FACT SHEET

Safely Managing Used Nuclear Fuel

January 2009

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Key Facts

■ All the used nuclear fuel produced by the U.S. nuclear energy industry in 50 years of operation—approximately 60,000 metric tons—would, if stacked end to end, only cover an area the size of a football field to a depth of about 7 yards.

■ Used fuel is a solid material that is stored safely and securely at nuclear power plant sites, either in enclosed, steel-lined concrete pools filled with water, or in steel or reinforced concrete containers with steel inner canisters.

■ The U.S. Nuclear Regulatory Commission determined that used fuel could be stored safely at power plant sites or central storage facilities for at least 120 years. Diligent monitoring and maintenance of safety systems ensure public health and safety are protected.

■ Advanced technologies are being developed to recycle used nuclear fuel. These technologies would reduce the amount of radioactive byproducts in the material, while recovering valuable energy, but would not completely eliminate the byproducts. Under any used fuel management scenario, disposal of radioactive byproducts in a permanent geologic repository is necessary.

■ Congress and President Bush approved Yucca Mountain, Nev., as the site of a federal geologic repository for used nuclear fuel and high-level radioactive defense waste in 2002. In June 2008, the U.S. Department of Energy submitted to the NRC a license application to build the repository. The application was accepted by the NRC and is now under technical review. Provided the application is approved, DOE will construct and operate the facility.

Solid Used Fuel: Small Volumes, Safely Stored

To generate electricity, nuclear power plants use uranium oxide fuel—in the form of small ceramic pellets—that is placed inside metal fuel rods. These rods are grouped into bundles called assemblies. Fission—the splitting of uranium atoms in a chain reaction—produces a tremendous amount of heat energy for the amount of material consumed. This energy is used to boil water into steam, which drives a turbine generator to produce electricity.

Every 18 to 24 months, the plant is shut down and about one-third of the fuel, consisting of the oldest fuel assemblies—which have released a considerable amount of energy but have become intensely radioactive as a result of fission—are removed and replaced.

Used nuclear fuel from nuclear power plants is in solid form. A typical 1,000-megawatt nuclear plant produces enough electricity for 740,000 homes and generates about 20 metric tons of used fuel each year.

The country's 104 commercial nuclear reactors together produce about 2,000 metric tons of used fuel annually. Today, this used fuel is stored safely and securely at plant sites, either in enclosed, steel-lined vaults filled with water known as used fuel pools or basins, or in steel-and-concrete containers.

Commercial reactor sites have the capability to deploy additional steel-and-concrete containers on site. Many of these containers are licensed both for storage on site and for transport.

Eventually, used fuel will be moved from plant sites to a centralized storage facility, recycling facility or federal repository. The path chosen will depend on the availability of advanced recycling technologies, the location of the nuclear plants and the age of the used fuel at the time it is removed from the reactor sites. Under any scenario, a permanent geologic disposal facility is necessary.

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Interim Options: Expanding On-Site Storage

The delay in the construction of the repository has forced nuclear power plants to store more used fuel on site than expected for longer than originally intended. The result is that many nuclear plants are running out of existing storage capacity. When a plant's used fuel pool nears its designed capacity, a company has two options.

Expanding Pool Capacity

Typically, the first choice is to re-rack the used fuel pool, moving the fuel assemblies closer together. More than 130 re-rackings have been completed safely at various nuclear plant sites. But re-racking has its limitations.

Eventually, even re-racked pools reach their capacity. Building a new used fuel basin is not an option due to the expense and the lack of room to fit such an extensive new structure inside the plant layout. Although a few companies have shipped used fuel from one plant to another with extra storage capacity, this option is not available to most companies.

Container Storage

Most nuclear plants have used the additional capacity gained by re-racking, and a growing number have built or are building storage facilities on or near the plant sites using concrete-and-steel bunkers or storage containers on concrete pads.

About one-half of U.S. nuclear plants are storing used fuel in large, rugged containers made of steel or steel-reinforced concrete. These dry storage containers use materials like steel, concrete and lead—instead of water—as a radiation shield. Depending on the design, a container can hold up to 56 fuel assemblies.

The NRC has certified several container designs for use by utilities. The containers have a 20-year license. After 20 years, they must be inspected and, with NRC approval, the license could be extended for another 20 to 40 years.

Loaded containers are filled with an inert gas such as helium, sealed, and stored either on reinforced concrete pads or in concrete bunkers. The containers are designed to prevent the release of radioactivity while withstanding natural disasters such as tornadoes, hurricanes and floods. The designs require no mechanical devices for cooling and ventilation.

Building a dry storage facility at a plant site requires an initial investment of $10 million to $20 million. Once the facility is operational, it will cost $5 million to $7 million a year for the maintenance and security of the facility and for adding more containers as storage needs grow. These costs are in addition to the fee that electricity consumers pay into the Nuclear Waste Fund.

Centralized Off-Site Storage Facility

Until a recycling facility or a repository is ready to accept used fuel from nuclear power plants, the United States could benefit from centralized interim storage. Interim storage would provide for a more effective and efficient used fuel management system by consolidating the material and optimizing the transportation infrastructure that would be necessary for the eventual movement of the material to a recycling facility or a permanent geologic repository. It would also demonstrate that the United States can centrally manage used nuclear fuel.

Closing the Nuclear Fuel Cycle

The resurgence of nuclear energy in the United States and around the world has led to a reassessment of the nation's long-term used fuel management program, including renewed interest in nuclear fuel recycling and advanced nuclear fuel-cycle technologies. These technologies include advanced reprocessing of used nuclear fuel, advanced fuel fabrication and development of new reactor designs that could further minimize byproducts of the uranium fuel cycle. These technologies, taken together, could reduce the volume, heat and radiotoxicity of nuclear waste byproducts requiring disposal.

These advanced technologies will also take advantage of the enormous amount of energy

remaining in the fuel rods after they are removed from the reactor. Existing recycling technologies already do this to a certain extent. However, advanced recycling technologies would accomplish a more complete recycling in a way that does not produce nuclear materials that could be diverted to weapons-related activities.

Any decision to pursue advanced fuel cycles in the United States must consider economic and nonproliferation challenges associated with recycling uranium fuel.

Whether or not the United States decides to pursue recycling, it will still require a permanent repository. All nations that reprocess used fuel, such as France and Japan, also are developing repositories.

Yucca Mountain Central To Managing Used Fuel

DOE is developing a permanent disposal facility for used nuclear fuel and radioactive defense waste at Yucca Mountain, Nev., about 90 miles northwest of Las Vegas. Congress charged DOE with developing a geologic disposal facility in 1982 and set a 1998 deadline for its completion. That deadline is long past due.

Presidential and congressional approval of the Yucca Mountain site in 2002 was a significant step toward meeting this obligation. Before any fuel is deposited at the Yucca Mountain repository, DOE must obtain approval from the NRC to build and operate the specially designed repository.

DOE submitted a license application for repository construction to the NRC in June 2008. In September 2008, the NRC accepted the application and has begun a rigorous process where the application will be both questioned by the NRC's technical staff and challenged by repository opponents. Depending on the outcome of this process, DOE estimates the repository is not likely to open before 2020.

To fund this federal program, the law established the Nuclear Waste Fund. Since 1983, consumers of electricity produced at nuclear power plants have paid into the fund a fee of one-tenth of a cent for every kilowatt-hour of electricity. Through January 2009, these customer commitments, including interest, totaled more than $30 billion.

The law also requires the federal government to pay its share of disposal costs for high-level radioactive waste from national defense programs and other material slated for the repository.

Safely Transporting Used Nuclear Fuel

Used nuclear fuel will be transported from nuclear power plants to storage, recycling and disposal facilities by rail, truck or barge.

The transportation containers used to ship used fuel typically have walls one foot thick, with radiation-shielding materials sandwiched between outer and inner metal shells. Those designed for truck transportation weigh between 25 and 40 tons and carry one to seven used fuel assemblies. Rail containers weigh up to 125 tons and carry up to 68 assemblies.

To ensure the transportation containers retain their integrity even in the event of an accident, they are designed to with-stand a consecutive series of highly destructive tests: a 30-foot fall onto a flat, unyielding surface; a 40-inch drop onto a vertical steel rod; exposure to a 1,475 degree Fahrenheit fully engulfing fire for 30 minutes; and submersion under 3 feet of water for eight hours.

NRC studies show that the container requirements presume forces far more destructive than would occur in real accidents. Actual tests carried out in the United States and Europe have verified the accuracy of computer models and scale-model tests to analyze the ability of containers to withstand the most severe accidents.

In these tests, containers were crashed into unyielding concrete walls at more than 65 miles per hour and hit by locomotives traveling at 80 mph. Researchers also exposed the containers to fully engulfing fires, dropped massive weights on them and detonated gas tanks next to them. The containers used in these brutal tests survived

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intact, verifying the integrity of their design.

During the past 40 years, more than 3,000 shipments of used fuel have been completed safely in the United States, covering 1.7 million highway, rail and barge miles. Outside the United States, there have been tens of thousands of safe shipments of used nuclear fuel.

Although vehicle accidents have occurred, there has been no release of radioactive materials from the containers or a single injury attributed to the cargo's radioactive nature. According to DOE, when the federal government opens a permanent repository, about 175 used fuel shipments will travel to Yucca Mountain each year, moving 300 to 500 containers annually.

Conclusion

Since the 1950s, scientific organizations around the world have examined the issue of radioactive waste management. Most organizations—including the National Academy of Sciences, Office of Technology Assessment, International Atomic Energy Agency, and the Organization for Economic Cooperation and Development's Nuclear Energy Agency—have reached the same conclusion: the best and safest long-term option for safely managing high-level radioactive waste is deep geologic disposal.

High-level radioactive waste can be disposed as used fuel directly from nuclear power plants or as a final waste form after the used fuel is recycled.

After nuclear fuel is removed from a reactor, it is stored on the reactor site in vault-like, water-filled basins or in heavily shielded dry casks.

Prior to either recycling or disposal, used fuel may be sent to a central interim storage facility that would be located near the recycling facility.

For disposal of either used fuel or high-level waste from recycling, a geologic repository is needed. Yucca Mountain is the most extensively studied geologic disposal site in the world.

Multiple analyses of the scientific data collected at the site show that used nuclear fuel can safely be stored there for thousands of years until radioactive decay renders the material no longer hazardous.

This fact sheet also is available at www.nei.org*, where it is updated periodically.*