DOE also included a forecast based on the assumption that existing plants would complete only 30 years of their licensed operating lives. Under this assumption, DOE forecast that cumulative volumes of spent fuel discharged would peak at approximately 69,000 MTU in 2025.[245] To date, no independent analysis of the effects of electric utility industry restructuring on the future levels of spent fuel discharges has been reported.

B. Effects on Nuclear Waste Program Funding

The number of nuclear plants operating for how long at what capacity factor will also affect the level of nuclear waste program funding. This is because the NWPA funding formula is one mill per kwh of electricity actually generated and sold by operating nuclear plants. Closed plants generating and selling no electricity also pay no fees to the Nuclear Waste Fund. As a result, the disaggregation of the electric utility industry and the deregulation of electricity generation and marketing could potentially have a significant effect on Nuclear Waste Fund revenues.

However, the DOE has included no analysis of the likely effects of electric industry restructuring and deregulation in its periodic Nuclear Waste Fund Fee Adequacy Assessments. The most recent Fee Adequacy Assessment was published in December 1998, in conjunction with the Yucca Mountain Repository Viability Assessment.[246] In this report, DOE did assess the projected effect on fee adequacy of an increase in program costs of twenty percent above "reference case" estimates.[247] The agency also presented a sensitivity case showing the effect of assuming "reference case" cost estimates but interest rates fifteen percent lower and inflation rates fifteen percent higher than the reference case.[248] However, even though it expressly acknowledged that, "fee income projections may vary with either early reactor shutdowns before license expiration, or by service life extensions," the 1998 DOE report did not analyze any such effects.[249] Notably, the 1998 Fee Adequacy Report included no projection of Nuclear

244. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, ANNUAL REPORT TO CONGRESS: FISCAL YEAR 1997 9 (1998).

245. *See id.* at tbl.

246. *See* OFF. OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, NUCLEAR WASTE FUND FEE ADEQUACY: AN ASSESSMENT (1998).

247. *See id.* at 17-21.

248. *See id.*

249. *Id.* at 21.

Waste Fund revenues using the thirty year operating life assumption for existing reactors included as a "sensitivity case" in the Department's January, 1998 projection of spent fuel volumes.[250]

An independent analysis prepared at the same time as the most recent DOE Fee Adequacy Assessment for the author and two public interest groups by an independent consultant, Synapse Energy Economics (Synapse), suggests that the effect of electric industry restructuring on Nuclear Waste Fund revenues could be significant.[251] In a report released in January 1999, Synapse economists Bruce Biewald and David White modeled the effects of electric industry restructuring on nuclear plant retirements and then evaluated the effects on Nuclear Waste Fee revenues of three different retirement scenarios. In their reference case, the Synapse economists predicted that thirty-four existing nuclear plants would be retired early, with a resulting loss of 479 gigawatt years of nuclear capacity compared to the DOE "reference case." In their high nuclear generation case, Biewald and White projected that only twenty reactors would close early, reducing the loss of nuclear capacity to 283 gigawatt years. But, in their low nuclear generation case, the consultants estimated that ninety reactors would be retired prior to the expiration of their operating licenses with a resulting loss in nuclear capacity compared to the DOE reference case of 1386 gigawatt years.[252]

To put these figures in perspective, current nuclear capacity is approximately 100 gigawatts. So, the loss of 1386 gigawatt years of capacity projected in the Synapse low generation case is equivalent to losing almost fourteen years of generation from the entire existing nuclear industry, or to retiring all its existing plants after an average operating life of roughly twenty-six years. By comparison, the Synapse reference case projects a loss of nuclear generation due to restructuring equivalent to approximately five years of operation of the entire nuclear industry, or that all existing units retire after an average operating life of approximately thirty-five years. To date, no nuclear plant has operated for its entire forty year operating life. Of twenty-two plants retired to date, only two operated for more than thirty years – Big Rock Point for thirty-four years and Yankee Rowe for thirty-one

250. *See id.* at 17-21.

251. *See* BIEWALD & WHITE, *supra* note 199.

252. *See id.* at 8-10, tbl. 2.3.

years.[253] Of the 106 plants still operating at the end of 1998, none had yet completed thirty years of operation.[254]

DOE has assessed Nuclear Waste Fee adequacy on the basis of whether the Nuclear Waste Fund would have a balance in 2042 of $2.5 billion or more in constant 1998 dollars.[255] Biewald and White have calculated that in both their reference and low nuclear generation scenarios, the 1.0 mill/kwh Nuclear Waste Fee will be inadequate to meet the commercial share of program costs. Specifically, they project that, to remain adequate, the fee would have to be increased beginning in 1999 to 1.2 mills/kwh (i.e. twenty percent increase) in their reference case and 1.5 mills/kwh (fifty percent increase) in their low generation case.[256] Biewald and White also assessed the combined effects on fee adequacy of restructuring-driven early plant retirements and the fifty percent increase in waste program costs recently projected by independent consultants retained by the State of Nevada.[257] In these two scenarios, the fee would have to be increased to 2.9 mills/kwh (i.e. a 190% increase) in the reference case and to 4.5 mills/kwh (a 350% increase) in the low generation case.[258] Biewald and White characterized the magnitude of the funding shortfalls that would result in these scenarios if the fee remained at its current level as "huge" and "a gross violation of the [NWPA] principle that the costs of the program are to be recovered from the generators of the waste in the fee charged to nuclear generation."[259]

Potentially even more significant, Biewald and White concluded that, as the Nuclear Waste Fee is increased to offset the effects of restructuring-driven revenue increases and program-related cost increases, "there is an important and troubling feedback effect upon fee adequacy."[260] In particular, "[a] higher fee will tend to cause additional nuclear unit retirements, which in turn

253. *See id.* at 3, tbl. 2.1.

254. *Compare* BIEWALD & WHITE, *supra* note 199 at 3, tbl. 2.1, *with* SPENT FUEL STORAGE REQUIREMENTS, *supra* note 24, at tbl. A-1.

255. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, NUCLEAR WASTE FUND FEE ADEQUACY: AN ASSESSMENT 17-18 (1998).

256. *See* BIEWALD & WHITE, *supra* note 199, at 19.

257. *See* INDEP. COST ASSESSMENT, *supra* note 30. This assessment projects total "to go" program costs of $53.9 billion in constant 1996 dollars. At the time of this assessment, the most recent DOE estimate projected NWF resources to meet these costs (current NWF balance plus future revenues) to be $28.1 billion, or approximately fifty-two percent of the Nevada consultants' "to go" cost estimate. *See id.*

258. *See* BIEWALD & WHITE, *supra* note 199, at 19.

259. *Id.*

260. *Id.*

will lead to a need to increase the fee. It is quite possible that in some scenarios this reinforcing feedback could result in a situation where increasing the fee is counterproductive."[261] For example, even assuming DOE's program cost projections; the Biewald and White analysis predicts that restructuring-driven plant closures would increase the cost of nuclear generation by 0.2 to 0.5 mills/kwh. Other things being equal, this comparatively small increase is enough to cause some number (presumably quite small) of previously marginal plants to become uneconomic to operate in a competitive market environment. But, combining both restructuring-driven plant retirements with a program-related cost increase on the order of magnitude of that projected by the State of Nevada's consultants, this "feedback effect" becomes much more significant. The Biewald and White analysis would show this scenario producing an initial increase in the cost of nuclear power of 1.9 to 3.5 mills/kwh. Using their reference case increase of 1.9 mills/kwh, Biewald and White then projected that the "feedback effect" from this initial price increase would result in a second round of an additional ten nuclear plant retirements, increasing the total early retirements to forty-four units and 654 gigawatt-years of generation.[262] Of course, this second generation of "feedback effects" would possibly result in another round of early plant retirements and generation losses.[263]

C. Effects to Date on Nuclear Waste Policy

Since the enactment of the NWPA in 1982, a fundamental premise of United States nuclear waste policy has been that "the costs of disposing of spent nuclear fuel and high-level radioactive waste [are] to be borne by the parties responsible for its generation."[264] For the producers of commercial nuclear power, this policy has been implemented through a one mill charge on each kilowatt/hour of nuclear energy generated and sold. However, electric utility industry restructuring manifestly has the potential to threaten both the validity of this fundamental policy premise and the efficacy of its existing financing mechanism. This threat is particularly acute if the costs of DOE's overall waste program increase significantly beyond current official estimates. Such a re-

261. *Id.*

262. *See id.* at 19-20.

263. *See* BIEWALD & WHITE, *supra* note 199, at 19-20.

264. OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, ANNUAL REPORT TO CONGRESS: FISCAL YEAR 1997 69 (1998).

sult was recently predicted in an independent study prepared by consultants retained by the State of Nevada.

Biewald and White have recommended an immediate increase in the Nuclear Waste Fee as the appropriate policy response to this clear and present danger to the financial integrity of DOE's nuclear waste program.[265] The State of Nevada has called for abandonment of the principal programmatic premises of current policy, particularly the licensing and construction of the Yucca Mountain repository and permanent emplacement there of both commercial spent fuel and defense high-level wastes.[266] The nuclear utilities have strenuously resisted both these policy prescriptions, vociferously opposing any increase in the Nuclear Waste Fee and aggressively attributing any Yucca Mountain program delays and cost overruns to DOE incompetence and inefficiency.[267] Instead, the Nuclear Energy Institute and its members have pursued a dual strategy. First, they have pushed Congress very hard for a bill to authorize an interim storage facility at the Nevada Test Site and the necessary transportation program to move spent fuel there from reactor sites.[268] Second, the nuclear utilities and their allies have repeatedly petitioned the federal courts for a ruling that, under current law, DOE must immediately accept logistical and financial responsibility for the wastes and their relocation.[269] To date, DOE's policy prescription has been to stay the course with a permanent repository at Yucca Mountain, interim storage at reactor sites, and maintenance of the Nuclear Waste Fee at one mill.[270]

Through this writing, Congress has enacted no new amendments to the NWPA to address the developing crisis in nuclear waste program financing. The bills which have passed in either the House or the Senate have essentially ignored the long-term financing issue, while making sure that the Nuclear Waste Fee is not increased in the near-term in response to cash flow pressures. Such pressures are projected to result from simultaneous con-

265. *See* BIEWALD & WHITE, *supra* note 199, at 19.

266. *See* NEVADA AGENCY FOR NUCLEAR PROJECTS, STATE OF NEVADA OVERSIGHT OF THE U.S. DEP'T OF ENERGY'S HIGH-LEVEL RADIOACTIVE WASTE PROGRAM 1-17 (1997).

267. *See* Schuler, *supra* note 185, at 34-35.

268. *See id.*

269. *See id.*

270. *See id. See also Hearings on S. 608 Before the Senate Committee on Energy and Natural Resources*, 106th Congress (1999) (March 24, 1999 Statement of Lake H. Barrett, Acting Director, Off. of Civilian Radioactive Waste Mgmt., U.S. Dep't of Energy).

struction of the Yucca Mountain repository and the Nevada Test Site interim storage facility as well initiation of a large-scale waste transportation program.[271] The D. C. Circuit told DOE that it had an unconditional obligation to accept spent fuel beginning January 31, 1998, but has thus far declined to mandate the agency to take any particular action to fulfill that obligation.[272] Instead, the court has directed the nuclear utilities to pursue the remedies available to them under their Standard Fuel Contracts. At this point, it does appear that DOE will have financial as well as logistical responsibility for interim storage of spent fuel after January 31, 1998.[273] However, it is not at all clear whether the Department will be able to use the Nuclear Waste Fund to pay that obligation or will have to pay it from the Department of Justice's litigation contingency fund or with a separate appropriation.[274] Thus far, the Supreme Court has shown no inclination to become involved.[275] Energy Secretary Richardson and several of the nuclear utilities have discussed a compromise in which at-reactor storage would continue until a permanent repository became available, with DOE contracting with the nuclear utilities (or their agents) to manage the at-reactor sites.[276] Apparently, this proposal would be designed to resolve both the Congressional impasse over legislation and the remedy for the D.C. Circuit/Court of Claims litigation over DOE's breach of the Standard Fuel Contracts. At this writing, however, the source of funding and other key elements of such a compromise were unclear and its prospects uncertain.

In sum, the restructuring of the electric utility industry now in progress has compounded the pre-existing complexities and exacerbated the prior controversies associated with the financing of

271. For example, S. 608 as introduced in the 1999 session provided for some flexibility in the annual level of the fee during construction of the Yucca Mountain repository, but required that the fee average 1.0 mill during construction and not exceed 1.0 mills after construction. *See Murkowski Introduces Nuclear Waste Bill, S. 608,* NUCLEAR WASTE NEWS, March 18, 1999, *available at* 1999 WL 10308951.

272. *See Northern States Power*, 128 F.3d at 761, *cert. denied*, 525 U.S. 1016 (1998); *see also* Bauser, *supra* note 172, at 392-93.

273. *See* Maine Yankee Atomic Power Co. v. United States, 42 Fed. Cl. 582 (1998).

274. *Compare Yankee Atomic Electric Co.*, 42 Fed. Cl. at 223, *with Northern States Power*, 43 Fed. Cl. at 374. *See* Gary Putka, *Court Rules U.S. Energy Dep't Broke Vow to Rid Plants of Nuclear Fuel*, WALL ST. J., Nov. 2, 1998, at A14; *Utility Must Pursue Contract Remedy for DOE Failure to Take Waste, Court Rules*, DAILY ENV. REP. (BNA), Apr. 12, 1999, at A-2.

275. *See Northern States Power*, 525 U.S. 1016.

276. *See* Joby Warrick, *U.S. to Offer Nuclear Waste Plan*, WASH. POST, Feb. 25, 1999, at A2.

the interim storage and ultimate disposition of spent nuclear fuel and other high level radioactive waste generated by commercial nuclear power plants. As a result, there is presently no political consensus regarding the public policy necessary and appropriate to address what is definitely an impending financial crisis.

VII. Policy Recommendations

The current national policy for isolation of spent nuclear fuel from the environment has been premised since 1987 on the successful development of a Yucca Mountain repository which would be operational by 1998 and could be characterized, designated, licensed, constructed, operated, and closed for a total cost less than or equal to the revenues raised by a Nuclear Waste Fee of one mill per kilowatt-hour imposed on the electricity generated and sold by the country's nuclear plants. The adequacy of the Nuclear Waste Fee has, in turn, been based on the assumptions that (1) most, if not all commercial nuclear reactors would generate electricity at comparatively high capacity factors during their licensed period of operation, namely 40 years, and (2) the cost of transporting spent fuel from reactors and isolating it forever at Yucca Mountain would be recoverable through the rates of electric utilities which were regulated monopolies holding exclusive franchises to provide electricity within their service territories.

But, in 1999, the site of the proposed Yucca Mountain repository has yet to be completely characterized, let alone designated, licensed or constructed. Indeed, there are significant unresolved uncertainties with regard to whether the Yucca Mountain site is suitable for a repository. Moreover, even assuming it will be constructed, a Yucca Mountain repository could not be operational before 2010 and former Secretary of Energy O'Leary told Congress that 2015 was its likely in-service date. Recent studies conducted on behalf of the State of Nevada also raise serious questions regarding whether the repository's total system life-cycle costs will substantially exceed even the most optimistic projections of Nuclear Waste Fee revenues. Moreover, the structural disaggregation of the electric utility industry and the introduction of competition and deregulation into its generation sector make it very unlikely that most commercial nuclear plants will operate for 40 years or that spent fuel isolation costs will continue to be recoverable through the rates of regulated monopolies. Indeed, the Biewald and White study suggests that the introduction of competition and deregulation for generators of electricity could precipi-

tate a shortfall in Nuclear Waste Fund financing of as much as $46.5 billion.[277]

As a result, current national policy for the isolation of spent nuclear fuel clearly faces an impending financing crisis occasioned by the virtually certain conjunction of rising costs and falling revenues. To resolve this crisis, American policy-makers will need to redefine the Nuclear Waste Fund and reconfigure its financing to take into account both the unresolved uncertainties in the nation's strategy for isolating spent fuel from the environment and the pending changes in the structure and regulation of the electric utility industry. The balance of this article will address this redefinition and reconfiguration.

A. The Nuclear Waste Policy-Making Environment

There are three critical characteristics of the decision-making environment for commercial nuclear waste policy, including especially but not exclusively its financing. First, the environment is much more political than it is technical. Second, the technical issues are extremely complex and highly controversial, even among experts in the scientific disciplines involved. Third, from both a technical and political perspective, there really is no precedent or analogy to follow: the policy-making problem associated with the discharge and isolation of spent nuclear fuel really is "a new species of trouble" because the 250,000-year time frame for the technical issues which are posed simply dwarfs the whole length of human history, let alone the major challenges of the past confronted by the Anglo-American political system such as protracted wars and depressions.[278] Indeed, the planning horizon for the high-level nuclear waste problem is more than 1,000 times longer than the entire history of the United States as a nation.

As a result, a policy that is technically "right" for the ages also must be politically "correct" for the moment. Or, as noted sociologist Kai Erickson has observed about the high-level nuclear waste policy-making process generally:

> [H]uman decisions do not always emerge from reflective counsels in which facts are arrayed in order and logic is the prevailing currency of thought. They emerge from complex fields of

277. *See* BIEWALD & WHITE, *supra* note 199, at 17, tbl. 4.1.

278. *See* KAI ERICKSON, A NEW SPECIES OF TROUBLE 203 (1994).

> force, in which the vanities of leaders and the moods of constituencies and the inertias of bureaucracies play a critical part.[279]

This decision-making process has also been characterized in a more generic context as "muddling through."[280] This approach posits a decision-making process which makes periodic, incremental adjustments at the margins of past policies to respond to new problems posed by the policy environment. As both Erickson and Kristin Shrader-Frechette have pointed out, this approach to policy "is uncomfortably like that of the famous drunk who looks for a missing set of keys under a streetlight not because he has any reason to think he lost them there but because it is the only light available."[281] But, "muddle through" is the approach which complex organizations typically adopt when confronted with large, difficult problems with expensive but uncertain and controversial solutions. Generally, this "muddle through" approach is the best such organizations can manage, whether or not it results in "good" policy in terms of the goals to which it is purportedly directed.[282]

B. The Political Constraints of the Moment

The technically correct policy for the ages must be developed within several significant constraints currently imposed by the correct politics of the moment:

1. While official national policy remains committed to its construction, the Yucca Mountain repository (and, with it, the entire premise of the NWPAA that "permanent" geologic emplacement at the Yucca Mountain site is the "solution" to the high-level waste problem) is clearly in jeopardy due to scientific uncertainties, schedule delays and projected cost overruns. Indeed, enthusiasm of the nuclear utilities themselves for Yucca Mountain would evaporate if they were to remain entirely responsible for its costs and it became clear those costs would escalate to an extent even approaching the fifty percent predicted by the State of Nevada's consultants.

279. *Id.* at 202.

280. *See* Charles E. Lindblom, *The Science of "Muddling Through,"* PUBLIC ADMIN. REV. (1959) at 79, *reprinted in* PUB. POLICY: THE ESSENTIAL READINGS 113 (Stella Theodoulou & Matthew Lan. eds., Prentice Hall 1995).

281. ERICKSON, *supra* note 278, at 211 (citing Kristin Schrader-Frechette, Expert Judgment in Assessing Rad-waste Risks: What Nevadans Should Know About Yucca Mountain 154 (1992) (unpublished study submitted to the Nuclear Waste Project Office, State of Nevada)).

282. *See* Lindblom, *supra* note 280, at 80, 83-84.

2. Backed by the credible threat of a sustainable Presidential veto, the Clinton Administration has adamantly and successfully rejected industry-backed proposals for a central interim storage facility at the Nevada Test Site until the future of the Yucca Mountain repository is assured. The nuclear utilities' continued pursuit under current law of a license for a privately-owned and - operated ISFSI at Skull Valley suggests that they harbor doubts about the prospects of the new legislation that would be required to authorize the Nevada Test Site as a government-owned and operated storage facility, even if Yucca Mountain proves non-viable. Certainly, the State of Nevada is going to be no less hostile to such a facility than it has been to a repository.

3. The development of above-ground dry cask technology as an alternative to underwater pools has made at- or near-reactor storage of spent fuel a viable technical option for periods of up to 100 years. As a result, at- or near-reactor storage in dry casks has become the de facto interim storage policy in the United States.[283]

4. The structural disaggregation of the electric utility industry and the introduction of competitive markets and deregulation in its generation sector have created significant uncertainty regarding the sufficiency of the future revenue stream produced by the Nuclear Waste Fee to finance the total system, life-cycle costs of the Yucca Mountain repository and its supporting subsystems, let alone the additional costs of a central interim storage facility. This potential revenue shortfall is particularly problematic if cost overruns materialize at the levels projected by the State of Nevada's consultants. However, the obvious response to this problem of an increase in the Nuclear Waste Fee would seemingly be both economically self-defeating and politically self-destructing.

C. The Politically Correct Policy for the Current Political Moment

The policy outcome to be expected from the current political moment will necessarily be consistent with the limiting constraints of the political moment. This outcome will thus involve waste isolation facilities that can be constructed and operated for the foreseeable future with the revenues projected to be realized from the existing fee of one mill ($0.001) per kwh of nuclear power generated and sold. This outcome is likely to combine near-term

283. *See generally* Denise Renee Foster, Comment, *Utilities: De Facto Repositories for High-Level Radioactive Waste?* 5 DICK. J. ENVTL. L. & POL'Y 375 (1996).

storage in at-reactor dry cask facilities operated by nuclear utilities with short-term financing provided by the Nuclear Waste Fund. In other words, the most likely policy outcome from the current political moment, de facto or de jure, is some variation of the Richardson Plan, deferring the issues of both long-term waste isolation and its financing to the indefinite future.

D. The Politically Correct Policy: Foreseeable Risks

There are significant risks associated with the predicted policy outcome, of course.

1. The Risk of Deferring Waste Management Problems to Future Generations

Federal policy has avowedly been to assure that the problem of establishing "waste management program will not be deferred to future generations."[284] By contrast, the predicted approach means that the problem will have to revisited by each generation, for generations to come. But, as Kai Erickson has so eloquently explained:

> We cannot promise our own children–never mind those who follow hundreds of thousands of years hence–that they will be safe from the wastes. And so long as that is so, we are not taking the *problem* out of their hands so much as we are taking the *solution* out of their hands.[285]

So, deferring the waste isolation problem to future generations is really a foregone conclusion. The only real issue is not whether the problem is deferred, but whether the means, especially the financial wherewithal, to address the problem is denied to future generations.

2. The Risk of Wishful Thinking Regarding Waste Isolation Costs

There is also the risk that policymakers will fool themselves into believing that the nation can afford a particular waste isolation "solution" when the available resources are actually inadequate to pay for it. This certainly seems to be a real risk with the Yucca Mountain repository at the present time, and has been a chronic problem in the past with nuclear facilities of all types.

284. Presidential Message, *supra* note 91, at 227.
285. ERICKSON, *supra* note 278, at 225 (emphasis in original).

Moreover, should Yucca Mountain not prove viable as a "solution" (as now seems likely), there would necessarily be costs (currently unknown, but certainly large) associated with the alternative (currently uncertain, but probably continued reliance on at-reactor dry cask storage at least until well into the twenty-first century). This risk can be addressed only by the availability of incremental resources should the need arise.

3. The Risk of Inadequate Near-Term Financing

Then, there is the risk that the available resources are insufficient for an adequate temporary solution, either because "muddle through" is an inappropriate response to the nuclear waste problem or because we have failed to allocate available resources in proportion to its significance to the protection of human health and the environment. "Muddle through" poses a particular concern here because monitoring and maintenance of dry cask storage sites will be required at approximately seventy nuclear plant sites where the generating facilities are presumed to be closing, raising the issue of transfer of institutional control, especially as the period of time after plant closure increases. Even though the storage sites themselves are decentralized, centralized institutional system for storage site monitoring and maintenance would certainly be feasible.[286] But, such a system would require adequate financial resources to pay for the best monitoring and maintenance practices at the decentralized sites and to assure that the sites continue to meet established and evolving performance benchmarks.

4. The Risk of Inadequate Long-Term Financing

Finally, there is the risk that the resources available may be sufficient for an adequate temporary solution, but not for an indefinite solution. This is a particular issue because the waste is expected to require isolation from the environment for up to 250,000 years into the future, yet the Nuclear Waste Fee is expected to generate revenues for only approximately forty years into the future.

286. Indeed, the existence of multiple sites provides the opportunity for performance "benchmarking" and development of "best practices" among competing vendors of monitoring and maintenance services. Certainly, the history of DOE management of other nuclear wastes provides no basis for the belief that one, huge central storage site out of the public eye in the Nevada or Utah desert would be better monitored and maintained than seventy much smaller sites more subject to public scrutiny.

E. The Politically Correct Policy: Necessary Refinements

The enumerated risks associated with the expected policy outcome from the current political environment are real and substantial. Patently, these risks will require important refinements to be made in the expected policy outcome.

1. Several Key Assumptions of the Waste Isolation Program Concept DOE Used to Assess the Adequacy of the Nuclear Waste Fund Should Be Redefined.

The DOE has conducted its most recent assessment of the adequacy of the Nuclear Waste Fee on the basis of its projections of the "total system life-cycle" costs of the Yucca Mountain repository and its supporting waste acceptance and transportation program assuming the repository is completed in 2010 and decommissioned in 2116.[287] Moreover, the DOE assessment assumes that Yucca Mountain will be the one and only repository, with no interim storage.[288] The DOE assumes that the total estimated costs for this program, in constant 1998 dollars, will be $37.0 billion.[289] The DOE projects that the Nuclear Waste Fee will generate future revenues, in constant 1998 dollars, of $23.2 billion on the assumption that currently open nuclear plants "will operate for forty years from the issuance of their operating licenses without extensions, and reactor performance will not be affected by aging."[290] These assumptions need to be redefined in at least three key respects to provide an appropriate assessment of Nuclear Waste Fund adequacy.

a. The DOE assessment should assume interim storage until at least 2025 and perhaps indefinitely.

The Yucca Mountain repository has not yet been proven to be viable as a method of "permanent" and "safe" isolation of spent nuclear fuel and there are increasing doubts that it ever will. Moreover, in the absence of both a repository and a central interim storage facility, at-reactor, dry cask storage is the only reasonable temporary storage alternative. Thus, the "conservative" approach to the financing of spent fuel isolation would be to assume that the Yucca Mountain repository will prove to be unsuita-

287. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., DEP'T OF ENERGY, NUCLEAR WASTE FUND FEE ADEQUACY: AN ASSESSMENT 1-3 (1998).

288. *See id.* at 9.

289. *See id.*

290. *Id.* at 12-13.

ble and the spent fuel will remain in at-reactor, dry cask storage while alternatives to Yucca Mountain are pursued.

This is the approach which was taken by the Nuclear Regulatory Commission in its 1990 Waste Confidence Decision Review: "In order to obtain a conservative upper bound for the timing of repository availability, the Commission has made the assumption that the Yucca Mountain site will be found to be unsuitable."[291] Because the 1987 Nuclear Waste Policy Act Amendments require DOE to consider alternatives to Yucca Mountain only *after* that site has been determined unsuitable and the Department had projected a twenty-five year period from initiation of characterization to acceptance of waste at an alternative repository site, the NRC concluded that it would be "reasonable to expect that a repository would be available by the year 2025" *if* Yucca Mountain was determined unsuitable in the year 2000.[292] In this connection, the NRC reasoned:

> Geologic disposal of high-level radioactive wastes is an unprecedented endeavor. It requires reliable projections of the waste isolation performance of natural and engineered barriers over millennia. After the repository is sealed, retrieval of the emplaced wastes will no longer be practicable, and the commitment of wastes to that site will, by design, be irreversible. . . . [T]he Commission believes that the confidence of both NRC and the public depends less on meeting the schedule for repository operation than on meeting safety requirements and doing the job right the first time. *Thus, given the Commission's assurance that spent fuel can safely be stored for at least 100 years if necessary, it appears prudent for all concerned to prepare for the better-understood and more manageable problems of storage for a few more years in order to provide additional time to assure the success of permanent geologic disposal.*[293]

Thus, according to the NRC in 1990, the "conservative" approach to financing assumptions would entail no repository until 2025 and on-site, dry cask storage in the interim.

In its 1990 Waste Confidence Decision Review, the NRC committed to perform another review in 1999.[294] But, the NRC has deferred this review. As a result, there is no way to know with

291. Waste Confidence Decision, *supra* note 116, at 38,505.
292. *Id.*
293. *Id.* at 38,507 (emphasis added).
294. *See id.* at 38,505-06.

certainty what the NRC would consider to be the "conservative" set of assumptions for waste isolation at this juncture. However, it would appear reasonable to conclude that the NRC would be no less "conservative" in 1999 than it had been in 1990 and assume no repository any earlier than 2025, with on-site, dry cask storage in the interim. Moreover, the results to date of the litigation between the nuclear utilities and DOE over financial and logistical responsibility for waste acceptance and storage strongly suggest that the "conservative" assumption is that DOE will, at the very least, have to bear the cost of at-reactor storage after January 31, 1998. In fact, former Energy Secretary James Schlesinger anticipated such an eventuality when, on the eve of leaving office in December, 1992, he proposed that Congress authorize the use of Nuclear Waste Fund monies to construct at-reactor dry cask storage facilities.[295]

Given the uncertainties regarding "permanent geologic disposal" which have emerged from the Yucca Mountain characterization, the 1990 NRC assumption that an alternative site suitable for a geologic repository capable of "permanent" isolation of spent fuel would be operational in 2025 may no longer be "conservative." Indeed, former NRC Chairman John Ahearne has recommended abandoning the repository effort and switching to a waste isolation strategy based on above-ground storage facilities which could be sited regardless of geologic conditions.[296] As a result, the truly "conservative" assumption is that an alternative repository site is no more likely to be determined suitable for "permanent disposal" than the initial site.

In light of these considerations, the waste isolation concept used to assess the adequacy of the Nuclear Waste Fund should be redefined to reflect at-reactor, dry cask storage continuing indefinitely (including periodic repackaging of spent fuel assemblies and replacement of casks) to cover the contingency that neither Yucca Mountain nor any alternative site will prove viable as a geologic repository capable of "permanent" waste isolation.

295. *See* JAMES FLYNN ET AL., ONE HUNDRED CENTURIES OF SOLITUDE: REDIRECTING AMERICA'S HIGH-LEVEL NUCLEAR WASTE POLICY 29 (1995).

296. *See id.*

b. If it does not assume that at-reactor, dry cask storage will continue indefinitely, then the DOE assessment should assume that the emplacement of waste at the Yucca Mountain repository will be "monitored and retrievable" rather than "permanent."

A recent review by a prestigious group of academics and consultants of the nation's continuing commitment to the Yucca Mountain repository as a "permanent" solution to the problem of high-level nuclear waste (HLNW) isolation concluded:

> Yucca Mountain very well could be unacceptable on any terms. There are no alternative plans, only the directions in the Nuclear Waste Policy Act to return to Congress for further instructions if Yucca Mountain is unsuitable. If Yucca Mountain is found to be unsuitable in 30, 40, 50 or 100 years, because no genuine site study was conducted, what options will exist? The nuclear power plants that produce the money for the HLNW program will have long been closed, and they no longer will be a source of funding. The Nuclear Waste Fund will have been spent. Loading Yucca Mountain with HLNW as if it were a repository, especially on compromised standards, and then finding that Yucca Mountain is unsuitable or that some other option for HLNW management is necessary, will place tremendous burdens on future generations, complicating rather than simplifying their abilities to manage the legacy of HLNW.[297]

Moreover, the Nuclear Regulatory Commission currently requires that any repository be designed to allow the retrieval of waste at any time up to fifty years after waste operations begin.[298] Given both the empirical uncertainties regarding Yucca Mountain and the requirements of NRC regulations, "DOE is designing the repository so that it could (with Nuclear Regulatory Commission approval) be either closed as early as 10 years after emplacement of the last waste package, or kept open for hundreds of years from the start of waste emplacement."[299] Moreover, DOE is assuming that "[r]etrieval of waste, if needed, would follow, in reverse order, the same steps taken in emplacing the waste."[300] DOE has made no provision in its assessment of Nuclear Waste Fund adequacy

297. *Id.* at 110.

298. *See* 10 C.F.R. § 60.111(b) (1998).

299. Office of Civilian Radioactive Waste Mgmt., U.S. Dep't of Energy, Viability Assessment of a Yucca Mountain Repository: Overview § 3.2 (1998), *available at* http://domino.ymp.gov/va/va.nsf.

300. *Id.*

for the costs of waste retrieval and isolation following retrieval. Indeed, DOE has not even estimated these costs. Instead, the DOE assessment simply assumes these costs will not be incurred because the waste will remain emplaced and the repository will be permanently closed and its costs will terminate in 2116.[301]

This assumption is clearly not "conservative" for purposes of assessing Nuclear Waste Fund adequacy. If the Yucca Mountain repository must be designed for the contingency that emplaced waste will have to be retrieved, then funding should also be assured to cover the costs of that contingency.

c. The DOE assessment should assume that future revenues to be realized by the Nuclear Waste Fee will be reduced by the introduction of competition and deregulation into the generating sector of the electric utility industry.

In January, 1998, DOE prepared an updated projection of the volumes of spent fuel which would require isolation. This analysis included a "sensitivity case" in which open reactors were assumed to complete only thirty years of their forty-year licensed operating lives. This change in assumptions resulted in a reduction in the total volumes of spent fuel to be discharged from approximately 87,000 MTU in the "reference case" to about 69,000 MTU in the "sensitivity case" - a decrease of twenty percent, as indicated in Figure 2, *infra*.[302] Perhaps more significant, this reduction of 18,000 MTU is all in post-1998 volumes of spent fuel to be discharge, supplying a reduction of approximately thirty-six percent in future nuclear generation and directly related NWF revenues. But, the DOE's 1998 Fee Adequacy Assessment does not include a parallel "sensitivity case."

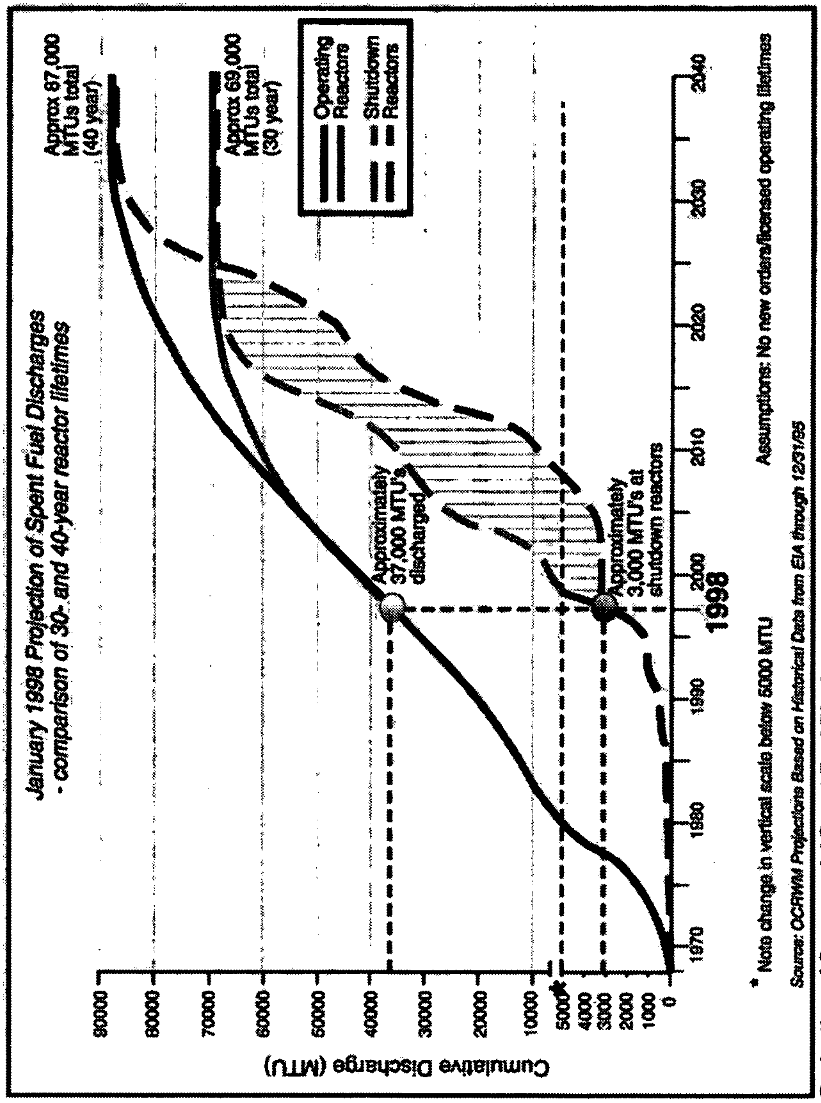
This omission is clearly not warranted in light of experience to date with nuclear plant longevity and the likely effects of electric utility industry restructuring. To date, no nuclear plant has operated for its entire forty-year operating life. Of twenty-two plants retired to date, only two operated for more than thirty years.[303] Of the 106 plants still operating at the end of 1998, none

301. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., DEP'T OF ENERGY, NUCLEAR WASTE FUND FEE ADEQUACY: AN ASSESSMENT 12 (1998).

302. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., U.S. DEP'T OF ENERGY, ANN. REPORT TO CONGRESS: FISCAL YEAR 1997 9 (1998).

303. BIEWALD & WHITE, *supra* note 199, at tbl. 2.1.

Figure 2



Projection of Commercial Spent Fuel Discharges

had completed thirty years of operation.[304] Moreover, the reference case in Biewald and White's study projects that restructuring will result in shortening the operating lives of existing plants to approximately thirty-five years, while their low generation case forecasts that competition and deregulation will reduce the average operating life of open plants to roughly twenty-six years.

This projected shortening of the operating lives of existing reactors is important because it would not be associated with a proportional reduction in OCRWM program costs. In particular, Biewald and White project that the Nuclear Waste Fund would prove inadequate in both their reference and their low generation cases.[305] Clearly, then, a "conservative" approach to assessing the adequacy of the Nuclear Waste Fund would require consideration of the effects on future revenues of the introduction of competition and deregulation into the generating sector of the electric utility industry.

2. The General Accounting Office Should Be Charged with Responsibility for Auditing the DOE's Assessment.

The DOE has chosen to assess the adequacy of the Nuclear Waste Fund on the basis of a programmatic scenario that does not consider the costs associated with interim storage before a repository becomes available. The agency has also elected to ignore the costs, which would result if waste needed to be removed from a repository at any time following its initial emplacement. These are clearly not appropriately "conservative" assumptions for purposes of assessing Nuclear Waste Fund adequacy. Consultants under contract to the State of Nevada, after a comprehensive review, have concluded that the Department of Energy has substantially underestimated the "total system, life-cycle" costs of the commercial waste isolation program. Biewald and White have found that OCRWM has significantly overestimated future Nuclear Waste Fund revenues in assessing the adequacy of the Nuclear Waste Fee. If the outside consultants are correct, DOE's underestimate of costs and overestimate of revenues would have "huge" implications for the future financing of the Nuclear Waste Fund.

304. *Compare id.*, *with* SPENT FUEL STORAGE REQUIREMENTS, *supra* note 24, at A.3 - 7, tbl. A-1.

305. BIEWALD & WHITE, *supra* note 199, at 16-19.

In 1995, the Nuclear Waste Policy Act was amended to provide that, at the request of either House of Congress (or any committee thereof), the General Accounting Office "shall conduct" an audit of the OCRWM's waste isolation program and "shall submit a report on the results."[306] Clearly, Congress should exercise its authority under this provision to charge the GAO with responsibility for auditing OCRWM's most recent assessment of the adequacy of the Nuclear Waste Fund, including its estimate of the "total system, life-cycle costs" of the waste isolation program and its projection of future revenues from the Nuclear Waste Fee. This audit should be conducted using "conservative" assumptions. This audit would provide an official and authoritative basis for developing future policy regarding the financing of the nation's commercial spent fuel isolation program.

3. The Nuclear Waste Fund Should Be Perpetual, Not Terminal.

DOE assumed in its 1998 assessment that the Nuclear Waste Fee is adequate only if it generates sufficient revenues to cover the costs of the Yucca Mountain repository through waste emplacement, with $2.5 billion in constant 1997 dollars left over to cover future costs.[307] Of this amount, $1.5 billion is the net present value of the costs of permanently closing and decommissioning the repository in 2016 and monitoring the open repository between 2042 and 2016.[308] The remaining $1 billion is a "program contingency" to cover costs in excess of the Department's estimate.[309]

Should a repository never become operational or, after becoming operational, develop problems which required emplaced waste to be retrieved before the repository is closed, costs will have to be incurred indefinitely to isolate the spent fuel discharged from commercial nuclear reactors. Neither of these contingencies can be ruled out at present; one of them cannot be ruled out even in the next century. As a result, prudence dictates that the Nuclear Waste Fund should be redesigned to be perpetual, not terminal.[310]

306. 42 U.S.C. § 10224(d) (Supp. 1997).

307. *See* OFFICE OF CIVILIAN RADIOACTIVE WASTE MGMT., DEP'T OF ENERGY, NUCLEAR WASTE FUND FEE ADEQUACY: AN ASSESSMENT 18 (1998).

308. *See id.*

309. *See id.*

310. Implicitly, DOE's financing scenario could accommodate this change in policy. If a repository never becomes operational, or waste has to be retrieved before it is closed, there would (at least in theory) be some amount of funds available to cover those contingencies because some of the projected costs of operating, closing and

In essence, the financing policy being recommended entails that the principal amount of the Nuclear Waste Fund be stabilized at a level such that the annual interest would be sufficient to pay indefinitely the current best estimate of the annual future costs of monitored, retrievable storage of all the spent fuel ultimately discharged, whatever the location of the waste, whether Yucca Mountain or elsewhere. While no one can guarantee the existence of the Fund for the next 250,000 years, it should be funded on the premise that the resources it represents should be available if needed during that period.

4. The Financing Methods for the Nuclear Waste Fund Should Be Modified to Reflect Both its Current Underfunded Status and the Future Development of Competitive, Deregulated Generation Markets.

Given the probability that the Department of Energy has significantly underestimated the future costs of spent fuel isolation and substantially overestimated the future revenues from nuclear electricity, it is virtually certain that the Nuclear Waste Fund is currently underfunded. Biewald and White have estimated that this underfunding could be as much as $46.5 billion. Hopefully, the GAO audit called for above will provide an official and therefore more authoritative estimate of the underfunding. But, assuming this underfunding is substantial, there is a critical need to find the means to fund both the existing shortfall and the future costs of isolating spent fuel, essentially in perpetuity.

a. The real policy issue is the source, not the method of financing.

At the highest level of generality, the policy dilemma posed by the financing of the costs of the interim storage and ultimate disposition of spent nuclear fuel is precisely the same as that posed by investment "stranded" by nuclear plant cancellations and early retirements. As noted legal scholar and policy commentator, Joseph P. Tomain, has explained, "the primary problem is: Who pays?"[311]

---

decommissioning the repository would be avoided. But, there would be no correlation between this unexpended balance and the level of funding necessary to finance either interim storage or retrieval and post-retrieval storage indefinitely.

311. TOMAIN, *supra* note 226, at 135.

> In a perfectly fair world, those responsible for incurring costs without producing benefits should pay. In an imperfect world, correlating responsible actors with irresponsible conduct is not often easy, particularly when the state actively promotes the capital expansion of a complex high-technology industry. Frequently, an exact correspondence between conduct, cause and consequence is lacking. . . .
>
> Likely candidates for imposing legal liability can be identified by noting the actors in the nuclear drama. These include the government and its officials, industry and its personnel, and consumers and investors. . . .
>
> In connection with cost absorption or legal liability, *government* is actually a euphemism for taxpayers. Only in the most outlandish of situations, when a government official acts outside the scope of his or her authority, usually with malice or other equally gross conduct, will an individual be held financially liable. Therefore, the word *taxpayers* must be substituted for *government*. . . .
>
> The fundamental fallacy in the arguments favoring imposition of cost liability on *government* is that government as such does not exist. The word *government* is a surrogate conception for taxpayers. Similarly, *industry* as such does not exist. Rather, industry is a collective concept including various public utilities and private construction and manufacturing corporations. Just as government passes its liability on to taxpayers, industry passes its liability on to owners and investors–the firms' shareholders and bondholders–or to consumers of the firms' goods and services. . . .[312]

Ultimately, then, the only real candidates presently available to nuclear waste policy-makers to pay the costs of spent fuel storage and disposition are federal taxpayers, electricity consumers and utility investors.

But, this necessarily short list of potential financiers need not pay *all* the costs of isolating spent nuclear fuel and other high-level radioactive wastes produced by nuclear power plants from the environment *now*. Because these wastes are hazardous to human health and the environment for approximately 250,000 years, their isolation is largely a matter of *long-term future* costs. Those long-term costs could be deferred to the future 10,000 generations of humanity who will require protection from the radioactive wastes produced by today's nuclear power plants while the

312. *Id.* at 135-38.

current generation who produced those wastes pays only the *present and near-term future* costs of their isolation. In effect, the current generation of policy-makers has the option of *deferring* the long-term costs of isolating high-level radioactive waste from the environment. This option poses what is generally characterized in the nuclear waste policy debate as the ethical problem of "temporal or inter-generational equity"–how much of the environmental risk and economic cost associated with nuclear waste discharged by the *current* generation may justifiably be shifted to *future* generations?[313]

In essence, then, the primary policy issue is how much of the cost of waste isolation should be paid by the current generation and how much should be deferred to future generations. While still very important, the allocation of the costs to be paid by the current generation among federal taxpayers, electricity customers, and utility investors is clearly secondary over the longer term.

b. The right policy for the ages requires the current generation of Americans to fund the existing Nuclear Waste Fund shortfall and to adopt a means of funding the costs of isolating spent fuel discharged in the future that is sustainable indefinitely.

By definition, the existing shortfall in the Nuclear Waste Fund results from past underfunding of future liabilities. In essence, the Nuclear Waste Fee has heretofore been too low. To adhere to the NWPA principle that nuclear generators pay all waste costs, and to assure equitable allocation of costs incurred among waste generators, the method for calculating the one-time assessment necessary to eliminate the existing shortfall and allocating it among utilities and their customers should be retrospective. The method which immediately comes to mind is the one-time fee per kilogram of heavy metal which was imposed on spent nuclear fuel generated prior to April 7, 1983, by the Nuclear Waste Policy Act when it was enacted in 1982.[314] However, that NWPA provision also expressly limited generator liability for the waste isolation costs of spent fuel generated prior to April 7, 1983, to that one-time assessment.[315] As a result, the new one-time assessment be-

313. *Compare* SCHRADER-FRECHETTE, *supra* note 25, at 182-212, *with* Berkovitz, *supra* note 35.

314. *See* 42 U.S.C. § 10222(a)(3).

315. *See id.*

ing proposed here could be calculated and allocated based only on spent fuel discharged on and after April 7, 1983.

While retrospective in its calculation and allocation, the proposed one-time assessment would necessarily be prospective in collection. Because the Nuclear Waste Fund shortfall developed during the regime of rate-regulated monopolies, it would seem appropriate to collect the one-time assessment the same way the Nuclear Waste Fee has been collected, i.e. through a non-bypassable charge per kwh imposed on all (and not merely nuclear) electricity sold during the collection period to the transmission and distribution customers of utilities which were nuclear generators during the calculation period. It would also seem appropriate that the charge should be collected over a relatively short period (e.g., not to exceed ten years) to recognize the retrospective character of the underlying shortfall that the one-time assessment is intended to offset. While the specific mechanics of calculating and collecting such a charge for affected utilities are beyond the scope of this article, it would seem evident that the total assessment would necessarily take into account spent fuel discharges from previously closed as well as currently operating plants. Additionally, it would appear equitable to credit each affected utility (and its transmission and distribution customers) with amounts heretofore collected for spent fuel storage pursuant to 10 C.F.R. § 50.54(bb).[316]

316. While it is seldom noted or considered in discussions of the issues associated with spent nuclear fuel, the NRC regulation found at 10 C.F.R. § 50.54(bb) is potentially very significant to the financing issue. The wording of the regulation seems relatively innocuous on its face, requiring commercial nuclear plant licensees to "submit written notification to the Commission for its review and preliminary approval of the program by which the licensee intends to manage and provide funding for the management of all irradiated fuel at the reactor following permanent cessation of operation of the reactor until title to the irradiated fuel and possession of the fuel is transferred to the Secretary of Energy for its ultimate disposal in a repository." *See* 10 C.F.R. 50.54(bb) (1998). But, licensees and their state regulatory commissions have interpreted the regulation to require collection in a nuclear utility's annual decommissioning charge not only the costs of plant decommissioning activities, but the incremental amounts necessary to fund spent fuel management during and following such activities. *See, e.g.* Testimony of Bruce M. Barber on behalf of Indiana Michigan Power Company, at 24, Cause No. 36760-S1 (Ind. Util. Reg. Comm'n 1999). The amounts collected pursuant to Section 50.54(bb) were neither separately identified nor significant in amount before 1990, since the disposition of any spent fuel remaining at the reactor site was assumed to occur in parallel with the major activities of decommissioning. But, this assumption changed in 1990 to reflect the extension of the at-reactor spent fuel storage period associated with projected delays in completion of the Yucca Mountain repository and DOE's acceptance of spent fuel for shipment and ultimate disposition. *Id.* at 23-25. The incremental amounts being collected and

The financing of the costs of isolating spent nuclear fuel discharged in the future presents a somewhat different problem than financing the shortfall associated with wastes discharged in the past. In particular, the future financing of the Nuclear Waste Fund must take into account the introduction of competition and deregulation into the generating sector of the electric utility industry. In this context, it is critical that the financing of the costs of isolating spent fuel discharged in the future be internalized in the market price of electricity generated and sold after deregulation. This is true for two reasons.

First, cost internalization is important for environmental reasons because it is the key to sustainable development. As Professor David Hodas has explained:

> If there is any agreement on what sustainable development means, it is that economic and environmental factors are combined into a single decision, or in economic terms, that the externalities of each activity must be internalized. Principle 16 of the *Rio Declaration* confirms this vision: "[n]ational authorities should endeavor to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment." Whatever else sustainable development may mean, it must mean that in every development decision the environmental costs are internalized.[317]

Second, cost internalization is important for classic economic reasons. In a competitive, deregulated market, costs attributable to a generator of electricity which do not have to be recovered in the price it charges its customers represent a subsidy which provides a competitive advantage to that generator. As the Massachusetts Department of Public Utilities has found:

---

reported as necessary to fund spent fuel management during and following decommissioning have also become significant. For example, Northeast Utilities filed a 1999 report with the NRC which stated that $159 million of a total $691 million in estimated decommissioning costs for the closed Millstone Unit 1 were associated with post-closure spent fuel management. *See Millstone Decommissioning to Cost $691 Million*, MEGAWATT DAILY, June 24, 1999, *available at* 1999 WL 13892507.

317. David R. Hodas, *The Role of Law in Defining Sustainable Development: NEPA Reconsidered*, 3 WIDENER L. SYMP. J. 1, 2-3 (1998) (citing *Rio Declaration on Environmental Development*, U.N. Conference on Env't and Development, Principle 16, at 879, U.N. Doc. A/Conf. 151/5/Rev. 1 (1992)).

> In a competitive resource market in which price plays a predominant role in determining business success of competing resource developers, there is a danger of increasing the pollution of valuable environmental resources. This occurs because resource developers have the incentive to minimize environmental controls in order to minimize production costs, which in turn enables them to keep their price as low as possible (thus increasing their chances of winning a competitive resource solicitation), and affords them the opportunity to make private profits.[318]

The key to cost internalization is to identify and quantify the incremental future costs of waste isolation which are attributable to the future discharges of spent fuel and to differentiate them from future costs attributable to past discharges of spent fuel. This task is well beyond the scope of this article; it is unquestionably a task requiring technical expertise which will have to be performed by engineers and economists under the watchful eyes of interested parties and regulators. But, certain observations do seem in order here. First and foremost, incremental discharges of spent fuel do have incremental isolation costs, from extra storage casks, additional fuel assembly handling, and enlarged storage areas at-reactor, to additional shipments and transportation cask handling during waste acceptance and transportation, to incremental waste packet handling, emplacement, and, potentially, retrieval at a repository. Second, the costs associated with incremental discharges will be significant. Depending upon the impacts of electric industry restructuring on future nuclear energy generated and sold, it appears quite likely that 30,000 to 50,000 MTU of spent fuel will be discharged after January 1, 2000. Comparatively, this means that between forty to sixty percent of the total volume of spent fuel projected to be discharged by commercial nuclear plants will be discharged after January 1, 2000.

The implications of incremental cost internalization for the level of the Nuclear Waste Fee is unclear at this point. Biewald and White's study does not posit a one-time assessment to fund the existing shortfall in the Nuclear Waste Fund with respect to waste isolation costs attributable to spent fuel discharged in the past. Their study also does not attempt to differentiate costs at-

318. Re Pricing and Rate-making Treatment for New Electric Generating Facilities Which Are Not Qualifying Facilities, Decision No. 86-36-G, at 79 (Mass. Dept. Pub. Utils. 1989), *quoted in* Rudy Perkins, *Electricity Deregulation, Envtl. Externalities and the Limitations of Price*, 39 B. C. L. REV. 903, 1033 (1998).

tributable to spent fuel discharged in the past from those attributable to spent fuel to be discharged in the future. As a result, their conclusion that the Nuclear Waste Fee will have to be increased promptly and significantly to compensate for DOE's underestimate of future waste isolation program costs and its overestimate of future Nuclear Waste Fund revenues does not necessarily hold given the recommendations made here. In view of the apparent size of the current shortfall attributable to a period when the fee was also one mill, it appears doubtful that the current one mill fee would prove adequate to internalize in the price of nuclear electricity the incremental costs of spent fuel to be discharged in the future, even assuming the shortfall associated with costs attributable to past discharges is funded by the one-time assessment proposed in this article. But, any definitive conclusion regarding the required level of the Nuclear Waste Fee in the future will have to await the outcome of the General Accounting Office audit of fee adequacy proposed here.

VIII. Conclusion

A. Restatement of Thesis

This article has evaluated the adequacy of current law and policy for financing the Nuclear Waste Fund created by the Nuclear Waste Policy Act of 1982 in light of the structural disaggregation of the electric utility industry and the introduction of competition and deregulation into its generating sector which are now underway in the United States. This evaluation has been conducted in the context of a concise history of the development of national policy regarding the isolation from the environment of the commercial, high-level nuclear waste commonly known as "spent nuclear fuel." This evaluation has concluded that significant changes in current law and policy would be required and expected even in the absence of electric industry restructuring. However, this article has also concluded that electric industry restructuring may be expected to precipitate a crisis for current law and policy, the resolution of which will require significant changes in the structure and financing of the Nuclear Waste Fund. This crisis will almost certainly face the new President because it is highly unlikely to be resolved in the waning days of the Clinton administration.

B. Summary of Conclusions and Recommendations

National policy for financing the costs of isolating from the environment the spent nuclear fuel discharged from commercial nuclear power plants has heretofore been premised on a traditional paradigm involving "cost of service" regulation of vertically-integrated electric utilities with exclusive, franchised service territories. However, the restructuring of the electric utility industry now underway entails the structural disaggregation of generation, transmission, distribution and marketing and the introduction of competition and deregulation for electricity generation and marketing. Deregulation of and competition among generators of electricity will result in the early retirement of a significant number of uneconomic commercial nuclear plants. In turn, the early retirement of a significant number of nuclear plants, coupled with the escalating costs for the proposed Yucca Mountain repository, will create a financing crisis for commercial nuclear waste policy.

Specifically, the Nuclear Waste Fund is almost certainly underfunded substantially at the present time. Moreover, its future funding will undoubtedly be affected adversely by the introduction of competition and deregulation into the generating sector of the electric utility industry. Consequently, the structure and financing of the Nuclear Waste Fund requires a major overhaul. In particular:

(a) Several critical components of the waste isolation program concept used by the Department of Energy to assess the adequacy of the Nuclear Waste Fund should be redefined to reflect more "conservative" assumptions.

(b) The General Accounting Office should be charged with responsibility for auditing the Department of Energy's assessment of the adequacy of the Nuclear Waste Fund.

(c) The Nuclear Waste Fund should be perpetual, not terminal.

(d) The financing method for the Nuclear Waste Fund should be modified to respond to both its current underfunded status and the future development of a competitive, deregulated generation market.

"There never has been a no-regulation or free-market approach to nuclear power,"[319] nor will there be as a result of the

319. Tomain, *supra* note 226, at 30 n.1.

restructuring of the electric utility industry now underway. The need to monitor and maintain facilities for the safe isolation of spent fuel and other high-level nuclear waste for up to 250,000 years will require a continuing regulatory role for government. A critical component of that ongoing role will be financing a restructured Nuclear Waste Fund in perpetuity. Financing is one part of the nuclear waste problem which the current generation of Americans can solve. Indeed, financing may well be the *only* part of the spent fuel problem which the current generation need not defer to future generations for a solution. Moreover, the ability of the current generation of Americans to solve the financing part of the problem could prove essential to future generations of Americans having the resources necessary to continue to address the crux of the nuclear waste problem - isolating spent nuclear fuel from the environment, essentially forever. To rephrase Kai Erickson:

> We cannot promise our own children–never mind those who follow hundreds of thousands of years hence–that they will be safe from the wastes. And so long as that is so, let us leave them as a legacy not only the wastes, but also the resources they will need to make themselves safe from the wastes.[320]

320. ERICKSON, *supra* note 278.