

Going the Distance?

The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States

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There are no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States. When conducted in strict adherence to existing regulations, the transport of spent fuel and high-level waste poses low radiological risk, and the safety, health, and environmental consequences are manageable. The successful initial implementation of large-quantity shipping programs, however, faces social and institutional challenges.

Spent fuel and high-level waste are byproducts of nuclear power production, defense-related activities, and research activities. Approximately 55,000 metric tons of the waste are now stored at more than 70 sites throughout the United States (see Figure 1). The majority consists of commercial spent fuel stored at nuclear power plants. The remainder is defense-

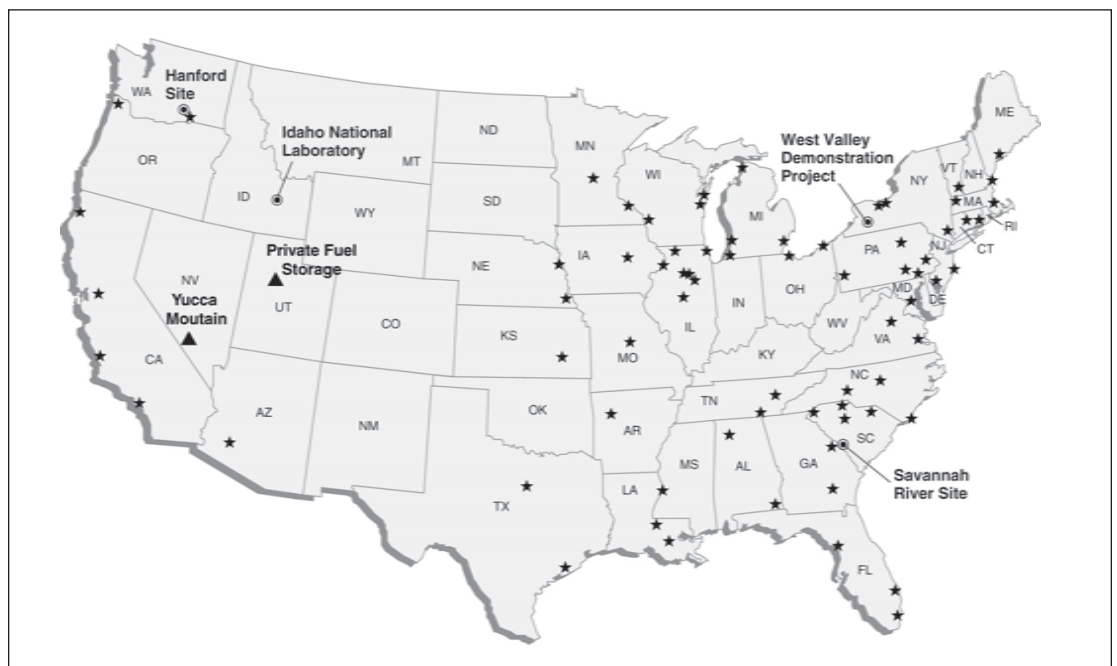
related spent fuel and high-level waste stored at four government-owned sites. Spent fuel and high-level waste are highly radioactive and—without the proper shielding—can be harmful or fatal to those exposed to it.

All of the U.S. sites are considered interim storage solutions. The federal plan is to transport spent fuel and high-level waste from those sites to permanent disposal in a geologic repository to be built at Yucca Mountain, Nevada. The U.S. Department of Energy (DOE) is responsible for transporting spent fuel and high-level waste to the repository.

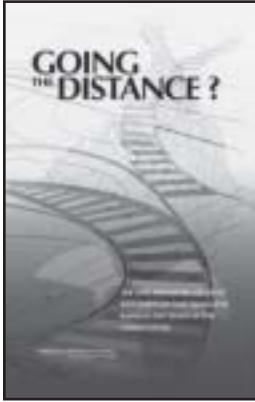
Larger Shipments

Since the 1950s, spent nuclear fuel has been transported on U.S. railways and highways in small amounts from a variety of sources, including nuclear-powered naval ships, research facilities, and nuclear

FIGURE 1 Locations of spent fuel and high-level waste storage sites, Yucca Mountain, and Private Fuel Storage, LLC, in Utah. (Stars indicate nuclear power plant sites; circles are government-owned sites for defense-related waste.)



SOURCE: DOE



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power plants that have shut down or that have run short of storage. Many other countries have transported spent fuel in much larger quantities. In the United States, only about 3,000 metric tons of the total inventory have been transported; the inventory increases by approximately 2,000 metric tons per year.

With the Yucca Mountain site scheduled to open in 2017, attention has turned to safely transporting much larger quantities of spent fuel and high-level waste. A challenge for a large-scale transportation program is that the storage sites for much of the commercial spent fuel in the United States are near large population centers. Moreover, shipments will pass through 31 states, including many major population centers, to reach the repository.

Recognizing the need for an independent examination of the risks and of the key concerns associated with this transport, the National Research Council's Nuclear and Radiation Studies Board and Transportation Research Board jointly initiated a study (see box, below). A key finding is that the transport of small-quantity shipments by highway and of large-quantity shipments by rail is an activity with low

radiological risk from a technical viewpoint; the safety, health, and environmental consequences are manageable with strict adherence to existing regulations. Nevertheless, the initial implementation of large-quantity shipping programs will encounter social and institutional challenges. In addition, the study committee notes that the challenges of sustained implementation should not be underestimated.

Assessing Risks

Risk is multidimensional. It includes the health and safety risks that can arise from the exposure of workers and the public to radiation from spent fuel and high-level waste. It also includes the social risks that arise from social processes and people's perceptions. Risks also can arise from incidents such as terrorist attacks, which the report does not address.

Health and Safety Risks

The two potential sources of radiation exposure during the transport of spent fuel and high-level waste are

- ◆ Emitted radiation, or radiation "shine," from packages during routine transport; and
- ◆ Potential increases in radiation shine and the release of radioactive materials in a severe accident that compromises the robust containers—also referred to as packages.

According to the report, the radiological risks associated with the transportation of spent fuel and high-level waste are well understood and generally are low. The report credits several factors, including

- ◆ Rigorous international standards and U.S. regulations covering the design, construction, testing, and maintenance of spent fuel packages;
- ◆ Full-scale crash testing of transport packages under severe accident conditions;
- ◆ A series of sophisticated analytical and computer modeling studies on the performance of the packages for transporting spent fuel; and
- ◆ Reconstructions of the mechanical and thermal loading conditions from severe accidents that did not involve spent fuel, to assess how spent fuel packages would have performed.

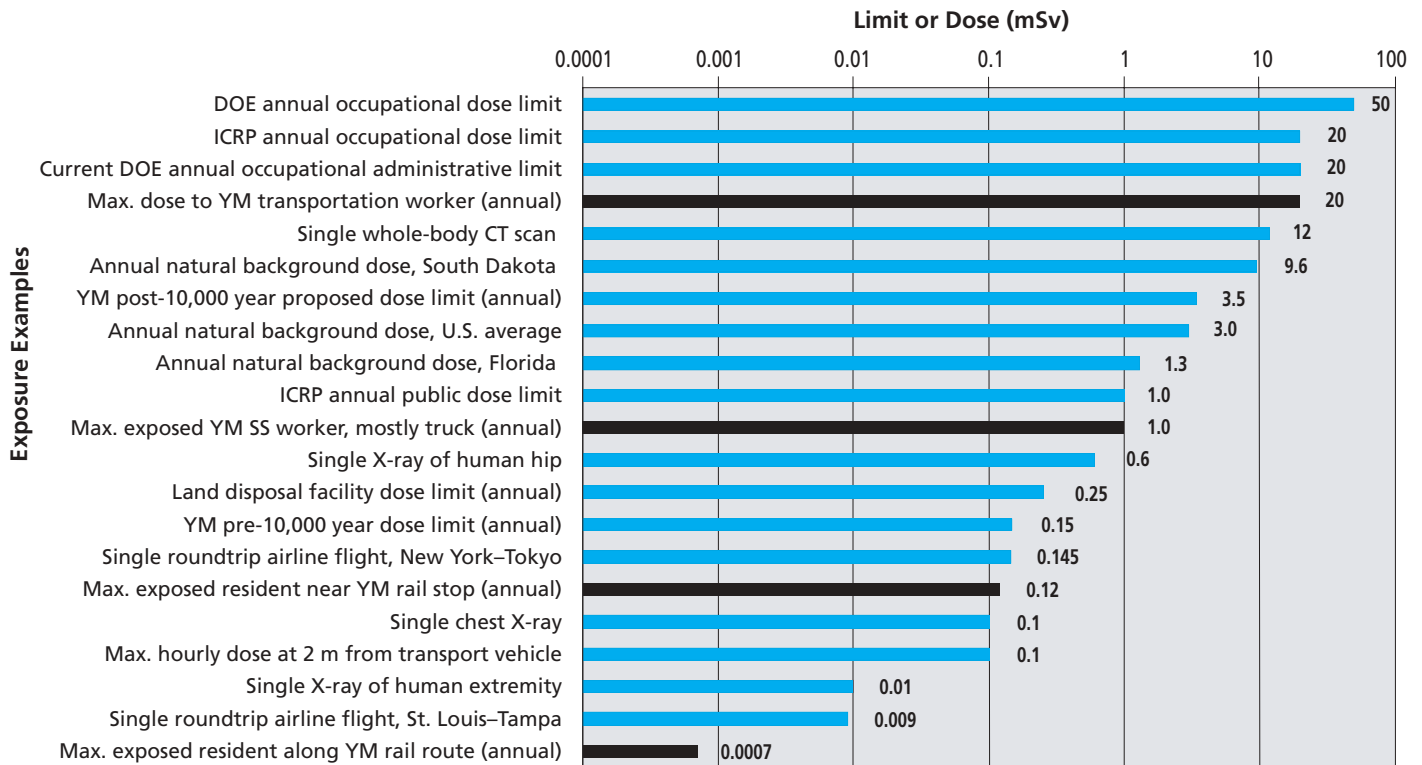
Extreme accidents generating fires of long duration that fully engulf the transportation package for hours or days, however, may compromise the radioactive contents. Although the likelihood of such extreme accidents appears to be small, the occurrence cannot be ruled out based on historical data for other types of hazardous materials shipments.

Committee on Transportation of Radioactive Waste

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The likelihood of occurrence and consequences can be reduced, however, with relatively simple operational steps and route-specific analyses. The report recommends that transportation planners and managers undertake detailed surveys of routes to identify potential hazards that could lead to or exacerbate extreme accidents involving long-duration, fully engulfing fires and take steps to avoid or mitigate the hazards. The report also recommends that the Nuclear Regulatory Commission conduct additional analyses to build on recent progress in understanding package performance in long-duration fires.

Radiation Exposure

Transportation packages contain heavy shielding to protect workers and the public from the radiation emitted by the spent fuel or high-level waste. The packages are effective in shielding more than 99 percent of the emitted radiation, but a small amount of radiation, primarily gamma rays, can escape from the packages and expose workers and the public to small doses that are below the regulatory limits. Under routine transportation conditions, the workers responsible for loading, inspecting, and transporting the packages also may receive doses. In addition, individuals who travel, work, and live along the shipping routes may receive small doses of radiation when loaded packages are transported in the vicinity.

Figure 2 compares estimated radiation doses from a Yucca Mountain transportation program with doses received in the course of other daily activities. The report also estimates exposures for severe accident conditions and concludes that expected fatalities from exposure to severe accidents involving spent fuel are significantly lower than for exposure to severe accidents involving other types of hazardous materials.

Managing Social Risks

Social risks can result in a variety of effects—for example, reduced property values along the transportation routes, declines in tourism, increased anxiety, or the stigmatization of people and places. The social risks pose important challenges to the successful implementation of programs for transporting spent fuel and high-level waste in the United States.

The committee recommends early and proactive steps to establish formal mechanisms for gathering high-quality, diverse advice about social risks and the ongoing management. The committee advises DOE to gather information about the social risks associated with the Yucca Mountain transport program:

1. Expand the membership and scope of the current advisory group to obtain outside advice on social risks; and
2. Establish a transportation risk advisory group to

FIGURE 2 Estimates of radiation exposure from the transport of spent fuel and high-level waste under routine conditions. (mSv = millisievert; YM = Yucca Mountain; DOE = Department of Energy; ICRP = International Commission on Radiological Protection; SS = service station.)



PHOTO: DOE

South portal of the Exploratory Studies Facility, Yucca Mountain, Nevada.

provide guidance on characterizing, communicating, and mitigating the social, security, and health and safety risks that arise from the transport of spent fuel.

Although addressed to DOE, these recommendations apply to any large-quantity shipping program, including the program to ship commercial spent fuel to a central interim storage such as Private Fuel Storage, LLC, in Utah.

Route Selection

One of the most controversial issues in the transport of spent fuel has been the selection of highway and rail routes. The report examines DOE's procedures to select rail and highway routes for transporting spent fuel from research reactors to its facilities. According to the report, the procedures appear adequate and reasonable—they are risk-informed; they use standard risk-assessment methodologies to identify a suite of potential routes; and they select final routes taking into account security, preferences of state and tribal governments, and information from states and tribes on local transport conditions.

The report recommends that DOE continue to ensure the systematic, effective involvement of states and tribal governments in decisions about the routing and scheduling of spent fuel shipments from research reactors. The U.S. Department of Transportation (DOT) should ensure that states support the designations of routes with sound risk assessments and that all potentially affected states are



PHOTO: DOE

Tunnel into Yucca Mountain was excavated with 25-foot-diameter, laser-guided boring machine.

aware of and prepared to fulfill their responsibilities for the designated routes.

Malevolent Acts

The report notes that malevolent acts against spent fuel and high-level waste shipments are a major technical and societal concern. The study committee does not provide an in-depth technical examination of transportation security because of information constraints. Instead, the committee recommends that an independent examination of the security of spent fuel and high-level waste transportation be carried out before the commencement of large-quantity shipments to a federal repository or to an interim storage. This examination should provide an integrated evaluation of the threat environment, the response of packages to credible malevolent acts, and the operational security requirements for protecting spent fuel and high-level waste during transport.

Additional Recommendations

The report offers several other recommendations for improving DOE's program for transporting spent fuel and high-level waste; some are summarized below. Many of the recommendations would apply to the implementation of any large-quantity shipping programs in the United States:

- ◆ **Rail shipments and routing.** The report strongly endorses DOE's plan to ship spent fuel and high-level waste to a federal repository using a mostly rail option. The report recommends that DOE fully implement this option before commencing large-quantity shipments. DOE also should identify and make public its suite of preferred highway and rail routes for transporting spent fuel and high-level waste to a federal repository as soon as practicable to support state, tribal, and local planning, especially for emergency response.

- ◆ **Emergency response planning.** DOE should begin immediately to execute its emergency responder preparedness responsibilities, defined in Section 180(c) of the Nuclear Waste Policy Act.

- ◆ **Information sharing.** DOE, the Department of Homeland Security, U.S. DOT, and the Nuclear Regulatory Commission should develop, apply, and disclose consistent, reasonable, and understandable criteria for protecting sensitive information about the transport of spent nuclear fuel and high-level waste. These agencies also should commit to openly sharing information that does not require such protection and should facilitate timely access to that information.

- ◆ **Organizational structure.** The Secretary of Energy and the U.S. Congress should examine options for changing the organizational structure of DOE's program to improve the chances of its success.