Principles for Safe Management and Geological Isolation of Irradiated Nuclear Fuel

This document proposes a set of principles for the safe management of commercial irradiated nuclear reactor fuel (i.e., commercial spent fuel) and high-level radioactive waste. The principles are designed to address the significant public health, environmental, and security risks posed by irradiated fuel. They recognize that irradiated fuel poses hazards for periods of time far longer than human history and must be managed in a way that minimizes its environmental, health, and security risks to the extent possible. And they recognize that nuclear power and nuclear weapons are intimately connected, not least in the issue of nuclear spent fuel and its management.

The environmental risks posed by irradiated fuel are extreme: As observed by the U.S. Court of Appeals, it has "the capacity to outlast human civilization as we know it and the potential to devastate public health and the environment." *Nuclear Energy Inst., Inc. v. Envtl. Prot. Agency, 373 F.3d 1251* (D.C. Cir. 2004).If irradiated fuel is dispersed into the environment, its radionuclides are sufficiently toxic to cause irreparable contamination of large areas of land and entire river and lake systems and coastal ecosystems.

The risk of nuclear weapons proliferation posed by irradiated fuel is also significant. Each metric ton of spent fuel typically contains more than one Nagasaki-bomb equivalent of plutonium – and, as of 2016, well over 70,000 metric tons had already be been created in the United States by the commercial nuclear power reactors. Spent fuel, storage and/or disposal may pose a risk of theft if it is stored or disposed of in a manner that would allow access in a few hundred years, when the fission product radiation barrier would have declined to low levels. .

Irradiated fuel therefore must be managed in a way that minimizes the risk of radioactive releases to the environment, and that ensures that the plutonium is secured and isolated from human contact so far as possible.

The principles of spent fuel/irradiated fuel management set forth below are designed to meet those goals. We consider the following areas:

1. Secure Hardened On-Site Storage (HOSS)
2. Transportation
3. Approach to long-term management
4. Technical principles of geologic isolation
5. Principles of informed consent

1.Hardened on-site storage (HOSS)

We are presently on track to achieving the worst of all possible worlds: inadequate safety measures for ongoing onsite storage at reactors; potential transport to consolidated "interim storage" sites that are likely to become permanent above ground dumps; and -- given that the federal government will have taken title to spent fuel at interim storage sites -- a lack of incentive for appropriating monies for deep geologic isolation. On top of that we also face likely revival of the licensing process for Yucca Mountain, an inadequate repository site from many points of view, including potential contamination of the only aquifer in the region.

Currently, the position generally accepted by many organizations is that nuclear waste should be stored in hardened dry storage and in open frame, low density configuration in spent fuel pools (as per the Hardened On-Site Storage (HOSS) principles). These principles originated in the wake of 9/11 because spent fuel pools are attractive targets for malicious acts. In establishing these principles, the endorsing organizations recognized that dense spent fuel storage can result in devastating and irreparable damage to millions or tens of millions of people in case of large releases due to severe accidents or malevolent acts. At the same time, we recognized that the dry cask storage designs presently in use are not satisfactory for purposes of interim on-site storage, much less for meeting HOSS criteria.

Despite continued fuel pool vulnerability, the HOSS principles have yet to be implemented. Given that nuclear spent fuel (irradiated fuel) is going to be stored at many reactor sites for decades, it is essential for us to come together and work to get the HOSS approach implemented. Robust dry storage is an essential part of our purpose.

We reject consolidated interim storage. It would add an additional site or sites to the ones already posing risks all over the country. Furthermore, consolidated storage could compromise the objective of long term waste management and isolation. Once the federal government takes title to the waste and moves it away from reactor sites, there will be no incentive to initiate a repository program, which by all accounts is costly. Indefinite consolidated storage will pose severe risks. As discussed below in Section 3, long-term above-ground storage of irradiated fuel is not a credible means of protecting irradiated fuel from the environment. Transportation to a Consolidated Interim Storage facility also poses severe risks. Finally, the facilities now proposed, in the West Texas and New Mexico border region, are not based on informed consent. For example there has been no discussion of the risk of long-term abandonment of the waste at these sites.

2.Transportation

Transportation is strictly to be minimized because the spent/irradiated fuel would pass through cities, over rivers and aquifers, and agricultural lands, raising the risk of malicious acts or accidents that could result in severe contamination causing serious harm to health, society, and the economy. Given their attractiveness as targets and the damage that could be caused by a breached transportation cask, irradiated (spent) fuel transport can be likened to thousands of rolling dirty bomb shipments. For example, the Congressional Research Service has estimated that a 1,000 curie cesium-137 dirty bomb in a city would result in $80 billion in costs for clean up to normally accepted maximum exposure levels. This does not include economic and property losses or increases in cancer and other health damage. Typical spent fuel shipments would likely contain far more than 1,000 curies of cesium-137 so that releases of even a fraction of the inventory could cause damage comparable to this example.

In order to minimize risks, transportation should be strictly connected to removing the spent fuel to a geologic isolation system that has been designed to the highest standards of radiation protection, security, and technical proficiency. For the same reasons, we reject “consolidated interim storage” and transportation to an interim storage site. Finally, we support the implementation of HOSS principles for storage at or as close to reactor sites as possible.

3.Approach to long-term management

Long-term above-ground or other similar storage for hundreds of years or longer would be very dangerous because of the risk of devastating ecological and economic damage due to loss of institutional control and dispersal of highly dangerous radionuclides like strontium-90 and plutonium-239. The Nuclear Regulatory Commission’s (NRC’s) “Continued Storage” rule and its assumption that the federal government will exist and be able, for tens of thousands of years, to appropriate money each year for security and safety, is an illusion. Indeed, the assumption is ill-considered, divorced from history, common sense, and the basis of NRC’s own rules (such as the low-level waste regulation) that provide for facility design for public protection based on the assumption that institutional control will be lost in a hundred years and physical barriers will not last more than 500 years. The risks of a loss of institutional control include severe irreversible contamination of the environment and devastating nuclear proliferation consequences.

Long-term above-ground storage of irradiated fuel is also very dangerous from a security point of view. Radiation levels that make the fuel lethal to handle will decrease, making the material less hazardous to handle. It would then be far less difficult, especially with loss of institutional control, to steal the spent fuel and process it for recovery of nuclear-weapons-usable plutonium. Ecological and security risks would be aggravated by climate change, which would increase the risk of dispersal of large amounts of radioactivity and of loss of institutional control.

Deep geologic isolation is the least harmful solution by far in a menu of bad options, not a “solution” in the sense of a guaranteed satisfactory outcome. Rather, deep geological isolation will reduce the worst case outcomes -- either in terms of ecological damage or security risks – in comparison to long-term above ground storage by many orders of magnitude. For instance, plutonium has a half-life of more than 24,000 years – isolating it from human society and making it as difficult to get at it again as possible is a central aim of geologic isolation.

Stopping the production of more spent fuel as soon as possible is a critical complement to this approach.

4.Technical approach to geologic isolation

A geologic isolation system is much more than a site for disposal or dumping of radioactive waste. It is a system that consists of three principal elements: geologic setting, engineered barriers, and sealing systems. These elements must work together to isolate the waste as completely as possible.

1. The *geologic setting* in which a mine would be built for creating the isolation system. The geologic characteristics should be suitable for containing the wastes and keeping them from the human environment without reliance on engineered barriers for long-term waste isolation. The characteristics of an appropriate geologic setting can and should be determined generically, without selecting or designating any specific site.
2. *Engineered barriers*, including containers for packaging the waste that would be designed to provide redundancy in waste isolation under the conditions of the geologic setting and the mine to be created in it.
3. *Sealing systems* for the drifts, tunnels, and the entire mine that would allow conditions similar to the integrity of the original unperturbed geologic setting to be reestablished. In addition, making accessibility as difficult as possible (to keep the plutonium isolated) should be a primary consideration for the sealing of the system.

These three elements would need to work together to isolate the wastes for long periods so as to limit maximum radiation doses at most to those we find acceptable for ourselves today. Moreover, they should be of a character that would allow estimation of waste isolation performance with reasonable confidence, using combinations of field and laboratory data, modeling, and systems analyses.

5.Informed Consent

Consent in a democracy necessarily means informed consent. Because we seek an isolation system that would protect society far into the future, informed consent requires specifying the standards of protection in advance of any technical work: What are the levels to which maximum health risks will be limited? What are the standards for making access difficult so as to minimize security risks associated with human intrusion for multiple half-lives of plutonium-239? Further, standards for radiation doses, appropriate geologic settings, and the difficulty of accessibility *should be established prior to consideration of specific isolation systems*. In other words, the first aspect of consent should be general acceptance of these public protection standards by the well-established process of notice-and-comment rulemaking. Isolation system work should begin only after standard setting is complete and the public understands the nature and extent of the risks.

Once these standards are established, a significant effort will need to be made, prior to the start of any site selection or even site identification, to study and understand how a variety of combinations of the three elements described in Section 4 above would work together to provide isolation corresponding to these pre-established standards. The aim will be to identify those combinations that may perform to acceptable predefined levels and those unlikely to do so. A decade or more of scientific and technical work, done transparently and with public participation would be necessary before any site selection process could begin.

Once the unworkable and potentially workable isolation systems are identified, a site selection process based on informed consent could be initiated. Consent should be at all levels of community, up to and including city, county and state and tribal governments. In addition to obtaining consent from potential disposal site communities, consent should be obtained from communities along transportation routes.

Once the consent process is initiated, it should be science-driven, transparent and open to the public. Data and analysis that indicate unsuitability should allow decision points that would terminate a specific investigation. On no account should public protection standards be weakened if an inquiry into a particular isolation system indicates that the system may not conform.

This document is intended to provide a well-considered basis for serious discussion. The names below are the authors of this document, listed here for purposes of attribution. This list does not imply organizational endorsements, nor is the purpose of this document to seek organizational endorsements.

Diane Curran
Tim Judson
Deb Katz
Arjun Makhijani