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Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste to a Repository

Factsheet

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The transport of spent nuclear fuel (SNF) and high-level radioactive wastes (HLW) to the proposed Yucca Mountain repository site in Southern Nevada has the potential to impact communities across the nation. Studies by the State of Nevada and the Department of Energy (DOE) indicate that 43 states would be directly impacted by thousands of SNF and HLW shipments to the proposed Yucca Mountain repository. At least 109 cities with populations over 100,000 plus thousands of smaller communities could be affected by such shipments.

The many uncertainties surrounding the transportation of nuclear waste to a repository make it extremely difficult to assess potential impacts and plan for contingencies. DOE and the nuclear industry point to the past history of spent nuclear fuel shipments as an indication of the inherent safety of this type of transport activity. While it is true that, since 1962, there have been no radioactive releases as a result of transportation accidents, the amount of waste shipped to a repository in the first full year of operations alone will exceed the total amount shipped in the United States for the past 30 years. In addition, the distances over which SNF and HLW would have to be shipped will be much greater for future repository shipments than for past shipments, which have often been shorter-distance transfers of spent fuel from one utility location to another.

The amount of waste shipped to a repository in the first full year of operations alone will exceed the total amount shipped in the United States for the past 30 years.

The State of Nevada has been examining transportation issues associated with the proposed repository for over 10 years. As a result of the State's work, a number of unresolved safety issues have been identified. These issues suggest that DOE's transportation planning process is, at present, inadequate to assure safe and uneventful shipment of nuclear waste to a repository or some other interim storage location.

Unresolved Safety Issues

1. Rail Transportation Feasibility and Risks

The way in which waste is shipped is an area of troubling uncertainty. DOE believes it would be safer to ship waste by rail, since rail shipments could be larger, carry more waste and ultimately require fewer numbers of shipments. However, a number of reactor sites, where waste is currently generated, do not have rail access or are not capable of handling large rail casks. In addition, there is no rail access to Yucca Mountain and providing such access could require up to 400 miles of new rail construction, could cost in excess of \$1 billion, and have to undergo detailed and lengthy environmental reviews under the National Environmental Policy Act (NEPA).

To date, DOE has identified three potential rail spur routes in Nevada. Detailed analysis has been performed on only one, and DOE has no plans to study others in more detail in the near term. The route DOE has studied would require the construction of 360 miles of new track from the Union Pacific main line near Caliente, Nevada along a roundabout route to

Yucca Mountain. The cost would be between \$1 billion and \$1.4 billion (in 1990 dollars). DOE's own analysis indicates there would be significant engineering challenges and environmental hurdles involved with this spur construction.

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All of the other possible rail spur options identified by DOE have similar problems, and it is questionable whether rail access can be provided - or whether Congress will appropriate the funds needed for an exceedingly expensive and potentially controversial rail line when highway access is presently available.

Legislation currently before Congress would require DOE to use an intermodal system of SNF and HLW transportation to Yucca Mountain or an interim storage site. This would entail the shipment of wastes in large containers by rail to eastern Nevada, and then transferring the canisters to very large "heavy haul" trucks for the trip to Yucca Mountain. Such transport poses new problems, including interference with routine traffic on existing state and U.S. highways, possible weather related problems and risks for large heavy haul vehicles in the winter months, added risks associated with extra handling and long distance truck transport associated with intermodal shipments, increased susceptibility to terrorist attack, and other problems.

2. Highway Transport Risks and Issues

Without rail access to Yucca Mountain or some form of intermodal transfer system, all waste would have to be shipped by truck along the nation's interstate highways and alternative routes that may be designated by states. This creates the possibility that between 35,000 and 100,000 shipments will be required during the 25-year emplacement phase of the proposed repository.

Under present federal routing requirements for spent nuclear fuel and high-level radioactive materials, most of these shipments would be routed through the heavily populated areas of major U.S. cities. Under federal regulations, alternative routes could be designated by the states, but any alternative route designations would involve tradeoffs in terms of risk to population centers versus risks associated with the use of longer routes on two lane highways over difficult terrain and through rural communities. States actions to designate alternative routes are further complicated by a recent court decision in New Mexico which could make state and local governments liable for loss of property values along designated shipping routes.

Truck shipments in the numbers needed for moving wastes to a repository from reactor sites around the nation would impact major population centers across the country and put nuclear waste trucks on the country's interstate highways in large numbers year round for almost 3 decades. Because of the numbers of shipments involved, the chances for accidents will increase, and because the new casks will carry more waste per shipment, the consequences of a very severe accident could also increase

3. Radiological Effects of Routine Shipments

One area of concern in nuclear waste transportation is the exposure of waste handlers, drivers, and the general public to radiation even during routine (non-accident) conditions. Even though shipping containers are shielded and designed to reduce exposures to radiation being emitted by the spent fuel or high-level waste, federal regulations allow a low level of radiation to emanate from the casks. This level is not dangerous under normal conditions. Nevertheless, repeated and long-term exposure to these low levels of radiation can have health consequences that need to be monitored and managed.

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Even after ten years of cooling, spent nuclear fuel emits dangerous levels of gamma and neutron radiation. A person standing one yard away from an unshielded spent fuel assembly could receive a lethal dose of radiation (about 500 rems) in less than three minutes. A 30 - second exposure (about 85 rems) at the same distance could significantly increase the risk of cancer and/or genetic damage. Defense high-level waste, which contains even higher concentrations of gamma-emitting fission products, is similarly dangerous. The surface dose rate of spent fuel is so great (10,000 rem/hour or more), that shipping containers with enough shielding to completely contain all emissions would be too heavy to transport economically. Federal regulations allow shipping casks to emit 10 millirems/hour at 2 meters from the cask surface, equivalent to about one chest x-ray per hour of exposure.

Routine exposures become especially problematic in situations where the transport vehicle is caught in heavy traffic with cars and other vehicles in close proximity for extended periods. Routine exposures also are of concern when the cask vehicle is stopped for repair, fueling, inspections, etc.

The health effects of low level radiation are poorly understood. There is evidence that even small amounts of radiation can have long-term health implications. The potential effects of repeated exposures to large numbers of nuclear waste shipments along highways or railroads during the 25-year repository emplacement phase have not been adequately addressed and could have adverse health consequences for certain segments of the public.

4. Probability of Serious Accidents

Between 1957 and 1964, there were 11 transportation incidents and accidents involving spent fuel shipments by the US Atomic Energy Commission and its contractors. Several of these incidents resulted in radioactive releases requiring cleanup, including leakage from a rail cask in 1960 and leakage from a truck cask in 1962. There is no comparable data for the period from 1964 to 1970, when utility shipments to reprocessing facilities began.

Between 1971 and 1990, there were six accidents and 47 incidents involving spent fuel cask shipments. Three accidents (two truck, one rail) involved casks loaded with spent fuel. No radioactivity was released in these accidents. Most of the incidents involved excess radioactive contamination on cask surfaces, a result of the so-called "weeping" phenomena on casks loaded and unloaded in wet storage pools.

Based on the 1971-1990 accident data, DOE calculated accident and incident rates for commercial spent fuel shipments to a repository. For truck shipments, DOE calculated 0.7 accidents and 10.5 incidents per million shipment miles. For rail shipments, DOE calculated 9.7 accidents and 19.4 incidents per million shipment miles. Because of the small number of spent fuel shipments and accidents during these years, DOE compared these accident/incident rates to the general accident rates for large commercial trucks and general rail freight movements. Based on this analysis, DOE concluded that accident rates for general truck and rail transportation should be used in repository transportation risk and impact studies. DOE recommended use of a truck accident rate of 0.7 - 3.0 accidents per million shipment miles and a rail accident rate of 11.9 accidents per million shipment miles.

An estimate of the number of accidents likely to occur during spent fuel shipments to a repository can be obtained by multiplying the anticipated accident rates by the anticipated cumulative shipment miles. If all spent fuel were to be shipped to the repository by truck in larger-capacity casks, requiring about 46,000 shipments and over 100 million shipment miles, between 70 and 310 accidents and over 1,000 incidents would be expected over the operating life of the repository. Under the DOE base case scenario (88% rail, 12% truck), about 50 to 260 accidents and 250 to 590 incidents would be expected.

While accidents severe enough to cause a failure of the transport cask and a resulting release of radioactive material are likely to be rare, the potential exists for serious accidents to occur. Transport containers for waste shipments to a repository have not yet been designed or built. Nor has DOE committed to full scale testing of the casks - something Nevada and other states have been advocating for ten years.

Both DOE and Nevada researchers have looked at the potential for a worst-case accident to occur. While there is disagreement over the specifics of a credible worst-case occurrence, there is agreement that

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such an accident would involve the release of some of the radioactive material inside the shipping cask.

to cleanup.

Spent nuclear fuel is both highly radioactive and thermally hot. Nuclear fission inside a reactor transforms a small percentage of the original uranium fuel into additional uranium isotopes, isotopes of plutonium and other transuranic elements, and fission products such as strontium-90 and cesium-137. Fission products, which account for most of the radioactivity in spent fuel during the first hundred years after removal from a reactor, emit both beta and gamma radiation. Reactor operations may also coat the exterior of the fuel rods with corrosion products, or "crud", containing radioactive isotopes of cobalt, nickel, and iron.

A typical ten-year old spent fuel assembly from a Pressurized Water Reactor (PWR) contains about 26,000 curies of strontium-90 (plus many thousands of curies of other dangerous isotopes). The strontium-90 in just one spent PWR assembly would be sufficient to contaminate twice the volume of water in Lake Mead (23 trillion gallons). While the strontium -90 and most of the other dangerous radionuclides are part of the solid pellets that make up the fuel, and therefore not easily dispersed, a severe accident or series of human errors could cause a release of fuel and/or crud particles mixed with smoke accompanying a fire. They could then be inhaled or enter the soil and contaminate the food chain. Other isotopes that remain highly radioactive for decades are so hazardous that inhalation or ingestion of amounts too small to be seen can lead to cancer, radiation-induced disease, and death.

A 1985 DOE contractor report concluded that a maximum severe, credible accident involving a single, current-generation rail cask could result in release of radioactive materials to the environment. The study assumed a severe impact followed by a massive fire fed by large quantities of fuel. According to the study, release of only a small fraction (1380 curies) of the cask's contents would be sufficient to contaminate a 42 square mile area. The costs of cleanup after such an accident would exceed \$620 million, and the cleanup effort would require 460 days, if it occurred in a rural area. An alternative analysis by an Agency contractor estimated cleanup costs for the same rural accident ranging from \$176 million to \$19.4 billion, depending primarily upon permissible post-accident soil concentrations of cobalt-60, cesium-134, and cesium-137, and upon regulatory requirements for disposal of the contaminated soil. Cleanup after a similar accident in a typical urban area would be considerably more expensive and time consuming (perhaps \$9.5 billion just to raze and rebuild the most heavily contaminated square mile or so). Much more detailed studies are necessary to estimate accident cleanup costs for a specific urban location in metropolitan Las Vegas or elsewhere in Nevada.

The conditions under which a worst-case accident could occur are poorly understood. DOE places great faith in the design and performance of the shipping container to prevent such an occurrence. However, without full-scale testing, shipping cask performance is, of itself, an area of significant uncertainty. Moreover, new shipping cask designs create new opportunities for human error. The longer shipping distances required because of Yucca Mountain's location (more than 2,200 miles on average compare to 600 miles for past shipments) will create additional opportunities for equipment failures and human errors.

5. Shipping Cask Performance

The first line of defense against an accident involving the release of radioactive material is, in DOE's planning for repository shipments, the shipping container. Designed to be extremely rugged and to withstand severe accident conditions, these casks are intended to assure adequate isolation of spent fuel and nuclear wastes from the reactor to the repository (or to some other storage location). DOE and the nuclear industry point to a good (although not flawless) record of shipping spent fuel since 1964 as evidence that casks will perform as they are intended.

While shipping casks are required to be licensed by the U.S. Nuclear Regulatory Commission, there is no requirement for the actual testing of full-scale casks to determine how they perform, and DOE and the nuclear industry have resisted all attempts to require such testing.

State of Nevada concerns regarding cask performance involve questions about the cask's ability to withstand severe accidents under real world conditions, the adequacy of testing requirements, and implications of new cask designs for repository-related shipments.

While shipping casks are required to be licensed by the U.S. Nuclear Regulatory Commission (NRC), there is no requirement for the actual testing of full-scale casks to determine how they perform. A cask is required by NRC to be able to withstand, in succession, the following four tests: a drop from 30 feet onto an unyielding surface; a drop from 6 feet onto a spike (a puncture test); a 30 minute fire at 1425 degrees (F); and a 30 minute submersion in three feet of water. NRC regulations do not require full-scale tests for licensing casks. The NRC allows cask designers to substitute scale-model (1/10 to 1/2) tests and computer simulations for full-scale testing. Moreover, the NRC performance standards are based on hypothetical accident scenarios supported mainly by a technical study known as the Modal Study, prepared by Lawrence Livermore National Laboratory. The Modal Study's transportation assumptions are not relevant to DOE's Yucca Mountain transportation plans. Additionally, detailed case studies of recent truck and rail accidents have raised serious doubts about how well the NRC standards reflect real world accident conditions. This is particularly the case regarding accidents involving high speed impacts (over 55 miles per hour), long duration (up to several days) and high temperature (over 2000 F) fires, and collisions with vehicles carrying high-energy explosives.

None of the spent fuel casks currently in use have been tested full-scale. The spectacular crash and burn films shown by DOE and the nuclear industry actually depict obsolete casks (withdrawn from service) being tested in the 1970's to validate computer models. Those tests were successful for that purpose, and also provided valuable insights into the importance of cask tie-down systems

The casks to be used in a repository shipping campaign are currently being designed, and none have yet been built. All of the new designs would hold more fuel assemblies, be less heavily shielded, and pose greater risks in the event of a severe accident

and other issues. The tests also demonstrated the vulnerability of lead gamma shielding to long duration fires and to multiple impacts. However, the tests were not intended to simulate worst-case accidents or to prove the overall safety of spent fuel shipments. DOE's misuse of these tests films can be fairly labeled as propaganda. **that results in a loss of containment.**

The casks that might be used in a repository shipping campaign are currently being designed. None have yet been licensed or fabricated. Such casks are very likely to be markedly different from current casks. All of the new designs proposed by DOE would hold more fuel assemblies and be less heavily shielded (due to the age of the fuel to be shipped). How these casks will perform in real world accident situations is uncertain. NRC regulations do not require casks to be physically tested.

New, larger transportation casks (100-125 tons) being considered for future spent fuel shipments have the potential, if not properly loaded, to allow the fuel assemblies to go critical under certain conditions - i.e., start a nuclear chain reaction that would cause a catastrophic temperature rise in the canister. The imperative for accurate and verified fuel loading calculations increases the potential for human error and thereby increases the risks and uncertainties associated with waste transport.

The use of such larger shipping containers raises questions about the adequacy of NRC cask licensing regulations and about the appropriateness of these regulations for assuring these new and much larger canisters will be able to withstand real world accident conditions.

The State of Nevada, the Western Interstate Energy Board, the Western Governors' Association, and numerous other states and multi-state organizations have made detailed recommendations to DOE for full-scale cask testing to demonstrate compliance with the current NRC performance standards, reexamination of the adequacy of the NRC standards, and possible extra-regulatory testing to determine cask failure thresholds. To date, DOE has ignored these recommendations and has no plans to test proposed new cask designs.

6. Waste Type and Volume

The issue of how much and what type of wastes would be shipped to a repository remains unclear. The first repository is currently limited by law to no more than 70,000 metric tons of uranium (MTU). However, given the expected amount of spent fuel from currently operating reactors and defense high-level waste requiring disposal in a repository, more than 100,000 MTU of high-level wastes could be earmarked for the proposed Yucca Mountain repository. Additionally, an unknown amount of "miscellaneous wastes requiring geologic disposal" could also be shipped to Yucca Mountain.

The volume and types of waste make a great deal of difference in terms of transportation operations and transportation risks. If all waste available for disposal in a repository is shipped to Yucca Mountain, the numbers of shipments increase significantly. Civilian spent fuel from nuclear power plants will be the largest source of high-level radioactive waste shipped to the repository. Under current law, with capacity limited to 70,000 MTU, DOE has reserved 90% of the repository capacity,

or about 63,000 MTU, for civilian spent fuel. However, the currently operating nuclear power plants are projected to generate between 80,000 MTU and 85,000 MTU of spent fuel by the year 2030. Since there are presently no plans for constructing a second repository, the Agency's planning studies assume that DOE will attempt to ship all civilian spent fuel to Yucca Mountain if the site is licensed. DOE-owned spent fuel, from foreign and domestic research reactors and from nuclear-powered naval vessels, will likely also be shipped to Yucca Mountain. This has implications for accident risks, routine exposures, and emergency preparedness.

The total amount of defense high-level wastes requiring geologic disposal is unknown. DOE has allocated 7,000 MTU of capacity at the repository (about 14,000 canisters) for high-level wastes generated at DOE weapons facilities at Hanford, Washington, Idaho Falls, Idaho, Savannah River, South Carolina, and for a small amount of civilian reprocessing waste currently stored at West Valley, New York. Most of this waste is presently stored in liquid form in underground tanks. Prior to shipment, these wastes would be solidified in borosilicate glass logs inside stainless steel canisters. The total amount of such high-level wastes requiring disposal in a repository has been estimated to be as high as 40,000 canisters, equivalent to 20,000 MTU of spent fuel. The shipping containers for these wastes have not been designed yet, but for planning purposes, DOE has assumed two canisters per truck cask and 5 canisters per rail cask. Shipment of 7,000 MTU of these high-level wastes would require 7,000 truck loads or 2,800 rail casks; shipment of 20,000 MTU would require 20,000 truck loads or 8,000 rail casks.

In addition to spent fuel and vitrified high-level wastes, a significant quantity of "miscellaneous wastes" will likely be shipped to a repository. These are transuranic wastes from commercial reactors and industrial facilities, radioactive cesium capsules used in commercial irradiation facilities, reactor decommissioning wastes, and wastes from routine power reactor operations which are too radioactive for disposal in low-level waste sites. No one knows for sure what will be the amount of these wastes or their transportation package capacities. In 1987, DOE estimated that these wastes could total between 12,100 and 20,600 cubic meters. Such an amount would be equivalent to between 12,100 and 20,600 canisters of defense high-level waste in volume.
