U.S. NUCLEAR WASTE LAW AND POLICY: FIXING A BANKRUPT SYSTEM

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INTRODUCTION

The current U.S. system of nuclear waste law and policy is bankrupt. The 1982 Nuclear Waste Management Acts (NWPA) set a 1998 deadline for opening a deep geologic repository to receive spent nuclear fuel (SNF) and high level waste (HLW) from reprocessing. In 1987, Congress amended the act to designate Yucca Mountain as the only potential site, and severely restricted the development of any federal facility for consolidated storage of nuclear waste. Twenty years later, and ten years after the deadline, the proposed Yucca repository remains mired in controversy and unremitting opposition by Nevada. There is no prospect for an alternative repository, or for the development of a federal consolidated storage facility. The wastes destined for Yucca continue to be held at several Department of Energy (DOE) nuclear facilities and over a hundred nuclear power plants across the country. The volume of these wastes already exceeds the current maximum storage capacity set by Congress for Yucca, and continues to grow. The only bright spot is that in 1998 the Waste Isolation Pilot Project (WIPP) repository in New Mexico, which was developed entirely outside of the rigid NWPA framework, is

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successfully operating and receiving large volumes of certain defense wastes from DOE facilities. But the highly prescriptive approach of the NWPA, aimed at permanent burial of SNF and HLW as soon as possible, lies in ruin.

From the viewpoint of environment, health, and safety protection, the current situation is by no means necessarily a bad one. Existing arrangements for waste storage have a high degree of safety. But in the larger political context, it is a disaster. The waste status quo is a serious obstacle to expanding nuclear power. Nuclear power is a proven, reliable technology that can make important contributions as part of a portfolio of energy strategies, including renewables and efficiency, to reduce fossil fuel use in order to address climate change and other air quality problems. Nonetheless, permanent burial is widely regarded, in part because of the expectations generated by the NWPA, as an indispensable "solution" to the nuclear waste "problem." The failures of the NWPA to "solve" the "problem" so defined have fueled public distrust of the government and opposition to using nuclear power. NWPA's failure to achieve permanent disposal has helped to sustain public opposition to expansion of nuclear power. Opposition has, however, tempered somewhat in the face of concerns over global warming.

We should not be too quick to bury spent nuclear fuel, for it contains a significant amount of useful energy that could potentially be tapped through reprocessing, contributing to U.S energy security. Reprocessing might also reduce both the amount and the near term radioactivity and heat of the radioactive wastes that must ultimately be disposed of. Finally, it could generate an additional source of uranium for use by developing countries who wish to use nuclear power without building uranium enrichment or SNF reprocessing plants that risk proliferation of nuclear weapons. To be sure, there are very significant economic, technological, and security concerns with reprocessing, which could require the development of new types of nuclear reactors. Yet, reprocessing represents a valuable option that should not be foreclosed without good reason. A precautionary approach to nuclear waste policy would preserve options and not be quick to bury nuclear wastes.

This article first provides a brief overview of nuclear wastes and a summary history of federal nuclear waste law and policy to date, which are indispensable for understanding our current situation. It then diagnoses the major failures in the current design,

and proposes a suite of new measures to launch a comprehensive new approach. These measures include a reconsideration of the ethical principles underlying the drive for immediate waste burial; the creation of a high-level National Waste Management Commission; the creation of two new federal entities to manage nuclear wastes and to site waste storage facilities and repositories; the elimination of Environmental Protection Agency (EPA) regulatory authority over these activities; the adoption of a thoroughgoing risk-based approach to waste regulation and management; and the adoption of new, more flexible and adaptable strategies for siting storage and disposal facilities. Congress will have the principal responsibility for launching most of these initiatives, but the new President will also need to play a leadership role.

I. OVERVIEW OF NUCLEAR WASTE TYPES, SOURCES, AND STOCKS

The Atomic Energy Act (AEA), other statutes, and various federal regulations classify nuclear wastes for regulatory purposes into six main categories: SNF, HLW, transuranic waste (TRU), low level waste (LLW), mixed waste that is both radioactive and chemically toxic and regulated under RCRA as well as the AEA, and uranium mill tailings (UMT). These categories are legal constructs which are often not based on risk-relevant differences in their radioactive and other characteristics or the treatment, management, storage, and disposal issues that they pose. This article focuses on the more highly radioactive wastes in the first three categories: SNF, HLW and TRU. These wastes have triggered the greatest controversy; LLW,[1] mixed waste (much of

[1] Until recently, most LLW was disposed of in three privately owned facilities located in South Carolina, Utah, and Oregon, all licensed by the NRC. The South Carolina facility closed in July 2008. In August 2008, the Texas Commission on Environmental Quality issued a draft license for a new LLW disposal facility in Texas. *See Valhi, Inc. Announces Low-Level Radioactive Waste Disposal License Decision*, REUTERS, Aug. 12 2008, *available at* http://www.reuters.com/article/pressRelease/idUS250474+12-Aug-2008+PRN20080812. The Low-Level Radioactive Waste Policy Act of 1980, amended in 1985 (current version at 42 U.S.C. § 2021(b) *et seq*. (2000)), attempted to create incentives for the development of new LLW sites by encouraging states to enter into compacts for joint waste disposal at a site within one of the states. Compact states with a disposal facility may exclude waste from non-compact states. None of the ten approved group state disposal compacts, or individual states that have not joined compacts, has succeeded in finding a new low level waste disposal site. Waste generators have reacted to the shortage of disposal sites by

which contains TRU and HLW), and UMT have posed substantial but much less acute regulatory and policy issues.

Spent Nuclear Fuel (SNF) refers to the spent fuel rods that have been irradiated in a nuclear reactor. The great majority of SNF comes from civilian nuclear power plants, the remainder from the federal government's past use of nuclear reactors to make weapons and conduct research. SNF includes both highly-active but relatively short-lived fission products (principally cesium and strontium) as well as medium-active but long-lived radionuclides with half lives of thousands of years.

High level waste (HLW) is highly radioactive material resulting from the reprocessing of SNF. Most of the current stock of HLW was generated by defense programs, which use chemical processes to break down irradiated fuel rods into their various constituents, including specifically uranium and plutonium to be used for weapons. The other radioactive elements constitute HLW. SNF from nuclear power plants can also be reprocessed with the aim of producing uranium and plutonium for use as nuclear fuel.[2] Other countries, including Russia, France, Japan, and the UK, have engaged in reprocessing of civilian SNF on a large scale. In the U.S., only a limited amount of civilian HLW was produced at an SNF reprocessing facility in West Valley, New York in the late 1960s and early 1970s, before civilian SNF reprocessing halted in 1977.[3]

Transuranic Waste (TRU). In contrast to HLW and SNF, which are defined by the processes that produce them, TRU is defined by its characteristics. TRU includes waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes with half-lives greater than twenty years per gram of waste, but excluding HLW and certain other wastes. TRU consists primarily of protective clothing and equipment as well as soils and sludge that have been contaminated during nuclear fuel assembly and

minimizing waste volumes, but when one or more of the three operating facilities are filled to capacity or not accepting new waste, which is a looming prospect, the issue of finding more suitable LLW storage sites will come to the fore again.

[2] For an overview of advanced fuel cycles based on reprocessing and their performance, see ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, NUCLEAR ENERGY AGENCY, ADVANCED NUCLEAR FUEL CYCLES AND RADIOACTIVE WASTE MANAGEMENT (2006).

[3] U.S. DEP'T OF ENERGY, OFFICE OF ENVTL. MGMT., LINKING LEGACIES: CONNECTING THE COLD WAR NUCLEAR WEAPONS PRODUCTION PROCESSES TO THEIR ENVIRONMENTAL CONSEQUENCES 34 (1997).

decommissioning, and during nuclear weapons research, production, and cleanup.[4] There are two subcategories of TRU: lower radioactivity contact-handled TRU (CH-TRU), which constitutes the great bulk of TRU, and higher radioactivity remote-handled TRU (RH-TRU) which must be handled and transported in shielded casks.

The current total amount of highly radioactive wastes (SNF and HLW) in the United States is 73,000 metric tons in the form of heavy metal (MTiHM). Of this total 2,500 MTiHM consists of defense activity SNF stored at DOE sites. More than 54,000 MTiHM is civilian SNF now being stored in reactor pools or in dry storage air cooled containers at sites contiguous to the 131 civilian nuclear reactors at 64 locations in 39 states. Defense HLW at DOE sites amounts to 12,505 MTiHM (22,280 canisters). Even if a repository at Yucca Mountain is built and operates, current law limits the amount of SNF and HLW that may be stored there to 70,000 MTiHM. Thus, currently existing SNF and HLW would more than fill Yucca to its authorized capacity. Further, an additional 47,000 MTiHM of civilian SNF will have been generated by 2048 even if no new nuclear power plants are built.

II. THE PATH TO THE PRESENT IMPASSE: A SHORT HISTORY OF U.S. NUCLEAR WASTE REGULATION

A. *The First Three Decades*

In 1946, Congress passed the AEA, which created the Atomic Energy Commission (AEC) to run a federal monopoly on both military and non-military applications of nuclear power.[5] In the 1950s, the Eisenhower administration promoted private sector use of nuclear technology for electricity production and other uses; Congress amended the AEA to authorize such use. While the AEC was to "control the production, ownership, and use of fissionable material," neither the original nor amended acts specifically addressed nuclear waste or its disposal. Although the AEC's broad

[4] *See* NAT'L SAFETY COUNCIL ENVTL. HEALTH CTR., A REPORTER'S GUIDE TO THE WASTE ISOLATION PILOT PLANT (WIPP): GLOSSARY OF TERMS AND ACRONYMS, https://www.nsc.org/ehc/guidebks/wippglos.html (last visited Mar. 7, 2008).

[5] The Atomic Energy Act of 1946, 79 Pub. L. No. 585, 68 Stat. 921 (current version at 42 U.S.C. § 2011 (2000)).

regulatory authority encompassed wastes,[6] disposal of defense HLW from weapons production was a low priority and the search for disposal sites progressed very slowly; in the early decades of the Cold War the Commission focused on weapons development and production. In the case of civilian SNF, the fundamental assumption until 1977 was that it would be reprocessed after the fuel rods had reached the end of their initial useful life in order to extract uranium and plutonium for use as new fuel. Reprocessing would result in a much smaller volume of waste in the form of HLW, and postpone the need to dispose of it.

A seminal 1957 National Academy of Sciences (NAS) report found that a deep geologic repository was the best available option for nuclear waste disposal and that salt was likely the best medium in which to build such a repository. Oak Ridge National Laboratory began a research program to test this proposition. A 1969 fire at the AEC's Rocky Flats nuclear weapons production facility in Colorado raised public concerns about the safety of nuclear waste management activities at Rocky Flats and other weapons plants. The furor over Rocky Flats threatened to close the facility, regarded by the government as vital to the defense effort,[7] and prompted the AEC to take faster action on developing a geologic disposal site for defense wastes. It began tests on disposal in an abandoned salt mine site in Lyons, Kansas, but was forced to abandon it after state officials discovered water intrusion into the mine and boreholes penetrating the salt formation. This experience engendered public mistrust about the federal government's ability

[6] *Id*. Section 116 gives the AEC (now NRC) the power to:

> establish by rule, regulation, or order, such standards and instructions to govern the possession and use of special nuclear material, source material, and byproduct material as the Commission may deem necessary or desirable to promote the common defense and security or to protect health or to minimize danger to life or property.

[7] The fire at Rocky Flats was one of the most costly industrial accidents in U.S. history, and had it not been contained, could have spread airborne plutonium throughout the Denver metropolitan area. LUTHER J. CARTER, NUCLEAR IMPERATIVES AND PUBLIC TRUST: DEALING WITH RADIOACTIVE WASTE 66, n.59 (Resources for the Future 1987). Cleanup after the fire filled hundreds of railroad cars full of plutonium-contaminated debris from the plant. These were sent to the National Reactor Testing Station (NRTS) near Idaho Falls, where over 50,000 tons of TRU waste had already been buried. Alerted by an irate trout farmer who feared contamination of the groundwater that fed his farm, Idaho's governor and two Senators protested the shipment. AEC appeased them by promising that all of the TRU, including the wastes previously buried at NRTS, would be sent to a federal repository in a salt mine. *Id.* at 66–67.

to select a safe means of disposing of radioactive waste.[8]

Because of the AEC's failures to develop a waste disposal program and the desire to separate nuclear regulation from management and operations, Congress in 1974 passed the Energy Reorganization Act. The Act split the AEC into the Nuclear Regulatory Commission (NRC), an "independent" agency with five members, and the Energy Research and Development Administration (ERDA), whose head answered to the President.[9] The NRC was put in charge of licensing civilian nuclear reactors and reprocessing facilities and all stages of commercial HLW and SNF management, storage and disposal. The NRC's licensing authority did not extend to defense facilities and wastes, which were to be managed and regulated solely by ERDA. However, the NRC was given authority to regulate ERDA facilities for HLW from civilian SNF reprocessing.[10] ERDA became the DOE in 1977.[11] Also, after its creation, the EPA acquired the AEC's authority to issue radioactivity standards for environmental protection.

B. *The Carter Interagency Review Group and the Push for Nuclear Waste Burial*

In 1977, President Carter withdrew federal support for reprocessing of civilian SNF, citing concerns about nuclear proliferation because of potential diversion of the plutonium produced by reprocessing to weapons. Carter hoped that the U.S. example would persuade other countries, notably the Soviet Union, Japan, UK, and France, to halt reprocessing, but this did not occur.[12] In the absence of federal financial support, the private sector abandoned reprocessing. The elimination of reprocessing in the U.S. left no clear path for disposal of the large amounts of SNF

[8] CHUCK MCCUTCHEON, NUCLEAR REACTIONS: THE POLITICS OF OPENING A RADIOACTIVE WASTE DISPOSAL SITE 11 (Univ. of New Mexico Press 2002).

[9] Energy Reorganization Act, 93 Pub. L. No. 438, 88 Stat. 1233 (1974) (current version at 42 U.S.C. § 5841, as amended by the Energy Policy Act of 2005, 109 Pub. L. No. 58 (2005)).

[10] Energy Reorganization Act §§ 104, 201, 202, codified in 42 U.S.C. § 5801 *et seq.*

[11] Department of Energy Organization Act, 95 Pub. L. No. 91, 91 Stat. 565 (1977).

[12] MICHAEL J. BRENNER, NUCLEAR POWER AND NON-PROLIFERATION 142, 212 (Cambridge Univ. Press 1981).

that had begun to accumulate.[13] Also, there had accumulated substantial amounts of defense HLW, a much smaller amount of HLW from commercial reprocessing of SNF at West Valley (which had shut down because of economic and environmental problems), TRU waste from defense activities, and LLW from various government and civilian activities.

Seeking to engage both experts and the broader public in an effort to develop a coherent and comprehensive national nuclear waste disposal policy, President Carter in 1978 assembled the Interagency Review Group on Nuclear Waste Management (IRG), comprised of representatives of 14 federal agencies and other key stakeholders.[14] IRG conducted an extensive public involvement process, including public hearings and small group meetings throughout the country. Over 3,300 public comments were received on the IRG's draft report and recommendations, most of it anti-nuclear.[15] The IRG's report was based on the premise that the generation of citizens which has enjoyed the benefits of nuclear energy has an obligation to responsibly dispose of the waste in perpetuity.[16] It evaluated a variety of potential disposal technologies for accomplishing this goal, including disposal in outer space, in the deep seabed, in deep boreholes, and at the polar ice caps. It endorsed deep geological storage, and recommended that detailed studies of specific potential repository sites "in different geologic environments" (including salt, shale and tufa) should begin "immediately" in order to identify at least two (and possibly three) repositories that could become operational by the end of the 20th Century. These repositories should be located "ideally in different regions of the country."[17] A DOE Final Environmental Impact Statement for Management of Commercially-Generated Waste reached similar conclusions.[18]

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[13] Thomas A. Cotton, *Nuclear Waste Story: Setting the Stage, in* UNCERTAINTY UNDERGROUND: YUCCA MOUNTAIN AND THE NATION'S HIGH-LEVEL NUCLEAR WASTE 29, 31 (Allison M. Macfarlane & Rodney C. Ewing eds., M.I.T. Press 2006).

[14] U.S. D.O.E. INTERAGENCY REVIEW GROUP ON NUCLEAR WASTE MANAGEMENT, REPORT TO THE PRESIDENT BY THE INTERAGENCY REVIEW GROUP ON NUCLEAR WASTE MANAGEMENT (1979) [hereinafter INTERAGENCY REPORT].

[15] *Id.* at app. C-3.

[16] *Id.* at 16, 31, app. H-4.

[17] *Id.* at app. H-9.

[18] DOE, FINAL ENVIRONMENTAL IMPACT STATEMENT FOR MANAGEMENT OF COMMERCIALLY-GENERATED WASTE, DOE EIS-0046F (1980), *available at*

Additional impetus for developing a disposal strategy for SNF was generated by California's 1974 adoption of legislation banning the construction of new nuclear power plants in the state unless and until the State Energy Commission "finds that there has been developed and that the United States through its authorized agency has approved and there exists a demonstrated technology or means for the disposal of high-level nuclear waste."[19] A number of other states also adopted similar measures.[20] The NRC was prompted to initiate a waste confidence rulemaking to address the question of whether or not it should license new nuclear plants because of the environmental risks posed by additional quantities of SNF.[21] Concerns that the lack of a repository would stifle the future of the nuclear power industry led the industry and DOE to press for a legislative solution.

C. *The WIPP Repository*

One result of the heightened concerned over nuclear waste disposal was that DOE pressed forward with the development of a deep salt bed repository on federal land in southeastern New Mexico. The Lyons, Kansas site which had been the subject of the first in situ demonstration testing for a salt formation repository, had been pushed forward too hastily. After Lyons failed, the economically depressed town of Carlsbad, New Mexico proposed the idea of hosting a repository. The idea was picked up by the AEC and subsequently ERDA and DOE.[22] At various times the

http://www.ocrwm.doe.gov/documents/1980_FEIS/33515/33515.pdf.

[19] CAL. PUB. RES. CODE § 25524.2(a) (2007). The Supreme Court subsequently upheld the California measure against claims that it was preempted by the Atomic Energy Act. *See* PGE v. State Energy Res. Conservation & Dev. Comm'n, 461 U.S. 190, 203–23 (1983).

[20] CARTER, *supra* note 7, at 88.

[21] *See* UNCERTAINTY UNDERGROUND: YUCCA MOUNTAIN AND THE NATION'S HIGH LEVEL NUCLEAR WASTE 31, (Allison M. Macfarlane & Rodney C. Ewing eds., MIT Press 2006.). The NRC eventually concluded that the risks posed by additional quantities of SNF were de minimis and should not affect individual licensing decisions for new nuclear power plants. The NRC's decision was sustained against environmentalist challenges in Baltimore Gas and Electric Co. v. NRDC, 462 U.S. 87 (1983).

[22] MCCUTCHEON, *supra* note 8, at 12; U.S. DOE, PIONEERING NUCLEAR WASTE DISPOSAL, DOE/CAO-00-3124, 7 (2000), *available at* http://www.wipp.energy.gov/library/pioneering/pioneering.htm; Gary L. Downey, *Politics and Technology in Repository Siting: Military Versus Commercial Wastes at WIPP, 1972–1985*, 7 TECH. IN SOC'Y 47, 53 (1985). Some commentators have noted that Carlsbad residents may have been willing to

disposal at the site of defense HLW, defense TRU, and civilian SNF was considered. Politics in Congress and New Mexico eventually determined that the facility would be restricted to defense TRU. Representative Mel Price, Chairman of the House Armed Services Committee was determined to keep civilian SNF out of WIPP; if it were included, the NRC would have jurisdiction and military interests (and his committee) would lose exclusive control. While New Mexico was committed to helping the national defense mission, it had no nuclear power plants and saw no reason why it should take commercial SNF wastes generated in other states. It also feared HLW as significantly more radioactive than TRU—which is not always the case.

New Mexico used Congressional legislation, litigation, and political pressure to gain two agreements with DOE that gave the state the right to take part in WIPP decision making and forced DOE to come to the bargaining table.[23] Because some of the TRU to be deposited was mixed hazardous/radioactive waste, the state also successfully asserted RCRA regulatory authority. The state's

accept the potential risks associated with nuclear waste because of the community's participation in the Plowshares Project, an AEC project on the peaceful uses of nuclear materials and its residents' strong support of the national defense mission. In addition, New Mexico had been host to defense-sponsored nuclear testing and research projects and installations, including Los Alamos. MCCUTCHEON, *supra* note 8, at 22–25.

[23] These agreements included a Stipulated Agreement and a Consultation and Cooperation Agreement between DOE and New Mexico settling a 1981 lawsuit that the state brought against DOE over its decision to go forward with the construction phase of WIPP; such an agreement was specifically provided for under the appropriations legislation granting DOE its Fiscal Year (FY) 1980 budget. Stipulated Agreement and Agreement on Consultation and Cooperation (Appendix A of Stipulated Agreement.), State of New Mexico *ex rel.* Bingaman v. U.S. Dep't of Energy, (D.N.M. Civil Action No. 81-0363 JB, July 1, 1981). A Supplemental Stipulated Agreement, between the parties was reached in February, 1982.

Other concessions exacted by the state included DOE's decision in 1978 to fund the Environmental Evaluation Group (EEG), which was established to provide state oversight of WIPP. Federal funding was also provided for state measures to ensure safe transportation of wastes to the site. The EEG was established in 1978 with funds provided by DOE to the State of New Mexico. Section 1433 of the National Defense Authorization Act for FY 1989, Public Law 100-456, assigned EEG to the New Mexico Institute of Mining and Technology and continued the original contract DE-AC04-79AL1 0752 through DOE contract DE-AC04-89AL58309. The National Defense Authorization Act for FY 1994, Public Law 103-160, and the National Defense Authorization Act for FY 2000, Public Law 106-65, continued the authorization until 2004, when funding was left to lapse, and the EEG was disbanded.

main concerns, including most notably waste transportation issues, were extensively negotiated and eventually accommodated.[24] In 1992, Congress enacted the Waste Isolation Pilot Plant Land Withdrawal Act (WIPPLWA) to authorize operation of the facility and establish a regulatory framework for it. EPA was directed to issue site-specific radioactivity exposure standards for WIPP and determine whether the facility was suitable as a long-term disposal repository for TRU. EPA certified WIPP in 1998, and the next year it received its first shipment of waste. EPA recertified WIPP in 2004, five years after opening. It has received and deposited several thousand shipments of TRU wastes since that time without major controversy.

D. *The Nuclear Waste Policy Act*

The political saliency of nuclear waste and the work of the IRG also led to Congress's enactment in 1982 of the Nuclear Waste Policy Act (NWPA). This statute reflected the general approach of the IRG recommendations and mandated the development of permanent repositories for disposing of SNF and HLW. There was much debate in the legislative proceedings about whether centralized, monitored retrievable storage or disposal in a repository should be preferred, or both adopted. States that believed they were potential candidates for repository typically favored storage; states that were candidates for storage tended to favor a repository. DOE and the nuclear power utilities were strongly in favor of a permanent federal repository. They feared that allowing significant interim storage would diminish the impetus for repository siting. The utilities believed that without a repository "solution" in place for disposing of nuclear waste, the public would never accept the expansion of nuclear power.[25]

NWPA makes the federal government responsible for the disposal of commercial HLW and SNF in deep geological

[24] *See* MCCUTCHEON, *supra* note 8, at 79–91; Jennifer Biedscheid & Murthy Devarakonda, *Waste Isolation Pilot Plant as a Case Study for the Deployment of a National Repository Program*, PRACTICE PERIODICAL HAZARDOUS, TOXIC & RADIOACTIVE WASTE MGMT. 45, 52 (Jan. 2005).

[25] As discussed above, California and a half dozen other states enacted laws that imposed moratoria on reactor licensing until a solution to the waste problem was found. *See* CARTER, *supra* note 7, at 212. Enactment of the NWPA of the Act in 1982 was sufficient cause for the NRC to issue a preliminary finding of "confidence" that nuclear waste disposal needs could be met. *See* CARTER, *supra* note 7, at 228, 228 n.79.

repositories. It also provides for disposal of defense HLW in a repository for commercial SNF wastes unless the President otherwise determines; in 1985, President Reagan determined that defense HLW should not be disposed of separately from commercial wastes.[26] In an aim to promote regional equity, the Act provided for the siting and construction of two federal repositories on a tight timetable, with siting of the second repository to be conducted after the first.[27] In the first round of siting, DOE was required to nominate five sites suitable for characterization and, by January 1, 1985, to recommend three of these to the President for characterization as candidate sites. It was then to select one of the sites for licensing and construction of a repository with the goal of opening to receive wastes by 1998. The repositories were to be designed to permit retrievability of wastes during the first 50 years of their operation. Commercial nuclear power generators were to cover the costs of the repositories by means of a tax on nuclear energy produced.[28]

A limit was placed on the capacity of the first repository (no more than 70,000 metric tons), in order to ensure that the second repository would in fact be selected. It was anticipated that the first round of siting would concentrate on sites in the West and the second round of siting would focus on sites in the East. The NWPA also provides for the development of Monitored Retrievable Storage (MRS) facilities, constructed and operated by DOE. These facilities would be designed for indefinite storage of SNF and civilian HLW, but also allow for ready retrieval of wastes for further processing or permanent disposal. The NWPA requires the Secretary of Energy to "complete a detailed study of the need for and feasibility of one or more" MRS facilities and to present a construction proposal for one or more of these facilities. The NWPA also established an Office of Nuclear Waste Negotiator to identify communities that would be interested in hosting a federal repository or MRS facility and to negotiate with states or private entities over the conditions for siting such a facility. The Act also leaves open the possibility of a private consolidated interim storage facility.

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[26] James Flynn & Paul Slovic, *Yucca Mountain: A Crisis for Policy: Prospects for America's High-Level Nuclear Waste Program*, 20 ANN. REV. OF ENERGY AND THE ENV'T 83, 90 (1995).

[27] 42 U.S.C. § 10101 *et seq.*; § 10134(a)(2)(A) (2000); § 10132(a)(A)(B)(C).

[28] *Id*. at § 10131(a)(4).

The legislation specified roles for three different federal agencies. First, DOE was to create an Office of Civilian Radioactive Waste Management, charged with locating, evaluating, nominating, constructing, and operating facilities for storing and disposing of nuclear wastes.[29] Second, the NRC was required to regulate the design and operation requirements of the repository, including such matters as how the waste would be packaged and stored and how a repository should be sealed or decommissioned.[30] Finally, EPA would issue environmental standards to protect humans and the environment from the release of radiation from the repository, and assess the security and protectiveness of the site over time.[31]

The federal government encountered significant political hurdles in repository siting under NWPA. Pursuant to NWPA, in 1982 DOE identified nine sites for further evaluation. These sites were located in Mississippi (2), Louisiana, Texas (2), Utah (2), Nevada, and Washington. Later that same year it reduced the nine sites to five, and then to three—Yucca Mountain in Nevada (volcanic rock), the Hanford site in Washington (basalt), and a site in Deaf Smith County Texas (salt dome). DOE ranked Yucca Mountain site first among the three sites recommended to the President for full characterization. Its evaluations, however, were based on the available literature without significant DOE steps to investigate and characterize the sites, and the preliminary scores of all the sites were relatively close.[32] Although NWPA envisioned that a site would be selected no later than 1989, as of 1987 no site had yet been fully characterized and completion of this process was expected to take far longer than had originally been predicted.

E. *Congress Designates Yucca Mountain*

In 1987, Congress amended the NWPA to require that only the Yucca Mountain site be characterized, and dropped the second repository.[33] As a further incentive to move forward with Yucca,

[29] *Id*. at §§ 10132–10134. *See* 10 C.F.R. §§ 960, 963 (2008).

[30] 42 U.S.C. § 10141(b). *See* 10 C.F.R. §§ 60, 63.

[31] 42 U.S.C. § 10141(a). *See* 40 C.F.R. §§ 191, 193, 194.

[32] Telephone Interview with Frank Parker, Professor of Envtl. and Water Res., Vanderbilt Univ. (Sept. 27, 2007).

[33] The 1987 amendments require, however, that between 2007 and 2011, DOE report to Congress on the need for a second repository. 42 U.S.C. § 10172(a).

the amendments provide that no interim MRS facility for interim SNF could be sited until after a formal recommendation from DOE to the President that the Yucca site be selected as a repository, and construction cannot begin on an MRS facility until NRC licenses construction of a permanent repository.[34] The sites being evaluated for the first repository were located in the middle or western parts of the country. The expectation underlying the NWPA was that a second repository would be located in the eastern part of the country. The preliminary steps for siting the second repository generated strong resistance in eastern states and became a major issue in the 1986 congressional elections.[35] Congressional leaders, particularly Senator Bennet Johnson of Louisiana who chaired the energy authorization and appropriations committees, felt that it was imperative to move forward with selection of a permanent repository before the political window closed on the possibility of any repository. The 1998 deadline for federal government assumption of responsibility for SNF loomed. In order to avoid the technical hurdles and expense associated with detailed characterization of multiple sites, the decision was made to short-circuit the selection process established by the NWPA and have Congress select a site. The Yucca Mountain site had several apparent technical advantages over the other two sites: it was distant from population centers, had no mineral resources, was near the Nevada Test Site, and was vertically-distant from water sources.[36] The decision to select Yucca, however, was powerfully affected by the political influence of Representatives Tom Foley of Washington, the House Whip, and Jim Wright of Texas, the House

[34] *Id*. at § 10168(d)(1).

[35] In January 1986 DOE announced tentative screening choices in 12 preferred crystalline rock bodies in seven states: Minnesota, Wisconsin, Maine, New Hampshire, Virginia, North Carolina, and Georgia. CARTER, *supra* note 7, at 410. This announcement provoked a political furor. The two New England sites were near highly populated areas and, in the case of the site in Maine, near Portland's drinking water supply. Key Senate races were being held in four of the states at a time when Republicans were in danger of losing control of the U.S. Senate. Republican Governor of New Hampshire, John Sununu, arguing that the second round was mobilizing huge opposition that was dangerous to the whole nuclear industry, mobilized the industry to work to kill the second round. In May 1986, DOE succumbed to the pressure and dropped the second round on the grounds that lowered projections for spent fuel generation made the second repository unnecessary; only a month earlier, however, DOE had testified before Congress that a second repository was needed. *Id*. at 208.

[36] *Id*. at 175.

Majority Leader. Nevada had little political clout.

The 1987 Amendments authorized the Secretary of Energy, after further evaluation of the Yucca site, to decide whether or not to recommend to the President to go forward with construction and operation of a repository at Yucca. The President could then only approve or disapprove the Yucca site. Although the State of Nevada could object to the President's approval of Yucca through a "notice of disapproval," Congress was given the power to override the state's objection by a joint resolution approving the site. Unless major technical problems with the site emerged, the new law made construction of a repository at the Yucca Mountain site a virtual fait accompli.

The 1992 Congressional Energy Policy Act (EnPA) directed the NRC and the EPA, respectively, to issue safety and environmental protection regulations and licensing criteria geared specifically for the Yucca Mountain site, superseding the generic repository regulations that it had previously issued. DOE was charged with preparing pre-closure and post-closure suitability requirements for the site. Transportation of wastes to Yucca was to be regulated by the Department of Transportation and by the NRC.

DOE Secretary Spencer Abraham recommended the Yucca Mountain site to President Bush, along with submission of a Final EIS in February 2002. President Bush approved the site. Nevada then issued its expected notice of disapproval, but in July of 2002 Congress overrode Nevada's opposition. The President signed the law approving Yucca as the SNF and HLW waste repository.

Having no real leverage in the political decision making process, Nevada has resorted to tying the project up in litigation and delays. Aided by environmental groups opposing the facility, the State raised a variety of technical objections to the repository site and brought legal challenges to the Yucca-specific regulatory standards promulgated by DOE, NRC, and EPA for the Yucca facility. In 2004, plaintiffs achieved a partial victory, when the D.C. Circuit Court of Appeals remanded the NRC and EPA rules to the agencies for revision. The period of peak radiation releases from a repository are a function of the radioactive decay of the wastes on the one hand, and the time it would take for the waste containment packages to break down and for radioactivity to escape from geological containment on the other. EPA issued a standard limiting the peak radioactive exposure to an individual in the vicinity of the site to 1 millirems at any time during a 10,000-

year compliance period. The EnPA had directed the EPA to issue standards consistent with the report of an NAS committee, which found that the period of greatest exposure would occur long after 10,000 years. The court found that the compliance period specified in EPA's standards were inconsistent with the report and accordingly contravened the Act.[37]

F. *Government and Private Centralized Storage Facilities*

Pursuant to the 1982 NWPA, DOE had proposed that a federal MRS facility be built at Clinch River, Tennessee, and also identified two alternative MRS sites in the state. But, bowing to political pressures from the Tennessee delegation, Congress as part of the 1987 NWPA amendments revoked the proposal to site a MRS facility in Tennessee. It also limited the Secretary to constructing only one MRS facility elsewhere, and not in Nevada. Further, the Secretary may not select a site for evaluation as a possible MRS location until he has recommended "a site for development as a repository," and construction cannot start until the NRC licenses construction of a permanent repository. Finally, the amendments imposed a tight cap on the amount of spent nuclear fuel and HLW that may be stored at the MRS facility: 10,000 MTiHM before the repository is built and 15,000 MTiHM once the repository opens. DOE has not taken any concrete steps to site an MRS facility.

In the absence of any federal repository or storage facility, a utility-owned Private Fuel Storage (PFS) consortium has sought to build a private SNF storage facility on lands of the Skull Valley Band of Goshute Indians in Utah, with the capacity to store 40,000 metric tons of SNF, far more would be permitted at a federal MRS facility.[38] The PFS facility was granted an NRC license in 2006,

[37] Nuclear Energy Inst., Inc. v. EPA, 373 F.3d 1251 (D.C. Cir. 2004). Although the court invalidated the 10,000 year compliance period, it did not strike down any other provision of the rule.

[38] NWPA limits a federal MRS to storing 10,000 metric tons of heavy metal before licensing of a federal repository and 15,000 metric tons thereafter. 42 U.S.C. §§ 10168(d)(3)–(4), 101601. The PFS facility and its history is described in PRIVATE FUEL STORAGE, LLC, SKULL VALLEY BAND OF GOSHUTE INDIANS (2005), http://www.privatefuelstorage.com/project/partners-svb.html (last visited Sept. 25, 2008); PRIVATE FUEL STORAGE, LLC, THE NEED FOR SAFE, CLEAN, TEMPORARY FUEL STORAGE (2005), http://www.privatefuelstorage.com/project/need.html (last visited Sept. 25, 2008); NUCLEAR INFO. AND RES. SERV., PRIVATE FUEL STORAGE TARGETS HIGH LEVEL RADIOACTIVE DUMP AT SKULL VALLEY

following a nine-year licensing process. Construction of the PFS facility, however, has been blocked by the Department of the Interior.[39] The Bureau of Indian Affairs refused to approve the Tribe's lease of its land for the facility on the ground of risk that the facility would become a de facto permanent repository, while the Bureau of Land Management denied a right of way over federal lands for a railway line to the site. The future of the facility is in limbo. Given that it took over nine years to license the PFS facility,[40] it is unlikely that a private interim storage facility will be constructed any time soon.

G. *Government Liabilities for Utility SNF Storage Costs*

As already noted, the NWPA provides that DOE would take responsibility for civilian SNF and begin transferring it to the new repository beginning in 1998. As provided by the NWPA, the utilities have been paying the government a storage and disposal fee, based on the amount of nuclear electricity generated, into a federal Nuclear Waste Fund. Congress has, however, failed to appropriate most of the funds received for the intended purpose of developing a repository, in effect using the fund surplus to offset other federal spending. Because Yucca has yet to open, the federal government has defaulted on its obligation to take over civilian SNF. The utilities argued that they are entitled to specific performance—i.e., the federal government must take title to the wastes—but the federal courts have ruled that the utilities' remedy is limited to money damages for the costs incurred by the utilities for waste management and storage.[41] The courts have thus far awarded over $250 million to the utilities, and the government has

GOSHUTE INDIAN RESERVATION, UTAH (2006), http://www.nirs.org/radwaste/scullvalley/skullvalley.htm (last visited Sept. 25, 2008) (listing the quantity of waste that would be stored at the PFS). The site also includes a detailed history of the disputes around the PFS.

[39] MARK HOLT, CRS REPORT FOR CONGRESS: CIVILIAN NUCLEAR WASTE DISPOSAL 13 (2007).

[40] NUCLEAR ENERGY STUDY GROUP OF THE AM. PHYSICAL SOC'Y, CONSOLIDATED INTERIM STORAGE OF COMMERCIAL SPENT NUCLEAR FUEL 2 (2007). *See* PRIVATE FUEL STORAGE, LLC, THE LICENSING PROCESS (2005), http://www.privatefuelstorage.com/project/licensing.html (last visited Sept. 25, 2008); PRIVATE FUEL STORAGE, LLC, WHAT'S NEW: PFS RECEIVES LICENSE (2005), http://www.privatefuelstorage.com/whatsnew/whatsnew.html (last visited Sept. 25, 2008).

[41] *See, e.g.*, Indiana Michigan Power Co. v. DOE, 88 F.3d 1272 (D.C. Cir. 1996)

settled some utilities' claims for even larger amounts. The nuclear industry has recently claimed that the government's liabilities could mount to $50 billion, while the government contends that the figure will be closer to $7 billion.[42] Whether the DOI decisions to deny permits for the private PFS storage facility were connected with the government's push to open Yucca and minimize its liabilities to the utilities for SNF storage costs is unknown.

Assuming initial SNF storage at on-site cooling pools and dry cask storage thereafter, it is not clear if locating the dry cask SNF at reactor sites or in a consolidated facility, public or private, would be preferable. One study found that if Yucca were to open by 2017, the federal government would save money by paying for dry cask storage at reactors rather than building a MRS facility. The capital costs of the dry casks are the same no matter where they are put. In building a consolidated facility, DOE would need to acquire land, construct the facility, and likely have to improve the transportation infrastructure to transfer SNF to the facility.[43] Over the long run, scale economy operational savings with consolidated storage may offset these up-front costs, but only if the opening of Yucca or another permanent SNF repository is significantly delayed.[44] Also, if SNF is transported, either by rail or truck, to a consolidated storage site before final disposal in a repository, the waste will end up being transported twice. Yet, it appears that the risks produced by transporting SNF to an interim storage facility are so low as to be insubstantial.[45]

III. THE GLOBAL NUCLEAR ENERGY PARTNERSHIP AND THE REPROCESSING OPTION

A major new development in the nuclear waste picture is President Bush's proposal to reinstate reprocessing of SNF as a key element in a Global Nuclear Energy Partnership (GNEP). GNEP has three interlinked components: expanding use of nuclear power to promote energy security and address climate change,

[42] *See* Marcia Coyle, *Breach Cases Could Cost U.S. Government Billions*, Nat'l Law Journal, Sept. 8, 2008.

[43] *Id.* at 10.

[44] NUCLEAR ENERGY STUDY GROUP OF THE AM. PHYSICAL SOC'Y, AMERICAN PHYSICAL SOCIETY, CONSOLIDATED INTERIM STORAGE OF COMMERCIAL SPENT NUCLEAR FUEL: A TECHNICAL AND PROGRAMMATIC ASSESSMENT 10 (2007).

[45] *Id.* Also, the safety record of transporting almost 3,000 shipments of TRU waste to WIPP since 1999 has reportedly been excellent.

addressing the SNF waste problem, and preventing nuclear weapons proliferation by providing developing countries with uranium for nuclear power. A score of other countries have signed on in principle to GNEP, including the UK, Russia, Italy, Canada, Korea, Hungary, Poland and the Ukraine.

If adopted and successfully developed, GNEP would dramatically alter the waste management and disposal situation. It would reprocess SNF, producing additional HLW and TRU, but reducing significantly the total amount of highly radioactive waste. The reprocessing system envisioned by GNEP, known as UREX+, would separate out uranium to be re-used in light water reactors or disposed of as LLW.[46] It would also produce a new plutonium-based fuel, with radioactive elements that would make its conversion to weapons more difficult, for use in new fast "burner" reactors. By reusing the large amounts of energy stored in SNF, this system could support increased use of nuclear power to limit burning of fossil fuels and global climate change. The technologies proposed by GNEP are among a suite of advanced fuel cycle technologies that can secure waste management and energy resource goals.[47]

As for the HLW generated by reprocessing, DOE plans to separate out two relatively short lived fission product wastes, strontium-90 and cesium-137, and place them in surface storage, most likely at the reprocessing plant, until they have decayed to the point that DOE may dispose of them as LLW.[48] Long lived HLW fission products, including I-129, Cs-135, Tc-99, Sn-126, and Se-79, will still need to be disposed of in a HLW repository because none of these isotopes have a half-life less than 65,000 years.[49] But the volume of these wastes will be much less than that of the SNF that would have to be disposed of under the current once-through fuel cycle. Moreover, after removal of cesium and strontium, the

[46] U.S. DEP'T OF ENERGY, REPORT TO CONGRESS: SPENT FUEL RECYCLING PROGRAM PLAN 12 (2006) [hereinafter SPENT FUEL RECYCLING PLAN]; INST. FOR POLICY STUDIES, RADIOACTIVE WASTES AND THE GLOBAL NUCLEAR ENERGY PARTNERSHIP 13 (2007).

[47] For an overview of advanced fuel cycles based on reprocessing and their performance, see ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, *supra* note 2.

[48] INST. FOR POLICY STUDY, *supra* note 46, at 15–16; FRANK VON HIPPEL, MANAGING SPENT FUEL IN THE UNITED STATES: THE ILLOGIC OF REPROCESSING 11–12 (2007); SPENT FUEL RECYCLING PLAN, *supra* note 46, at 12.

[49] INST. FOR POLICY STUDY, *supra* note 46, at 15–16.

remaining HLW will be much less highly radioactive and physically hot in the near term than SNF. If, as currently planned, SNF is shipped directly to Yucca without reprocessing, the strontium-90 and cesium-137 in the SNF will provide the main sources of radioactive decay heat in the repository on a century scale.[50] Reprocessing technologies could reduce the repository volumes required for disposing of SNF but the challenges of waste heat and radioactivity must also be addressed.[51] GNEP envisages that reprocessing would be carried out by the private sector; thus the additional wastes generated would be civilian wastes and thus would be regulated under the civilian waste legal and regulatory authorities.

As part of GNEP, the United States would also re-enter the uranium leasing business by joining with other fuel cycle countries, such as Russia and the UK, to provide enriched uranium produced by reprocessing to foreign governments that wish to build a civilian reactor, so that these countries may enjoy commercial nuclear energy without needing to construct either enrichment or reprocessing facilities.[52] The lessees will then return the spent fuel to a fuel cycle country for reprocessing. DOE has yet to decide if the waste materials that require disposal will remain in the fuel cycle nation or be returned to the user nation.[53] Attempting to dispose of wastes attributable to foreign nuclear power plants would aggravate domestic U.S. disposal politics.

The GNEP program is highly controversial, and has been challenged on a wide variety of grounds. Many contend that the technology required, including a new type of reprocessing and a new type of reactor to burn the plutonium-based fuel produced, is unproven and enormously costly.[54] The economics of once-

[50] *Id.* at 4.

[51] *Costs of Reprocessing Versus Directly Disposing of Spent Nuclear Fuel: Hearing Before the S. Comm. on Energy and Natural Resources*, 110th Cong. (2007) (statement of Peter R. Orszag, Director, Cong. Budget Office); Robert Vandenbosch & Susanne E. Vandenbosch, *Should the U.S. Reprocess Spent Nuclear Fuel?*, 35(3) PHYSICS & SOC'Y 7 (July 2006).

[52] AM. COUNCIL ON GLOBAL NUCLEAR COMPETITIVENESS, THE U.S. DOMESTIC CIVIL NUCLEAR INFRASTRUCTURE AND U.S. NONPROLIFERATION POLICY 12–14 (2007), *available at* http://www.nuclearcompetitiveness.org/images/COUNCIL_WHITE_PAPER_Final.pdf.

[53] Press Briefing, Clay Sell, Deputy Sec'y of Energy, Announcing the Global Nuclear Energy Partnership (2006), *available at* http://www.energy.gov/news/3171.htm.

[54] The General Accounting Office, for example, found that DOE's

through versus reprocessing systems are of course critically dependent on the price of virgin uranium for fuel. Today, uranium prices are at an all time high, $113 per pound, because of shrinking inventories caused by production interruptions. Climate regulations are likely to make it significantly more costly to use fossil fuel for electricity generation. But a report produced by the JFK School of Government in 2003 concluded that recycling the pure plutonium produced by existing reprocessing techniques will not become economically competitive until the price of uranium reaches $340 per kg ($155 per pound).[55] The UK and France have ceased reprocessing of SNF because of the unfavorable economics. The break even point for the undeveloped and unproven UREX+ process will likely be much higher.[56]

Some experts concerned over proliferation believe that adding other radioactive elements to the plutonium produced will do little to hinder conversion of the material to weapons.[57] Even if the technology is developed, it is unlikely to become available for use on a commercial scale for over 15 years.[58] And there is the nagging problem of whether the SNF generated by developing countries from uranium supplied by GNEP will be returned to the U.S. for reprocessing and disposal.[59] DOE's need to site fuel-recycling and product waste storage facilities, as well as new types of reactors, is also a concern.[60] Potential host communities, which may include

accelerated approach to implementing GNEP would likely lead to use of unproven technology and would not provide assurance that the problems raised concerning GNEP would be solved. GAO recommends that DOE reassess its schedule. GLOBAL NUCLEAR ENERGY P'SHIP, REPORT TO CONGRESSIONAL COMMS.: DOE SHOULD REASSESS ITS APPROACH TO DESIGNING AND BUILDING SPENT NUCLEAR FUEL RECYCLING FACILITIES 11 (2008), *available at* http://www.gao.gov/new.items/d08483.pdf.

[55] MATTHEW BUNN ET AL., THE ECONOMICS OF REPROCESSING VS. DIRECT DISPOSAL OF SPENT NUCLEAR FUEL § 4 (2003).

[56] INST. FOR POLICY STUDY, *supra* note 46, at 18.

[57] THOMAS COCHRAINE & CHRISTOPHER PAINE, NATURAL RES. DEF. COUNCIL, PEDDLING PLUTONIUM: NUCLEAR ENERGY PLAN WOULD MAKE THE WORLD MORE DANGEROUS 3, 7 (2006), *available at* http://www.nrdc.org/nuclear/gnep/agnep.pdf.

[58] *See id.* at 6.

[59] *Id.* at 3, 8.

[60] *See, e.g.*, Shundahai Network, 106 organizations urge Congress to oppose GNEP (Global Nuclear Energy Partnership) program and specifically GNEP activities in Piketon, Ohio (2007), *available at* http://www.shundahai.org/gnepletter12507.htm (asking Congress to oppose GNEP and expressing alarm over the designation of Piketon, Ohio as a DOE GNEP grant recipient);

those at current or former DOE weapons facilities, will balance economic benefits against the burden of storing decaying cesium and strontium over a long period. The House Appropriations Committee recently zeroed out funding for GNEP, primarily because of concerns that the overall package, including the fuel leasing arrangements, had not been adequately thought through. But, new initiatives on reprocessing remain a live option.

Not withstanding the many questions that have been raised about GNEP, it has served to underscore that the reprocessing option should not be ruled out. The nuclear waste issue should not be addressed in isolation from the entire nuclear fuel cycle, and from proliferation issues.

IV. THE CURRENT DILEMMA

Yucca Mountain is the only candidate site for a permanent repository for SNF and HLW. DOE has yet to file a license application for Yucca with the NRC, which will take years to process it. Litigation and other actions by the state have succeeded in holding up the process of licensing the Yucca site for construction of a repository. The next step is for DOE to submit a license application to the NRC, and for EPA to issue revised exposure standards, which will be incorporated in the NRC regulations for licensing the facility.[61] On July 19, 2006, DOE announced its plan to submit the required license application for the Yucca Mountain Repository to the NRC by June 30, 2008.[62] Once an application is submitted by DOE and docketed for review by the NRC, the NRC will likely take three years to decide on the license.

The new EPA radioactive release standards, NRC licensing standards, and if granted, an NRC license for Yucca will undoubtedly be challenged in court, adding further delays and uncertainty. Also, several of the legal claims that have already

DEMOCRACY FOR N.M., ATTEND HEARING IN NM ON DANGEROUS NEW NUCLEAR PLAN (2007), *available at* http://www.democracyfornewmexico.com/democracy_for_new_mexico/2007/02/attend_hearing_.html.

[61] EPA has published a new draft rule that the Agency asserts complies with the court's ruling. However, the final rule is reportedly being held up in OMB review and has not yet been issued. Public Health and Environmental Radiation Protection Standards for Yucca Mountain, NV, 70 Fed. Reg. 49014 (Aug. 22, 2005) (to be codified at 40 C.F.R. pt. 197).

[62] HOLT, *supra* note 39, at 10.

been brought against the Yucca Mountain repository were rejected by the court as not yet ripe—that is, the litigants have been forced to wait until the project reaches a point where it becomes clear that their legal concerns are not just speculation. As the Yucca project proceeds, these lawsuits will increasingly become ripe for consideration, and could further delay the project. Furthermore, Nevada's political power seems to be on the rise. The Senate Majority Leader is now Nevada Senator Harry Reid, and Barack Obama expressed opposition to Yucca during the Nevada primary. If and when the NRC issues a construction license for Yucca, the repository must be constructed and brought into operation, which will require additional regulatory approvals. DOE now predicts that the site is unlikely to be operational until 2017 at the earliest, and some utility representatives have informally indicated that they are planning on the assumption that it will not be open until 2035–2050.

Meanwhile, SNF continues to accumulate at reactor sites. The total amount of SNF and HLW on hand already exceeds Yucca's authorized capacity, and Yucca will not open for at least a decade. 54,000 MTiHM of civilian SNF is now being stored in pools or dry storage air cooled containers at sites contiguous to the 131 civilian nuclear reactors in 39 states. Of this, 47,000 metric tons were held in concrete-lined pools of water, 7,000 metric tons in dry casks.[63] Although dry cask storage is more expensive than pool storage, use of dry cask storage is expected to continue to grow, in part because existing pool storage is limited and because dry cask storage is considered safer.[64] A small risk exists that an earthquake, accident, or terrorist attack could drain a storage pool's water, possibly sparking a fuel assembly fire. In contrast, experiments have shown that dry storage casks are capable of resisting crashing airplanes, armor piercing rounds, and high-explosives.[65] Temporary pool storage will be needed as long as nuclear power plants are in operation, however, because it takes,

[63] NUCLEAR ENERGY STUDY GROUP OF THE AM. PHYSICAL SOC'Y, CONSOLIDATED INTERIM STORAGE OF COMMERCIAL SPENT NUCLEAR FUEL 6 tbl.1 (2007); John C. Yoo & Jennifer L. Koester, *Judicial Safeguards of Federalism and the Environment: Yucca Mountain from a Constitutional Perspective*, 75 U. COLO. L. REV. 1317, 1331 (2004).

[64] NUCLEAR ENERGY STUDY GROUP, *supra* note 63, at 3.

[65] U.S. NUCLEAR REGULATORY COMM'N, BACKGROUNDER: DRY CASK STORAGE OF SPENT NUCLEAR FUEL 3 (2007), *available at* http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/dry-cask-storage.pdf.

on average, five years of cooling in a pool before SNF may be transferred into dry cask storage units.[66]

Neither a federal MRS facility nor a privately-owned consolidated storage facility has been developed. The statutory authorization for the Office of the Nuclear Waste Negotiator (ONWN), charged with helping to identify and negotiate arrangements with willing host communities for a federal MRS facility, expired in 1994 and Congress did not renew it.[67] Having recommended the Yucca Mountain site to the President, DOE has since 2002 been authorized by the NWPA to conduct investigations of and characterize potential MRS facility sites.[68] DOE, however, has focused its energy on the Yucca repository, and has not undertaken any significant steps to move forward with siting an MRS facility since the mid-1980s.

Even if the licensing process for Yucca Mountain is eventually successful and construction goes forward, the NWPA permits only 70,000 MTiHM to be placed in the repository, unless and until a second repository is built. This amount of capacity is not sufficient to accommodate disposal of the total amount of SNF and HLW that currently exists. More SNF will continue to accumulate, and the amount will grow even larger if new nuclear power plants are brought on line. Congress could raise the capacity cap for Yucca. The utility industry's Electrical Power Research Institute projects the facility's functional capacity at between 260,000 and 570,000 metric tons of SNF.[69] A second repository cannot be constructed without changing existing law to enable a second repository to be characterized prior to licensing of Yucca;

[66] *Id.* at 1.

[67] *See* Alex Tallchief Skibine, *High Level Nuclear Waste on Indian Reservations: Pushing the Tribal Sovereignty Envelope to the Edge*?, 21 J. LAND RESOURCES & ENVTL. L. 287, 291 (2001); HOLT, *supra* note 39. Before the politics of opposition intervened, the ONWN's voluntary siting program successfully identified a number of interested hosts. Critics contended, however, that widespread use of this approach would result in poor communities hosting all of society's dangerous facilities; less compensation would be required to convince underprivileged communities to host such sites than their more affluent counterparts. Noah Sachs, *The Mescalero Apache Indians and Monitored Retrievable Storage of Spent Nuclear Fuel: A Study in Environmental Ethics*, 36 NAT. RESOURCES J. 881, 895–97 (1996).

[68] 42 U.S.C. § 10165(c) (2000). Construction of an MRS facility, however, may not begin until the NRC licenses the construction of a permanent repository. 42 USC § 10168(d)(1).

[69] VON HIPPEL, *supra* note 48, at 13.

DOE will reportedly issue a report to Congress on whether a second repository is needed relatively soon.[70] Meanwhile, the federal government's liabilities to the utilities for SNF storage costs continue to mount; the nuclear industry has recently claimed that the government's liabilities could mount to $50 billion, while the government contends that the figure will be closer to $7 billion.[71]

By contrast, the WIPP site opened in 1999, and has been receiving defense TRU waste since that time. It received environmental certification from EPA at its five-year mark (2004) and recently got a revised RCRA operating permit from New Mexico authorizing the facility to receive higher risk, RH-TRU.[72] WIPP is only authorized to dispose of defense TRU wastes under current law, and there is a statutory cap of 175,500 metric tons of TRU that can be disposed at the facility. Earlier studies of the site and facility indicated that it could well be suitable for disposal of SNF and/or HLW as well. Congress would need to amend relevant legislation concerning WIPP (and possibly the NWPA) to authorize disposal of such wastes at WIPP, which New Mexico would probably bitterly resist.

V. THE WAY FORWARD

President Carter's IRG was a thorough and thoughtful effort to rethink and restructure a U.S. nuclear waste policy that was in disarray. We face a similar challenge today. The current bankruptcy of nuclear waste policy can be traced in part to the ethical premises underlying the IRG's analysis and recommendations. That premise was that the current generation, having enjoyed the benefits of nuclear technologies, could not leave the burden of the waste that it generated to future generations, and must therefore arrange for its perpetual burial in a deep geologic repository as soon as possible. Implementation of

[70] DOE is required under the 1987 NWPA Amendments to report to Congress between 2007 and 2010 on the need for a second repository. 42 U.S.C. § 10172a.

[71] *See* Marcia Coyle, *Breach Cases Could Cost U.S. Government Billions*, NAT'L L.J., Sept. 8, 2008.

[72] Until the RCRA permit was revised and reissued, WIPP had been receiving only CH-TRU, which can be directly handled by workers because of their relatively low level of hazard. RH-TRU must be handled remotely using special equipment because direct exposure of workers to the waste is not safe.

this principle was given urgency by political opposition to further development of nuclear power unless the waste problem was solved, and opposition in some states to continued storage of defense wastes within their borders.

Congress in the 1982 NWPA sought to achieve early burial of nuclear wastes through a centralized, top-down system of science-based planning. DOE was to evaluate and winnow potential repository sites based on their technical merits, and select the best-qualified site. This meritocratic approach was complemented by providing for two repositories, the first in the West, and the second in the East, to secure regional equity. In order to ensure prompt selection, construction and operation of the repository, Congress imposed very tight deadlines and imposed a liability "hammer" on DOE by making it responsible for SNF beginning in 1998. In order to further force the opening of a repository, development of a federal consolidated MRS facility was subject to tight limitations. Short-term political considerations, however, led Congress in 1987 to override the meritocratic process that it established in 1982 and designate Yucca as the sole repository site for detailed characterization. The technical evidence indicated that Yucca was likely to prove a suitable site; indeed, it may have been the best-qualified of the final three. But Congress's short-circuiting of the process that it has previously mandated badly undermined the political legitimacy of its choice, creating a deep and abiding sense of grievance on the part of Nevada and making it extremely difficult to re-establish a credible meritocratic site selection process in the future.

Nevada has sought every legal, political, and other means available to stop the repository, which is not expected to open before 2020, and perhaps much later. Meanwhile, the existing stock of HLW and SNF already exceeds Yucca's statutory capacity limit, and continues to grow. Many local communities are becoming restive at the prospect of indefinite storage of SNF at reactor sites. There are no alternative storage facilities available or even planned. The failure to "solve" the nuclear waste problem is a political barrier to expanded use of nuclear power, a consideration that may influence at least some environmentalist challenges to Yucca.

There are five basic steps in moving forward from the current bankruptcy of nuclear waste law and policy. The new framework must be comprehensive and based on a fundamental reorientation

of approach; incremental reform of the present broken system will accomplish little. The steps to be taken include adoption of a different ethical framework for waste management; reinstating a high level process to review U.S. waste law and policy and chart a new course; creating new institutional arrangements for waste management and regulation; instituting a more thoroughgoing risk-based approach to regulation; and developing a new waste policy strategy that is more flexible, that can adapt to inevitable unforeseen circumstances and contingences, that preserves options for future decision makers, and that learns from experience, including mistakes.

A. *Rethinking the Ethics of Nuclear Waste*

The first step is to rethink the ethical principle embraced by the Carter IRG. It is not the case that the benefits of nuclear power and nuclear weapons have accrued only to past and current generations, and that our responsibilities to future generations require "in perpetuity" disposal of nuclear wastes as promptly as possible. At least a part of the national security and economic benefits of past uses of nuclear technology are embedded in the social and economic capital that future generations will inherit. Because carbon dioxide emissions reside in the atmosphere for centuries, the carbon emissions avoided by the use of nuclear power to date will benefit future generations for many years. Nor is it obvious that the interests of future generations are best served by burying current waste stockpiles as soon as possible. Our ability to evaluate repository sites and the technologies for containing wastes are likely to improve in the future. Thus, a repository built in the future is likely to pose lower risks to future generations than one built today. Moreover, SNF is a resource that contains large amounts of energy that can be transformed into useful form by recycling, not once, but several times. Nuclear fuel is a partially renewable resource. Burying this resource irretrievably will deny future generations the option to use it. While repositories can be built to permit retrieval of wastes—for longer or shorter periods depending on the geologic medium and repository design—incorporating retrievability adds to expenses and, perhaps, performance uncertainty. Moreover, once wastes are buried in a repository, it may be politically difficult to retrieve them even if retrieval is technically possible. Based on these considerations, a revised ethic is appropriate, one along the following lines:

Our obligation is to give succeeding generations a real choice and the opportunity to shape their own decisions while at the same time not imposing a burden that future generations may not be able to manage.[73] This principle points to a step-by-step approach to dealing with nuclear waste, through an iterative process of learning and public deliberation, as opposed to immediate decision on a final solution.[74] Developing a degree of consensus on the appropriate ethical foundations for nuclear waste policy will require debate and dialogue involving key political decision makers, experts, industry, NGOs, and the general public. The Nuclear Waste Commission recommended in the next subsection would jumpstart such discussions.

B. *Creating a Nuclear Waste Policy Commission*

The second step Congress and the President should take is to constitute a high level Nuclear Waste Policy Commission to engage in a total review and rethinking of the country's nuclear waste policy and chart a new course. The commission should include representatives of key federal agencies, including DOE, EPA, NRC, Defense, Interior, State, and Commerce; key members of Congress; and representatives of states with major nuclear facilities or sites, including Nevada, Washington, New Mexico, Idaho, and South Carolina as well as a cross-section of other states. Such an organization, which would have certain affinities to federal base closing commissions but would focus on general polices and institutional arrangements rather than specific decisions, would enlist the services of a strong staff as well as relevant existing expert advisory committees. Such an initiative is needed to kick start a thoroughgoing review of nuclear waste law and policy and give it prominence and potential buy-in to recommendations for change by key constituencies.

Neither the administration nor Congress has been able or willing on their own to institute such a review. Establishing such a commission to take the lead would be a politically attractive option

[73] I am indebted to Tom Isaacs, Director of Policy and Planning, Lawrence Livermore National Laboratories, for this formulation.

[74] Canada is currently developing such an approach to nuclear waste management. *See* NUCLEAR WASTE MGMT. ORG., MOVING FORWARD TOGETHER: ANNUAL REPORT 2007 (2008), *available at* http://www.nwmo.ca/Default.aspx?DN=173e8f68-4540-4056-b112-30898c3fe759 (proposing adaptive phased management).

for a new President. To make comprehensive proposals for a new approach, this high-level expert body, similar to the Carter IRG, would take the lead in portage around the existing nuclear waste policy logjam. The approach taken should be ambitious and comprehensive, including not only current and future wastes but issues relating to the back-end of the fuel cycle in general, alternative technologies including reprocessing and new types of reactors, and broader considerations including climate change, energy security, and domestic and international security against nuclear proliferation and terrorism. A focus on wastes in isolation would ignore the several ways in which they are embedded in this larger complex of issues, and thereby risk adoption of short-sighted approaches that overlook cross-cutting opportunities.

C. *Creating New Waste Management and Siting Agencies and Eliminating Regulatory Duplication*

The third step is for Congress and the President to establish new federal institutional structures for nuclear waste management, siting, and regulation, building on the analysis and recommendations of the Nuclear Waste Policy Commission.

The current arrangements, which place responsibility for management and siting with the Office of Civilian Radioactive Waste Management within DOE, suffer from a number of endemic problems. Top management turns over rapidly. OCRWM has had difficulty recruiting and retaining sufficient highly qualified personnel. Congressional funding for waste management is stop and go, and often driven by constituent interests. There is also a constantly shifting tug and pull over resources and attention among DOE components and support contractors. DOE still suffers from the culture of secrecy and arrogance inherited from the AEC. The culture of secrecy has been reinforced by government lawyers who have clamped down on any disclosure of records or views that might prejudice the government's liability litigation with the utilities over waste storage.

A solution to these difficulties is to create a new, separate entity whose sole function would be to manage nuclear waste. It would not site new storage facilities or repositories, but would be responsible for waste storage, treatment, and transportation; development and application of waste containers; construction and operation of interim consolidated storage facilities; and construction, operation, closure and post-closure monitoring of a

repository. The requisites for such an entity are a clearly defined mission, a business model of management, high quality technically adept personnel, and assured long-term stable funding. There are several institutional forms that such an entity might take:

- A federal agency with a single head who reports to the President.
- A federal agency with a single head that reports to the Secretary of DOE but located outside DOE (on the model of the Bonneville Power Authority).
- A federal corporation owned by the federal government with a presidentially-appointed board that selects a CEO to manage its operations, on the model of the TVA.
- A hybrid federal corporation owned in part by the federal government and in part by the nuclear utilities with a board selected in part by each.

A further option is a multi-member "independent" agency like NRC, FCC, etc. Such an organization, however, would lack the focus and unity of leadership most appropriate for waste management tasks. A final option would be a private corporation owned by the nuclear electric utilities, regulated by the government. While this model has been adopted by some European countries, it is probably too radical a departure from the status quo to be politically acceptable.

The advantages of a corporate form is that it would most fully realize the business model, and free the entity from federal personnel and procurement requirements, promoting flexibility and efficiency and enabling it to hire and retain highly qualified personnel.[75] Continuity of funding could be assured by making a nuclear generation fee payable directly to the entity, or establishing contractual arrangement for utility funding. Alternatively, funding by Congress could be accomplished through long term appropriations, possibly including a revolving fund separate from the unified federal budget. A further advantage of a hybrid corporate form is that it could build on the commonality of interests in successful waste management on the part of the government and the utilities; the NWPA waste management liability scheme makes them adversaries. Such an entity could assume ownership of wastes once they left the site of a reactor or

[75] *See* A. Michael Froomkin, *Reinventing the Government Corporation*, 1995 U. ILL. L. REV. 543 (1995).

reprocessing facility. Sweden, Finland and Canada have successfully adopted a model which gives operational responsibility for nuclear waste management to a utility-owned corporate entity.[76] As noted above, such an arrangement would probably be too drastic an innovation in the U.S. A hybrid federal corporation owned by the government and the nuclear utilities would represent a sensible compromise arrangement. Such a corporation might potentially engage in reprocessing as well as waste management.

The federal or hybrid corporate form, however, has certain disadvantages, most notably lack of clear arrangements for accountability in its policies and finances.[77] It could also make it difficult to coordinate waste management decisions with the functionally related decisions of existing federal agencies. A separate federal agency with a single head reporting to the President would ameliorate these problems but sacrifice many of the attributes and advantages of the business model. A separate agency that reports to the Secretary of DOE could promote coordination but sacrifice some of the advantages of independence. Assured funding for any new federal agency would have to be developed through a revolving fund or otherwise.

The IRG concluded that the operational tasks of SNF waste management required a managerial structure with well-defined program authority, efficient (i.e., businesslike) operations, and a predictable, transparent funding mechanism.[78] A 1982 Congressional Office of Technology Assessment Report examined a number of options, including a new executive branch agency similar to NASA; an "independent" agency with loose ties to DOE, such as Bonneville Power Administration; a government corporation, such as TVA; and a federally chartered non-federal entity such as Comsat. It indicated that a corporate structure might be most desirable because it would allow for direct funding through user fees and greater flexibility in personnel policies "thus increasing accountability for achieving program goals."[79] A 1982

[76] In Canada, the utilities have as a result of public pressures added representatives of other stakeholder interests to the board.

[77] *See* Froomkin, *supra* note 75, at 560, 594–95, 607–08.

[78] INTERAGENCY REPORT, *supra* note 14, at 118.

[79] OFFICE OF TECH. ASSESSMENT, MANAGING THE NATION'S COMMERCIAL HIGH-LEVEL RADIOACTIVE WASTE (1982).

National Academy of Public Administration[80] and a 1984 report to the Secretary of Energy by his Advisory Panel on Alternative Means of Financing and Managing Radioactive Waste Facilities[81] followed a similar analysis, stressing the need for a financing mechanism outside the normal congressional budget process. The advisory panel recommended creation of a federal corporation to take over nuclear waste management functions. An internal DOE group established to review the panel's recommendations concluded, however, that they should not be followed, and that internal DOE reforms would suffice.[82] Experience since that time confirms that the outside reports were right, and that fundamentally new institutional arrangements are needed.

Siting of storage facilities and repositories may call for different institutional requisites, depending on the siting approach that is followed. While technical competence is essential, experience indicates that a purely technocratic model is too narrow and rigid to be successful. In the future, successful development of new storage facilities or repositories will require considerable engagement with states and localities, with the utility and nuclear industry, and with environmental and local NGOs, and a capacity for negotiation within those various stakeholders. This will require an institution that is more open, that can represent different viewpoints and stakeholder interests, and that can develop good political connections with Congress and the states. The multimember "independent" commission form may best suit these specifications. The multimember structure facilitates representation of different viewpoints in its governance. Such agencies have typically had closer ties with Congress (and, through Congress, to local interests) than agencies with single heads who report to the President. An office of waste negotiator should be included as a component within the commission to take the lead in exploring and negotiating siting opportunities, building on experience gained under the now-expired provision of NWPA

[80] NAT'L ACAD. OF PUB. ADMIN., BUILDING THE INSTITUTIONAL CAPACITY FOR MANAGING COMMERCIAL HIGH-LEVEL RADIOACTIVE WASTE (1982).

[81] PANEL ON ALTERNATIVE MEANS OF FIN. & MANAGING RADIOACTIVE WASTE FACILITIES, MANAGING NUCLEAR WASTE: A BETTER IDEA: A REPORT TO THE SECRETARY OF ENERGY 2-3 (1984).

[82] DOE REVIEW GROUP, REPORT TO THE SECRETARY OF ENERGY ON THE CONCLUSIONS OF AND RECOMMENDATIONS OF THE ADVISORY PANEL ON ALTERNATIVE MEANS OF FINANCING AND MANAGING (AMFM) RADIOACTIVE WASTE MANAGEMENT FACILITIES (1984).

establishing the ONWN.

The creation of several new entities to assume functions now housed in DOE will create problems of coordination between the new entities and DOE, as well as with NRC, other federal agencies and states and localities, and perhaps make it more difficult to achieve an integrated approach to waste management that takes account of the entire nuclear fuel cycle and concerns over environmental protection, energy security, and security against terrorism and nuclear proliferation. But the failures of the current arrangement indicate that a new approach, relying on more independent and functionally specialized bodies and the flexibility that they would provide, is warranted.

Environmental health and safety (EHS) regulation of nuclear waste and storage facilities and repositories should, of course, be independent of management and siting. But there is, in balance, no adequate justification for having two regulators—NRC and EPA—rather than one. Indeed, the NWPA effectively establishes three regulators by requiring EPA's radioactive exposure standards, which must be incorporated by NRC in licensing requirements and decisions, to be "consistent" with NAS committee recommendations. The court invalidated EPA and NRC standards for Yucca on account of such inconsistency. Although institutional redundancy can guard against "capture" of regulatory agencies, having three regulators creates unwarranted duplication and potential for conflict and muddles accountability without sufficient gain.

The regulatory culture in EPA is based on a paradigm of controlling continuing releases of pollution from a wide variety of sources through source controls based on best available control technology and achievement of levels of pollution specified in environmental quality standards. This paradigm is not suited for the most important EHS hazards presented by waste storage and disposal facilities, which consist of stochastic risks of systems failures due to the interaction of multiple fault lines. As Abel González, Director of the International Atomic Energy Agency Division of Radiation and Waste Safety has noted, "the guiding safety principles" for nuclear waste are distinct: "rather than diluted and dispersed through the environment, highly radioactive wastes are confined, contained and isolated."[83] EPA's original

[83] Abel J. González, *The Safety of Radioactive Waste Management:*

Yucca standard—that there be "reasonable expectation" that releases from the repository to the most exposed individual will not exceed an annual effective dose of 15 millirems over a 10,000 year time period, reveals the limitations of the pollution control paradigm. The "reasonable expectation" standard implicitly recognizes the impossibility of applying to a repository system a pollution-control model of regulation in the form of a single numerical concentration or exposure standard.[84] Further, the notion that a regulator can assure even a "reasonable expectation" of compliance with a standard as low as 15 millirems 10,000 years into the future is an exercise in imagination. To put the 15 millirem EPA annual standard in context, the dose received by the average TV viewer is 30 millirems/year, while a single cross-country plane flight gives a passenger an 8 millirem dose.[85] The fantasy was compounded by the *Nuclear Energy Institute* decision, which enforced the NAS Committee's view—based on a scientists' paradigm that ignores regulatory realities—that exposure standards should be set for a much longer period during which peak releases might be projected. Asserting that it was feasible to perform compliance assessment for most physical and geological aspects of repository performance on a time scale of 1 million years at Yucca mountain, the report found "no scientific basis" for limiting the standard to 10,000 years.[86]

The NRC is experienced with regulating complex systems, most notably nuclear reactors and on-site storage facilities, and should have the sole responsibility for regulating nuclear waste facilities and repositories. The assignment of AEC radioactive

Achieving Internationally Acceptable Solutions, 42(3) IAEA BULLETIN 5, 5 (2000).

[84] In developing its generic 1985 repository standard, however, EPA did use probabilistic risk assessment of the type developed by the AEC/NRC for assessing the performance of nuclear reactors. *See* Rob P. Rechard, *Historical Relationship Between Performance Assessment for Radioactive Waste Disposal and Other Types of Risk Assessment*, 19(5) RISK ANALYSIS 763, 780–81 (1999). Also, EPA lawyers may have taken the view that the NWPA implicitly required EPA to adopt a single number exposure standard.

[85] Univ. of Iowa Hosps. and Clinics, Health Topics: Radiation Exposure: The Facts vs. Fiction, http://www.uihealthcare.com/topics/medicaldepartments/cancercenter/prevention/preventionradiation.html (last visited Mar. 14, 2008).

[86] COMM. ON TECH. BASES FOR YUCCA MOUNTAIN STANDARDS ET AL., TECHNICAL BASES FOR YUCCA MOUNTAIN STANDARDS 8 (1995), *available at* http://books.nap.edu/openbook.php?record_id=4943&page=R1; Nuclear Energy Inst., Inc. v. EPA, 373 F. 3d, at 1267.

protection standards to EPA in 1970 was part of a broader executive branch reorganization to consolidate existing environmental regulatory authorities, done before there was an institutionally separate nuclear regulator in the form of the NRC. This assignment should be reconsidered and reversed, and the EPA's responsibilities assigned to the NRC. Maintaining a second, duplicative regulator out of concern that the first may not properly do its job is hardly sound government. By the same token, expert advisory committees should advise, but their advice should not be given controlling legal effect. The existing pattern of regulatory authority, summarized in Appendix A, unduly multiplies regulatory authorities and should be simplified. The states' RCRA authority over the chemically toxic component of mixed wastes, however, should be retained. States play an important role in regulating federal facilities, and the WIPP experience suggests that the ability to exercise such authority may be essential to states' willingness to accept future nuclear waste facilities.[87]

D. *Instituting Risk-Based Regulation and Siting*

The fourth step is for Congress and the entities responsible for nuclear waste management and siting to institute a more thoroughgoing risk-based approach to waste policy and its implementation. Various reports have recommended this step.[88]

The existing system for classification of various nuclear wastes is in major respects based not on their radiological and other characteristics and the EHS risks that they pose, but on the processes by which they are produced. This is true of HLW and SNF, and largely also of LLW which is a residual category. Moreover, these categories include a wide variety of different kinds of wastes posing different levels and kinds of risks and requiring different approaches to treatment, storage and disposal. The time has come to rationalize this obsolescent approach, which

[87] Because EPA issues RCRA regulations and manages the overall RCRA program, it would continue to play a role in managing nuclear wastes, but would focus on the chemically toxic components of wastes, which fall within its regulatory expertise. As is the case today, there would be a need to coordinate RCRA's treatment of mixed wastes with regulation by NRC of the radioactive components, in coordination with the federal waste management entity, whether housed in DOE or outside of it.

[88] COMM. ON TECH. BASES FOR YUCCA MOUNTAIN STANDARDS ET AL., *supra* note 86, at 3–5, 33–42.

is not followed in most other countries.[89] This step will require legislation because existing law limits and creates uncertainty regarding the extent of administrative latitude in waste classification.[90] While this step would not solve the most fundamental challenges in siting nuclear waste storage and disposal facilities, it would permit a better tailoring of regulatory requirements to risks. It could also highlight waste characteristics relevant for broader policy decisions, for example, the higher shorter term radioactivity and heat generated by the strontium and cesium components of SNF, versus the less intense but longer-lived radioactive characteristics of other waste components. This could clarify the potential advantages of separating these components through reprocessing, and storing, treating and disposing of them by different means.

A risk-based approach to regulation would reinforce the institutional analysis made above: the risks posed by nuclear waste storage and disposal facilities are fundamentally different from those posed by ongoing pollution. They should be regulated though regulatory techniques that rely on probabilistic risk assessment and probabilistic performance assessment rather than maximum permitted exposure levels.[91] Especially in the case of risks posed over long time scales, the pollution model for risk characterization and regulation is ill-adapted for addressing storage

[89] *See* Allen G. Croff, *Risk-Informed Radioactive Waste Classification and Reclassification*, 91(5) HEALTH PHYSICS 449, 452 (2006); NAT'L RESEARCH COUNCIL, IMPROVING THE REGULATION AND MANAGEMENT OF LOW-ACTIVITY RADIOACTIVE WASTES (2006). The RCRA system for classifying hazardous waste is also in major part process-based and equally in need of reform.

[90] For example, in 1999, DOE amended its regulations to reclassify certain reprocessing wastes that had been treated to reduce their radioactive levels so that they no longer were required to be disposed of in a HLW repository. NRDC challenged this step in litigation. In NRDC v. Abraham, 271 F. Supp. 2d 1260 (D. Idaho 2003), the district court ruled that DOE's position was contrary to the relevant statute. The court read the statute to require that all liquid reprocessing wastes be classified as HLW regardless of their radioactive characteristics. The district court's decision was set aside by the court of appeals, which ruled that the controversy was not ripe for judicial decision. NRDC v. Abraham, 388 F.3d 701, 703 (9th Cir. 2004). Subsequently, DOE obtained from Congress legislation authorizing it to classify, under certain conditions, certain treated liquid wastes from reprocessing at its Savannah River Site and Idaho National Laboratory facilities as other than HLW.

[91] *See* Yacov Y. Haimes, *Risk Modeling, Assessment, and Management* (2nd Ed. 2004); *Accident Precursor Analysis and Management: Reducing Technological Risk Through Diligence* (James R. Phimister et. al. eds., 2004); *see also* Rechard, *supra* note 84.

facility and repository performance and provides a wholly misleading illusion of certainty.

Relatedly, there is significant opportunity for public education regarding the risks posed by nuclear waste storage and disposal in deep geological repositories. The public's perception of nuclear risks is powerfully shaped by inescapable qualitative factors, including the association with nuclear weapons, the invisible nature of the mechanism, and the dread character of cancer. Nonetheless, the Nuclear Waste Commission, entities responsible for waste management and siting, and scientific and educational bodies and even some environmental groups could help educate the public about the nature and magnitude of the risks posed by nuclear wastes and the trade-offs involved in dealing with them. They could communicate the high level of safety achieved by nuclear reactors, nuclear waste storage and transport, and WIPP, the non-cataclysmic and rather moderate character of repository risks, and the fact that countries that have engaged in reprocessing as well as Canada, which has not, have concluded that prudence does not require immediate burial of nuclear wastes. The commission should set out to stimulate discussion and debate, including among experts, NGOs, state and local authorities, and the general public. The dialogue should ensure that nuclear waste is considered in the broader context, international as well as domestic, of the potential contributions of nuclear power in addressing climate change; the relation of reprocessing to waste generation and disposal (including reduction of waste volumes and segregation of cesium and strontium for separate storage and disposal); energy security; and risks of proliferation and terrorism. Of course the economic, technological, and other risks presented by storage, reprocessing advanced fuel cycle reactors, and repositories should be fully explored.

It is also imperative to engage local publics in learning in connection with siting of nuclear storage facilities and repositories. The Consortium for Risk Evaluation with Stakeholder Participation (CRESP)[92] has developed a highly successful approach to engaging local communities in risk analysis as well as risk management decision making regarding waste cleanup at

[92] For materials on the CRESP approach to engaging local communities with risk assessment, see CONSORTIUM FOR RISK EVALUATION WITH STAKEHOLDER PARTICIPATION, http://www.cresp.org (last visited Sept. 15, 2008).

DOE's former weapons facilities and radiological hazards at nuclear test sites, and thereby building trust. The CRESP approach provides a model that should be followed in the siting context. The CRESP experience indicates that it is essential to involve local communities at the earliest possible stage in risk assessments through an open process, so that they can understand the approach taken by the government or private entities taking the lead in a risk assessment but also communicate their knowledge and concerns about relevant risks. The education must be two-way, rather than the outside "experts" telling the community what the risks are and then attempting to engage them in discussion about how they should be managed. The CRESP approach fits well with a negotiated approach to siting.

E. *Building a Flexible and Adaptive Waste Management Strategy that Preserves Future Options*

The fifth step is to develop a new approach to waste management and disposal that is less rigidly prescriptive than the 1982 NWPA and 1987 amendments, maintains options, proceeds step-by-step, adapts to unforeseen contingencies, and consciously seeks to distill the lessons from experience, including failures as well as successes.

The default outcome is that the waste will remain where it currently is, at reactors and DOE sites. Treatment, container, and storage methods are available to store these wastes safely at their present locations. The precautionary principle might well counsel leaving wastes where they are for the indefinite future. The uncertainties involved with depositing waste in a repository are probably greater that those involved in storage, and disposing of them in a repository is, sooner or later, an irreversible step. Also, there may be long run environmental and nuclear security advantages in reprocessing wastes which would also counsel against immediate burial in a repository. Given the uncertainties, there are significant advantages in preserving options and postponing a decision on final disposition or reprocessing pending the development of more information, including that provided by technological and scientific progress. Finally, there are political obstacles to siting new consolidated waste storage facilities, and such facilities may not have compelling environmental, security, and economic advantages over the status quo.

In the larger political and societal framework, however, it is

important to move forward to open at least one repository and develop consolidated interim storage facilities. So long as these steps are not accomplished, there will be growing local resistance to continued storage on site and more general opposition to expansion of nuclear power or the development of reprocessing facilities. Given the environmental advantages of expanded use of nuclear power and the potential security and other contributions of reprocessing, steps to convince the public that progress is being made on addressing nuclear waste are necessary.

Unless unanticipated technical problems with the Yucca site emerge, a repository at Yucca should be built and opened, but only a small portion of the statutorily authorized quantity of wastes deposited. The remaining waste could be stored in dry casks on site. This would enable the repository to be tested at pilot scale. This would demonstrate to the public that a repository can be built and successfully operated for waste disposal while reserving the decision to fill and close the repository for the future. Meanwhile, the stored waste would be available for potential future reprocessing to produce fuel or for later disposal. These steps might alleviate somewhat the intensity of Nevadans' concerns with and opposition to the site. Studies at other nuclear sites indicate that local communities become habituated to them and, over time, come to regard the risks posed as less hazardous. Successful demonstration of the Yucca repository will also help persuade the public that the nuclear waste "problem" can be "solved." If Yucca is abandoned, it will be extraordinarily difficult to site a new repository, and the public perception of failure will be reinforced. Actually opening one repository and successfully testing it will help reduce opposition to a second. Storing wastes on site at Yucca will also set a precedent for interim consolidated storage. Further, it will enable the federal government to discharge its responsibility for managing SNF and liquidate the running conflict with utilities over the government's liability for failing to do so. The NWPA may not have to be modified to accommodate this result. It provides only that the federal government must begin sending SNF to Yucca in 1998, and arguably does not preclude pilot-scale disposal (to test the repository performance and the retrievability feature required by law), together with on-site storage of the remaining wastes.

Siting new storage facilities and repositories will require a combination of technical competence; true engagement of local

communities in risk assessment and management, giving states a say in repository siting, design, and operation; steps to meet state and local safety concerns including waste transportation; and providing economic and other benefits (e.g., services, educational and health benefits/advantages, priority attention under certain federal programs, recognition of leadership or excellence, etc.) to the host locality and state.

Future siting strategies must build on the lessons from experience at WIPP and Yucca. A 2001 NAS committee report on WIPP summarized the factors that it believed enabled WIPP to succeed: (1) the geological suitability of the WIPP site for containment of waste; (2) local community support for the project; (3) the strong scientific and programmatic leadership of the WIPP project; (4) extensive external scientific reviews (including by NAS) throughout the project; (5) use of a transparent compliance certification process in accordance with criteria agreed upon in advance; and (6) the project's willingness to make changes to improve the engineered containment system in response to technical findings.[93] In addition, NAS and others have identified as significant the facts that WIPP, unlike Yucca, has been limited to receiving TRU, an intermediate-level rather than high-level waste, which people perceive as less hazardous.[94]

The attitudes and interests of state and local governments and procedures for accommodating them are critical and go a long way to explain why WIPP ultimately succeeded in meeting the State's tough requirements and is open for business; whereas Yucca has been tied up in state-generated delaying tactics.[95] Carlsbad and New Mexico were economically needy, and had a generally positive experience with federal nuclear activities. Nevada's

[93] NAT'L RESEARCH COUNCIL, DISPOSITION OF HIGH-LEVEL WASTE AND SPENT NUCLEAR FUEL: THE CONTINUING SOCIETAL AND TECHNICAL CHALLENGES 65–66 (2001).

[94] MCCUTCHEON, *supra* note 8, at 199.

[95] Looking at the history of nuclear waste siting, Luther Carter wrote that "[t]o establish a local base of cooperation and support is not a sufficient condition for host-state support, but it is surely a necessary condition." CARTER, *supra* note 7, at 417. Stronger state and local support made the WIPP project able to deal with other issues which significantly delayed or derailed the Yucca repository. For example, when, in 1987, the EPA's environmental standards in 40 C.F.R. 191 were set aside and remanded by a federal court, DOE was able to continue the project by agreement with local leaders. The similar court remand of the EPA's standards for Yucca has not been handled by similar negotiation, and simply produced delay.

experience was the opposite.[96] The experience indicates that providing significant economic benefits to host states and localities is an important factor, as is past positive experience with federal nuclear programs. Long run benefits that take the form of economic development and jobs for local communities appear to be much more significant than cash transfers, although federal grants to New Mexico to retool its highway system and build emergency response capacity for nuclear waste transport was also important. Most of the employment provided by waste storage facilities and repositories consists of transient construction jobs. Reprocessing facilities and new types of reactors as well as R&D installations to develop these technologies are likely to offer long-run economic benefits. A number of local communities, many of which currently have DOE facilities, have expressed strong interest in hosting GNEP facilities. If, as may well be the case, no significant investment in advanced reprocessing and reactor facilities is made in the near future, it will be necessary for Congress to steer other types of federal facilities to communities open to considering hosting nuclear waste repositories or consolidated storage facilities.

Equally important, the WIPP regulatory process ultimately provided real authority and voice for New Mexico, and significant changes were made to accommodate its interests. Yucca was unilaterally imposed by Congress. Although the 1987 NWPA Amendments gave Nevada rights on paper (limited monetary compensation, involvement, veto subject to legislative override), the fact that no other site could be considered, and statutory hammers/deadlines designed to force a quick decision circumscribed any meaningful state input to and influence on the key decisions. The difference in the "political legitimacy" of the type of waste that would eventually be stored in each site—defense TRU waste at WIPP, civilian SNF and a more limited amount of HLW at Yucca—may also have been significant. Adopting risk-based classification of nuclear wastes and the process of public debate and education initiated by the Nuclear Waste Management

[96] Nevada had been the site of extensive nuclear tests; the federal government covered up the fact that residents had been irradiated. In Nevada, a strong gambling and tourism industry provide residents with a steady revenue stream and there was serious concern that siting of a nuclear repository would scare off tourism and business from Las Vegas. MCCUTCHEON, *supra* note 8, at 89.

Commission may come to make nuclear waste facilities more politically acceptable.

The federal entity charged with siting, such as the multimember commission sketched above, will necessarily have to have considerable discretion in its work. Congress, however, can and should take the following steps. It can direct that Yucca, if opened, will receive only a limited amount of wastes, on a pilot basis. It can eliminate restrictions on the development and capacity of federal MRS facilities. It can mandate, in general terms, procedures to give states a genuine say in siting and operation of new facilities and a measure of regulatory authority over the operation. It can also declare that it stands ready to target other federal projects and financial assistance to host communities and states. It can also provide a statutory resolution to the liability controversies between DOE and the utilities, which are a running sore in the federal waste management program. It may not be impossible, with the right process and package of incentives, to persuade New Mexico to accept HLW or even SNF at WIPP, or even to lead Nevada eventually to accept raising the statutory ceiling on the amount of wastes disposed at Yucca.

Finally, Congress should endorse full consideration by the federal government of consolidated storage at Yucca and other locations (for example, at any future reprocessing facilities that may be built), and make the way clear for potential development of private consolidated storage facilities. The balance between consolidated storage and storage at reactors and other production facilities should be made in a level legal and policy terrain. There are no reasons for the federal government to have a monopoly on siting. The private sector has made some considerable headway in siting hazardous waste facilities and other locally unattractive land uses by engaging local communities in an informed dialogue on risks and benefits and providing risk management assurances as well as economic benefits to those communities. The challenges posed by nuclear waste siting are even greater, but not insurmountable, as the PFS project indicates. Once Yucca is on the way to opening and the problems of federal liability for waste liquidated, Congress and the administration should take a far more hospitable stance towards private facilities, avoiding a repeat of the PFS facility vetoes.

CONCLUSION

Nuclear waste management and disposal should follow a step-by-step approach, keeping options open to the extent feasible, learning from experience, and dealing with unforeseen developments through a strategy of adaptive management. This approach, which has been recommended by well-respected National Academy panels[97] and is proposed by the Canadian Nuclear Waste Management Organization,[98] is radically different from the approach taken under the NWPA of establishing a detailed blueprint at the outset and pushing insistently forward with it despite mounting evidence of fundamental problems with the design. Implementing the new approach will require some basic legal and institutional changes to establish the necessary infrastructure for moving forward. The new Congress and Administration should seize the opportunity to make a fresh start rather than continuing to tinker with a broken system and strategy.

[97] NAT'L RESEARCH COUNCIL, RETHINKING HIGH-LEVEL RADIOACTIVE WASTE DISPOSAL: A POSITION STATEMENT OF THE BOARD ON RADIOACTIVE WASTE MANAGEMENT 34 (1990); NAT'L RESEARCH COUNCIL, ONE STEP AT A TIME: THE STAGED DEVELOPMENT OF GEOLOGIC REPOSITORIES FOR HIGH-LEVEL RADIOACTIVE WASTE (2003).

[98] NUCLEAR WASTE MGMT. ORG., CHOOSING A WAY FORWARD: THE FUTURE MANAGEMENT OF CANADA'S USED NUCLEAR FUEL: FINAL STUDY (2005).