The High-Level Radioactive Waste Policy Dilemma: Prospects for a Realistic Management Policy

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Introduction

Since the dawn of the atomic age, the United States and every other nation that has chosen to use nuclear power have created hazardous substances that have the capacity to outlast human civilization, and possibly even the human species, and the potential to devastate the environment. The management of these substances that make up what has been termed high-level radioactive waste (HLRW) has presented a set of technical and socio-political challenges that are matched by few, if any, other science and technology policy issues. For the purposes of this discussion, high-level radioactive waste consists of spent fuel from civilian and military reactors, as well as transuranic waste which comes primarily from the fabrication of nuclear weapons. The most serious of these challenges stem from the fact that this type of waste is extremely harmful to all life and will remain so (and, therefore, must be secured) for a period of time that is beyond anything in human experience (at least 10,000 and, possibly, more than 1,000,000 years). The time frame over which the waste will remain dangerous depends on its composition and, to some extent, on the definition of what constitutes a dangerous level of radioactivity. In terms of spent reactor fuel, composition is a function of the type of reactor and on whether or not re-processing takes place.

U.S. policy for the management of HLRW has focused on long-term (permanent) containment which still has many technical and policy issues to overcome. This focus has been to the detriment of medium-term containment—in fact, existing U.S. law explicitly prohibits the federal government from developing an interim (e.g., medium-term) repository for HLRW before a permanent disposal facility is operational. Medium-term containment presents technical and policy challenges that are inherently much easier to address than permanent disposal. This article argues that without a coherent national policy for medium-term containment, the U.S. HLRW management system is compromised, and the risks to human health and the environment are made higher than they need be.

Problems Inherent in the Permanent Isolation Option

The focus of national HLRW management policy on permanent isolation of this waste from the environment has been long standing. As early as 1956, when the nation’s civilian nuclear power program was little more than a research effort, the U.S. Atomic Energy Commission (AEC) promulgated regulations that, in effect, required all highly radioactive wastes to be permanently removed from the environment (Hewlett, 1978). The scientific consensus at the time was that geologic disposal (a method whereby stable geologic formations constitute the final barrier to waste dispersal into the biosphere) was the only realistic disposal method offering the possibility of permanent isolation. This consensus was expressed in a report prepared by the National Research Council of the U.S. National Academy of Sciences (National Research Council, 1957).

In accordance with the findings of this report, the AEC began the search for an appropriate site in which to construct the first permanent geologic repository for spent fuel from civilian nuclear power plants (none of which yet existed)—a search that continues a half century later. The quest for a permanent geologic repository site which was begun by the AEC and was continued by its successor agencies, the Energy Research and Development Administration (ERDA, extant from1974 to 1977) and, since 1977, the Department of Energy (DOE), faced several setbacks over the years. The investigation covered numerous sites in 36 states but failed to identify a single suitable location. The failure was in some cases due to the clearly inappropriate characteristics of the geology of the site, but was more often due to political opposition which made it impossible to even begin to study a site’s geology in any detail (Easterling and Kunreuther, 1995, pp. 26-34).

The setbacks in the search for a geologic repository site led to the consideration of other possibilities, still, however, with the purpose of permanent disposal. Consideration was given to deep sea disposal, extraterrestrial disposal, and conversion of radionuclides to stable nuclides

(Hewlett, 1978, Hadjilambrinos 1999). Each of these options presented its own set of difficult challenges, but they were afforded serious consideration because they offered the possibility of reducing domestic political opposition to HLRW disposal efforts.

Deep sea disposal proposals envisaged burial of the waste in sub-seabed geologic formations. This meant that this option was essentially a variant of geologic disposal. As such, its primary advantage was that it would remove the waste a safe political distance from any voting constituency's "back yard." While offering a few technical advantages, it presented additional technical problems (such as the need for special emplacement technologies) and policy dilemmas (such as restrictions imposed by international treaties) which made it impractical as an alternative to geologic disposal on land (Miles, Lee, and Carlin, 1985).

In the mid-1970s, disposal in space was considered to be a viable option for the disposal of some of the most hazardous components of spent nuclear fuel: the actinides (NASA 1973-1974). Thus, this option would necessitate significant processing of HLRW and would not eliminate the need for terrestrial disposal of the remaining components of the waste. A 1982 study concluded that at least 750 space shuttle flights would be needed to carry even the significantly reduced volume of actinide waste into space, and it also estimated that the risk of a catastrophic shuttle accident would be very small (about 1 in 2,000 launches) and the risk of release of waste material would be negligible: about 1 in 100 million (Rice, Denning, and Friedlander, 1982). The accident that destroyed the space shuttle *Challenger* in January 1986 (after only 24 shuttle missions) cast serious doubts on the basic premise these calculations were based upon. The *Columbia* accident, seventeen years and 87 shuttle missions later, along with NASA's inability to achieve the launch rate for space shuttles that was projected in the early 1980s, essentially removed extraterrestrial disposal of any portion of HLRW from any realistic consideration in the foreseeable future.

The third option studied as an alternative to land-based geologic disposal, the conversion of radionuclides to stable nuclides, could be considered the ultimate "technological fix" to the HLRW disposal problem because it would actually eliminate this type of waste. However, the processes to this end that have been studied thus far have only been able to eliminate miniscule amounts of HLRW, and most have generated a significantly greater volume of intermediate and low level radioactive wastes (Lenssen, 1991). Despite some recent advances in this area, no proposed method has been shown to be even close to becoming feasible at the necessary scale (International Atomic Energy Agency, 2000).

As none of these three options proved to offer a viable alternative to land-based geologic disposal, the search for a geologic repository site by the AEC, ERDA and, finally, DOE continued. However, political opposition thwarted the efforts of four consecutive administrations to identify an appropriate site and, in 1982, the U.S. Congress took action to resolve the HLRW disposal issue. With the passage of the 1982 Nuclear Waste Policy Act (NWPA), the nation's commitment to geologic disposal was not only reaffirmed, but actually codified into law. The NWPA directed the DOE to investigate a variety of sites throughout the U.S. for their potential to host a geologic HLRW repository. The law assigned the responsibility for drafting the radiation release standards to which any proposed repository would have to abide to the Environmental Protection Agency (EPA), and gave responsibility for repository licensing to the Nuclear Regulatory Commission (NRC). The law required the DOE to investigate sites throughout the nation and propose a list of six candidate sites, three of which were to be in the eastern half and three in the western half of the U.S., to Congress which would select one site in each half of the country for the development of two HLRW repositories.

This attempt, however, to cut through the political quagmire by an exercise of political will did not produce the anticipated results. Pursuant to the directives of the NWPA, in 1983, the DOE selected nine locations in six states for consideration as potential repository sites. Each of these sites had been the subject of study already for a number of years. However, the investigation of multiple sites facilitated the coalescence of political opposition that became strong enough to stall the process. Consequently, after five years of no progress, Congress intervened again, passing the 1987 Nuclear Waste Policy Amendments Act (NWPAA). This law ended the investigation of multiple sites by directing the DOE to study only Yucca

Mountain, Nevada, for the purpose of determining whether or not the site geology is unsuitable for hosting a permanent HLRW repository. Changing the objective of the site characterization study from determining the suitability of the site to determining whether it is unsuitable essentially eases the burden of proof. In the first instance, it is necessary to positively prove that releases of radioactivity will remain within the limits set by the EPA. In the second instance, it is only necessary to show that there is no evidence that the EPA standard will be violated.

Status and Prospects of Yucca Mountain

The NWPAA succeeded in overcoming the political opposition to the site selection process by effectively isolating the Nevada Congressional delegation. Nevertheless, as the DOE focused its investigation on Yucca Mountain, a number of problems began to crop up that slowed down the process of developing a permanent geologic repository at this site.

The 1982 NWPA assigned the EPA the responsibility for drafting the radiation release standards with which any proposed HLRW repository would have to abide (the 1987 Amendments did not change this situation). When the EPA released its draft set of standards for public comment in 1983, it was criticized by the majority of the scientific community for trying to impose a threshold of safety that, given the high uncertainty of any prediction pertaining to a 10,000 year framework, would be impossible to meet. The proposed EPA standard was based on limits to exposure to radioactivity set by the Clean Water Act. Furthermore, the EPA required that these limits not be exceeded at any point in time within 10,000 years of the time the repository were to become operational. Instead of questioning the efficacy of a permanent geologic repository, however, the community of experts demanded that the standards be lowered to make such a repository feasible. In this case, the "community of experts" comprises of scientists whose areas of expertise are the most pertinent to the investigations necessary for the development of a geologic HLRW repository. While some propose that the opinion of these experts should bear the most weight in advising policymakers, others argue that this segment of the scientific community has the greatest vested interest in the development of a repository. Notwithstanding this criticism, in 1985 the EPA promulgated a set of standards that were not substantially different from its original proposals. As this meant that a permanent repository would be impossible to license, the Yucca Mountain project was thrown into disarray (Hadjilambrinos, 1999). Opponents of the project used the EPA standards to delay the process, while proponents, including the community of experts continued to argue that the standards were unnecessarily strict. The deadline set in the NWPA (and left unchanged in the 1987 Amendments) for the repository to become operational and the DOE to begin receiving HLRW from the nation's nuclear power plant operators—January 1, 1998—became increasingly difficult and, ultimately, impossible to attain.

In the end, the repository proponents, arguing that the level of acceptable risk should be defined on the basis of supposedly "objective" scientific analysis, rather than through open public debate, succeeded in their effort to convince policymakers to intervene. Regulatory relief was provided the DOE through the1992 National Energy Policy Act, in which Congress directed the EPA to draft site-specific regulations (i.e., regulations that would only apply to the proposed Yucca Mountain repository) based on "reasonable" standards that would be recommended by the National Academy of Sciences (Energy Policy Act, 1992, § 801). Pursuant to this act of Congress, the National Academy of Sciences issued its recommendations in 1995, in the form of a report of a specially formed committee of the National Research Council (the Academy's research arm) (National Research Council, 1995), and the EPA began the process of drafting regulations once again.

Soon after the release of the National Academy of Sciences' report, a potentially serious flaw with the Yucca Mountain site surfaced. In late April 1996, DOE released a report by Los Alamos National Laboratory researchers that documented elevated levels of Chlorine-36 in five of the geologic faults that exist within the proposed repository site. These elevated Chlorine-36 levels could only have come from the atmospheric nuclear tests conducted in the Pacific Ocean in the 1950s (the radioactive chlorine isotope was created through the activation of seawater salt by nuclear explosions). In order to travel in less than 50 years to the depths of 600 to 1,000 feet below the surface where it was discovered , this radioactive isotope had to have been carried there by water flowing rapidly downward from the ground surface. This finding posed a serious threat to the Yucca Mountain project because the DOE's own siting guidelines, and the Nuclear Regulatory Commission licensing regulations, required a site to be disqualified if it were shown that groundwater travel time through the repository to the accessible environment (e.g., the aquifer) is "less than 1,000 years along any pathway of likely and significant radionuclide travel." (10 CFR 960.4-2-1-d, in Department of Energy, 2001) The DOE argued that the elevated Chlorine-36 levels did not necessarily violate the siting guidelines, and that, furthermore, in light of the National Academy of Sciences' recommendation that standards for the proposed Yucca Mountain repository be based on limiting *risks* to individuals of adverse health effects from radioactivity releases from the repository, rather than limiting radioactivity releases themselves, the existing suitability guidelines would have to be modified. DOE's claim that the presence of Chlorine-36 did not exempt the Yucca Mountain site under its original suitability guidelines was based on an interpretation of "groundwater travel time" as an average flux, i.e., sum of travel times for a "discrete segment of the system." DOE, calculating average and median travel times for the entire system, estimated groundwater travel time to be no shorter than 8,000 years. See response to Comment EIS001020 / 0001, Final Environmental Impact Statement, Vol. III, Part 2, Section 4.2 (3547). Nevertheless, the U.S. Nuclear Waste Technical Review Board (NWTRB) considered the matter serious and recommended the DOE conduct further studies of water flow through rock fissures (Nuclear Waste Technical Review Board, 1997). The Board was created by the 1987 Nuclear Waste Policy Amendments Act as an independent federal agency for the purpose of evaluating the technical and scientific validity of the DOE's studies of Yucca Mountain. Consequently, the DOE contracted with the U.S. Geologic Survey (USGS) for an independent study to confirm or refute the findings pertaining to Chlorine-36.

Technical problems combined with budget levels that were too low for planned development activities forced the DOE to push back once again from 1998 to 2001 the important milestone of an official site suitability recommendation. Assuming that the Yucca Mountain site would be suitable, the projected date for completion of the repository was the year 2010.

The EPA, after a long drafting process, released its final, site-specific radiation protection standards in June 2001 (40 CFR 197 in Environmental Protection Agency, 2001). The standards essentially had three distinct parts:

1. A risk-based standard applied to a "critical" individual (termed "Reasonably Maximally Exposed Individual"—RMEI) living in the vicinity of the repository. This required that the health risk to such an individual not exceed a certain allowable level at any time over the 10,000 years following closure of the repository.

2. A standard for a stylized human intrusion scenario involving a single borehole drilled into the repository, penetrating a single waste package, at a point in time after the waste containers have began to disintegrate. This standard replicates the RMEI standard for this special case.

3. A groundwater protection standard requiring the DOE to demonstrate that there is a reasonable expectation that, for 10,000 years of undisturbed performance of the repository, releases of radionuclides will not cause the level of radioactivity in the groundwater to exceed the current limits established by the Safe Drinking Water Act.

Following the release of the EPA standards, the DOE promulgated its final site-specific suitability guidelines (10 CFR 963 in Department of Energy, 2001). Under these guidelines, the DOE may determine that the site is suitable for the hosting of a permanent HLRW repository if it meets the EPA's pre-closure and post-closure requirements as described in that agency's site-specific safety standards. The DOE would use safety analyses to show that the pre-closure criteria are met, and total system performance analyses to show that the post-closure criteria have been met for 10,000 years. It should be noted here that the total system performance analysis (TSPA) method makes it unnecessary to show explicitly that natural geologic barriers play a major role in containing the disposed HLRW. Instead, it relies on both natural and engineered barriers to limit radioactivity releases with in the levels established by the EPA, without distinguishing the level of protection provided by each type of barrier. According to some analysts, the move to TSPA and away from specific geologic criteria (such as those contained in the DOE's original *general* guidelines) to determine site suitability cast in doubt the fundamental assumptions that underlie the concept of a geologic repository. The NRC also published its final licensing rule for the Yucca Mountain repository in 10 CFR 63, incorporating the provisions in the EPA standard (Nuclear Regulatory Commission, 2001).

These developments allowed the DOE to complete the final environmental impact statement for the proposed repository, concluding that there was no evidence that the Yucca Mountain site would be unsuitable (Department of Energy, 2002). Pursuant to this finding, on February 14, 2002, then Secretary of Energy Spenser Abraham forwarded to President George W. Bush his official recommendation that Yucca Mountain be approved as the site for development of a HLRW repository, in accordance with Section 114(a)(1) of the 1982 NWPA. On February 15, 2002, President Bush submitted to Congress his recommendation that the Yucca Mountain site be developed. The State of Nevada exercised its right to veto the President's recommendation by submitting to Congress a "notice of disapproval" on April 8, 2002 (Gwinn, 2002). On July 9, 2002, Congress passed a joint "resolution of repository siting approval" overriding Nevada's veto and approving the Yucca Mountain site for a repository, despite numerous concerns about remaining technical problems, including better understanding of the behavior of the natural components of the repository system, the implications of the presence of Chlorine-36, possible volcanic action consequences, issues pertaining to corrosion of the waste canisters, etc. These problems have been identified by various actors in the Yucca Mountain suitability debate, including the NWTRB (Nuclear Waste Technical Review Board, 2002, 2003, and 2004). The President signed the joint resolution on July 23, 2003, clearing the way for the DOE to begin the process of obtaining approval from the NRC to begin construction of the repository.

With legislative action once again clearing the way, the HLRW repository at Yucca Mountain, Nevada, appeared to be on track to meet the goal of being ready to accept waste in 2010. The DOE announced its plans to submit a license application to the NRC some time in 2004 for construction authorization and Congress supported these plans by approving budget increases for the Yucca Mountain project of 22% for 2003 and 26% for 2004. However, 2004 was marked by a series of setbacks. Congress appropriated only $572 million instead of the $880 million requested by the DOE for 2005 in order to support the license application to the NRC (this was a slight decline over the previous year's appropriation). This forced the DOE to move its target date for the license application to 2006, making completion of the repository before 2012 impossible. More important, however, in July 2004, the District of Columbia Circuit Court of Appeals struck down important provisions of the EPA safety standards for Yucca Mountain, as well as related provisions of the NRC licensing rule, finding that the 10,000-year compliance period upon which both sets of rules are based "is not 'based upon and consistent with' the recommendations of the National Academy of Sciences." (U.S. Court of Appeals, 2004) The Academy of Sciences' report had recommended a standard based upon the time at which radiation doses from the repository reach their peak:

> We believe the compliance assessment is feasible for most physical and geologic aspects of repository performance on the time scale of the long-term stability of the fundamental geologic regime—a time scale that is on the order of 10^6 [one million] years at Yucca Mountain—and that at least some potentially important exposures might not occur until after several hundred thousand years. *For these reasons, we recommend that compliance assessment be conducted for the time when the greatest risk occurs, within the limits imposed by long-term stability of the geologic environment.* (National Research Council, 1995, pp. 6-7)

Since "peak risks might occur tens to hundreds of thousands of years or even farther into the future" (National Research Council, 1995, p. 2), standards extending the compliance period to the time of likely peak exposure are more difficult to develop, and much more difficult to comply with (in fact, in its rationale for choosing a 10,000-year compliance limit, the EPA argued that determining compliance beyond that time frame would likely be impossible). For example, the EPA states: "we are unaware of a policy basis that we could use to determine the 'level of proof' or confidence necessary to determine compliance based upon projections of hundreds-of-thousands of years into the future." (Environmental Protection Agency, 2001, p. 32097) and "As IAEA noted, beyond 10,000 years it may be possible to make general predictions about geological conditions; however, the range of possible biospheric conditions and human behavior is too wide to allow 'reliable modeling'" (Environmental Protection Agency, 2001, p. 32099). Thus, the court decision may well make the Yucca Mountain repository (and possibly *any* geologic repository) impossible to license.

While it is possible that legislative action could again rescue the Yucca Mountain project—by, for example, codifying the 10,000-year regulatory period into law—such action may be politically untenable. On the one hand, the repeated Congressional actions, always favoring the development of a HLRW repository at Yucca Mountain increasingly lend credence to the criticism that the policy objective is *not* the safe disposal of this type of waste (and certainly not finding the *safest* location and means for disposal), but disposal at Yucca Mountain regardless of the environmental and health risks. On the other hand, the elevation of Nevada Senator Harry Reid to the position of Senate Minority Leader following the 2004 elections may well have shifted Nevada's political position in Congress from a state of weakness to one of strength. Congressional intervention is made even less likely by the recent revelations that one or more USGS employees may have falsified data used to support the recommendation for the selection of Yucca Mountain (Struglinski, 2005; Werner, 2005). Thus, after twenty years of research, close to $10 billion expended, and four acts of Congress, the prospects for building a geologic HLRW repository in the U.S. are at the very least highly uncertain.

Dry Cask Storage: from Stopgap to Viable Alternative for HLRW Management

While progress in developing a permanent geologic repository in the U.S. has time and again ground to a halt, the nation's nuclear power plants have been facing serious spent fuel storage problems. When the DOE declared that it would be unable to begin accepting HLRW on the mandated deadline of January 1, 1987, several nuclear power plants had been in operation for 20 years or more, and their spent fuel cooling pools were running out of space. As problems with the proposed Yucca Mountain repository continued to mount, nuclear power plant operators were forced to begin exploring alternatives to permanent disposal—and a practical and relatively inexpensive solution has emerged: dry cask storage.

Dry cask storage allows spent fuel that has already been cooled in the spent fuel pool for at least one year to be removed from the pool and be stored in a container that can provide adequate shielding. Spent fuel assemblies are dried and placed inside a container called a cask. The casks are typically steel cylinders that are either welded or bolted closed. The steel cylinder provides a leak-tight containment of the spent fuel which is surrounded by inert gas. Each cylinder is then surrounded by additional steel, concrete, or other material to provide radiation shielding to workers and members of the public. The NRC reviews and licenses the cask designs and issues permits for dry cask storage facilities.

The first operating license for a dry storage installation was issued in 1986 for the Surry nuclear power plant in Virginia, and today there are approximately thirty approved dry cask storage facilities throughout the U.S. (Nuclear Regulatory Commission, 2003). Each of these facilities is located at a reactor site (all but two are at commercial reactor sites), and most consist of a concrete slab upon which the casks are vertically placed in the open air (some facilities consist of above-ground concrete or steel structures and the casks are placed inside, either vertically or horizontally).

As completion of the Yucca Mountain repository is pushed further into the future and may even become unfeasible, and as spent fuel storage pools at more reactor sites are filled to capacity, the prospect of proliferation of dry cask storage sites is growing. With 72 commercial power plant sites in 33 states, more than half of which are currently approaching the capacity limits of their storage pools, it is not difficult to postulate that 50 or more dry cask storage facilities will exist throughout the U.S. by the end of the decade. If the problems of developing Yucca Mountain become insurmountable, then it is very likely that these facilities, which were meant to be temporary, will have to continue holding waste for an indefinite amount of time (Wald, 2004). Both of these prospects present important policy challenges that the U.S. government's single-minded, narrow focus on geologic disposal has made it impossible to solve.

The policy challenges that dry cask storage presents as it becomes the *de facto* HLRW disposal option for the medium term (25 to 100 years), stem from a number of potential problems:

- The proliferation of storage sites presents monitoring challenges with attendant security and environmental safety implications. These challenges are magnified significantly by the prospect that increasing number of sites will be "orphaned" as the nuclear power plants to which they are attached are decommissioned (some, such as the Maine Yankee site are already "orphaned"). Costly site protection and monitoring activities will have to continue indefinitely without attendant revenue-producing activities. How will safety and security vigilance be assured for each site over time?

- The ongoing development of dry cask storage sites with a multitude of different cask designs poses possible environmental risks that may make the exercise of other options in the future difficult. Most cask designs are not transportable. This means that for waste to be transported either to a permanent repository or interim storage facility, it must be transferred from the casks to special transport vessels. However, the extraction of waste from the casks may be risky. In order to maintain shielding, the waste will most likely have to be extracted under water. Cask-stored waste is hot enough to vaporize water virtually upon impact. The resulting steam may cause damage to the stored spent fuel assemblies, may cause explosions, or may carry dangerous radionuclides as it is vented. Steam would make even routine maintenance of the casks difficult. With transportation from cask sites being riskier, more complicated, and, therefore, more expensive than directly from storage pools, consolidation of a large number of sites to a few may become unfeasible.

- Is the development of numerous storage sites going to be acceptable to the public, both at each site and at-large? What are the socio-political implications of this option? Alternatively, the development of one or a small number of central storage sites, while making the management of the waste simpler, will also have to contend with the issue of public acceptance, as well as with issues of transportation planning and safety.

The environmental, security, economic, and socio-political issues arising from dry cask storage have been ignored because this option for managing the nation's HLRW has been overshadowed by the apparently all-consuming efforts to develop a permanent geologic repository. Thus, the emergence of dry cask storage as the *de facto* interim and, possibly, indefinite-term HLRW management policy, has been characterized by an ad-hoc approach that highlights the drawbacks of this option. Nevertheless, intermediate and long-term dry cask storage appears to meet many of the criteria for a truly effective HLRW management policy that have been proposed by several analysts (Shrader-Frechette, 1993; Easterling and Kunreuther, 1995; Flynn, et al., 1995; Hadjilambrinos, 2000). Dry cask storage is a monitored, retrievable waste management strategy that permits flexibility of options as better techniques are developed in the future. It also allows future generations to participate in the decision-making process—an approach that is ethically preferable to geologic disposal, assuming adequate resources are set aside to finance the ongoing management activities. Dry cask storage cannot be ignored any longer. A policy debate must be initiated for the purpose of determining how this option should be implemented in order to meet two very important objectives:

1. Address the nation's need for interim storage of HLRW in the most effective way; and

2. Provide at least a backup solution for the disposal of HLRW waste.

This policy debate is necessary to alleviate the problems inherent in the ad-hoc exercise of the dry-cask storage management option. For example, even if a decision about consolidation into one or a small number of sites is not made immediately, such consolidation can nevertheless be facilitated by selection of transportable cask designs (a few such designs exist and have been used in some sites). The specification of cask design characteristics clearly requires regulatory action, and such action clearly would be much more beneficial if it considered the full range of possibilities of dry cask storage as a HLRW management option.

The unwillingness up until now of policymakers to even consider the full range of possibilities of dry cask storage, as well as of other flexible waste management alternatives for high-level radioactive waste is not in the public interest. No reason for it can be found other than that the development of credible alternatives to geologic disposal for the long-term management of HLRW may pose a threat to the speedy development of a geologic repository. In fact, the history of policy action in the U.S. suggests that the construction of such a repository is a goal in itself, and is tied to the prospect of further development of nuclear power in this nation. Recognition of this fact, and divorce of the issue of future nuclear power development from the issue of management of the HLRW that has been and will be generated by *existing* nuclear power plants can only facilitate the development of effective management options for this waste.

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~~The Societal and Ethical Implications of Nanotechnology:~~

~~A Christian Response~~

~~Franz A. Foltz and Frederick A. Foltz~~

~~Just about every magazine on the newsstands has featured nanotechnology in the past year or two. These articles usually speak of nanotech as the latest emerging platform technology that will substantially transform our material and social world, just as electricity and nuclear science did previously. It will create faster and smaller computers, allow us to combat all sorts of diseases, manufacture new stronger and lighter materials, and save our natural environment. The articles speak of the ways it will change how just about everything is designed and made and in the process change our entire world: not just the physical but the social and ethical aspects as well.~~

~~What is usually not mentioned in these articles is reference to the fact that nanotech could be the first platform technology to offer significant opportunities to include discussions of the social and environmental concerns in its development. Usually, it is not until a technology is well established that its social and ethical implications become known (Collingridge, 1980, pp.17-18). The National Science Foundation claims that with nanotechnology there is much “more opportunity to integrate the societal studies and dialogues from the very beginning and to include societal studies as a core part of the National Nanotechnology Initiative investment strategy” (Rocco and Sims, 2001, p. 2). The end result is that the development of nanotech may not be left solely to the experts. The public may play a greater role than it previously has.~~

~~Nanotech and SEIN~~

~~The government acknowledged the importance of this new platform technology in January 2000 when President Clinton (White House, 2000) established the National Nanotechnology Initiative (NNI), a federal program to coordinate funding of nanotech research and development. He justified the money by claiming nanotech promises to build materials ten times the strength of steel at a small fraction of its weight, to shrink all information in the Library of Congress into a device the size of a sugar cube, and to detect cancerous tumors when they are only a few cells in size.~~

~~Many go beyond this extensive vision to claim working on the atomic and molecular level will offer the opportunity to solve all of humanity’s basic problems. In fact, one of the popular ways to present nanotech is to ask the audience to list the most pressing current and future global challenges that have potential technological fixes and then to claim nanotech will solve every one of them. Of course, no one mentions the potential social and ethical impacts of this new technology.~~

~~The government provided the opening for the greater community to become involved when~~