# Nuclear Waste

## A Guide to Understanding Where We've Been and Where We're Going


National Conference of
State Legislatures

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# Timeline of Nuclear Issues in the United States

•1942 – Enrico Fermi achieves the first controlled nuclear chain reaction at the University of Chicago.

•1945 – The United States uses nuclear weapons against the Japanese in World War II.

•1946 – The Atomic Energy Act guides post-war nuclear weapons and power development under civilian control.

# Timeline of Nuclear Issues (cont.)

- 1953 – President Eisenhower promotes Atoms for Peace to distribute nuclear technology around the world "to serve the peaceful pursuits of mankind."


- 1955 – The Atomic Energy Commission announces a joint government/industry program to develop nuclear power plants.

  Arco, ID (population 1,000) is the first town powered by nuclear energy.

- 1957 – The Price-Anderson Act is enacted to protect nuclear power plant owners from financial hardships in the event of an accident.

# Timeline of Nuclear Issues (cont.)

- 1974 – President Ford replaces the Atomic Energy Commission with two new entities: the Energy Research and Development Administration and the Nuclear Regulatory Commission for oversight.
- 1977 – President Jimmy Carter bans the reprocessing of spent nuclear fuel due to concerns about byproduct (plutonium) proliferation.
- 1979 – A partial core meltdown at the Three Mile Island nuclear reactor in PA results in little radioactive release and calls for safety improvements at plants.

# Timeline of Nuclear Issues (cont.)

- 1981 – President Ronald Reagan lifts the ban on reprocessing of spent fuel and calls for a high-level radioactive waste storage facility.
- 1982 – Congress passes the Nuclear Waste Policy Act (NWPA), establishing a timeline for a permanent underground facility for nuclear waste disposal.
- 1987 - The NWPA Amendments pass, naming Yucca Mountain as the sole site to be characterized for development of a repository.
- 2002 - President Bush designates, and Congress approves, Yucca Mountain as the repository location.

# Timeline of Nuclear Issues (cont.)

- 2005 - President Bush signs the Energy Policy Act, supporting expanded development of nuclear power.
- 2010 - DOE suspends license application for Yucca Mountain.  Blue Ribbon Commission on America's Nuclear Future established.
- 2011 - FY2011 budget eliminates funding for Yucca Mountain

Timeline sources: Atomic Archive
Public Broadcast Service
U.S. DOE, Office of Environmental Management.

# Nuclear Power

Nuclear power generation in the United States began in the 1950s. Experimental and government-owned reactors proved successful in Idaho (1955), California (1957), and Pennsylvania (1957). Dresden 1 Nuclear Power Station in Illinois, the first plant built without government funding, achieved a nuclear reaction in 1959 and remained in operation through 1978.

Since the 1950s, 132 commercial reactors in 35 U.S. states have been licensed for operation. Today, 104 remain in operation at 65 sites in 31 states.

Worldwide, 442 reactors are in operation in 30 countries.

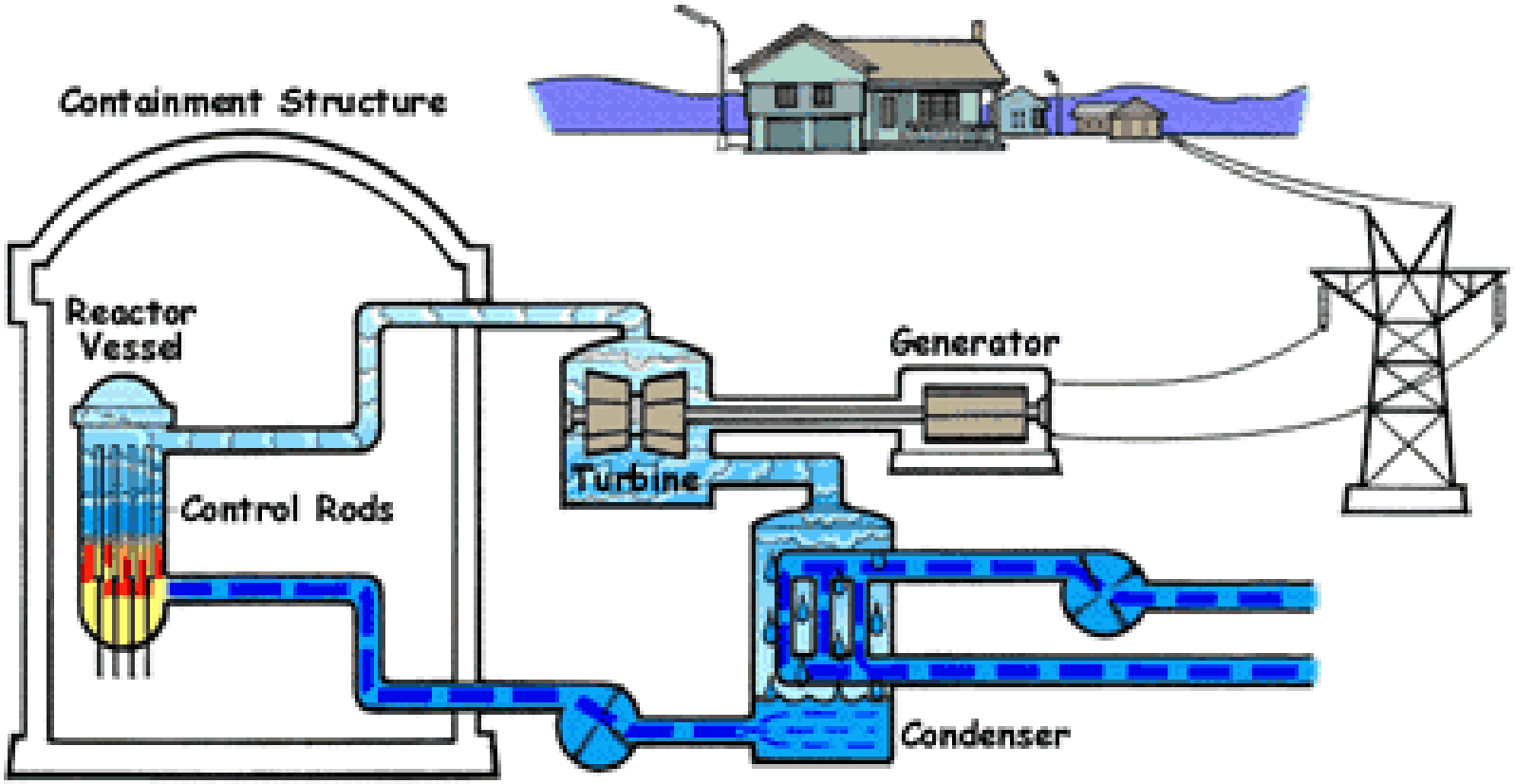
Source: NRC Information Digest, 2006-2007

# Nuclear Reactors

There are two types of commercial nuclear power reactors in the United States:

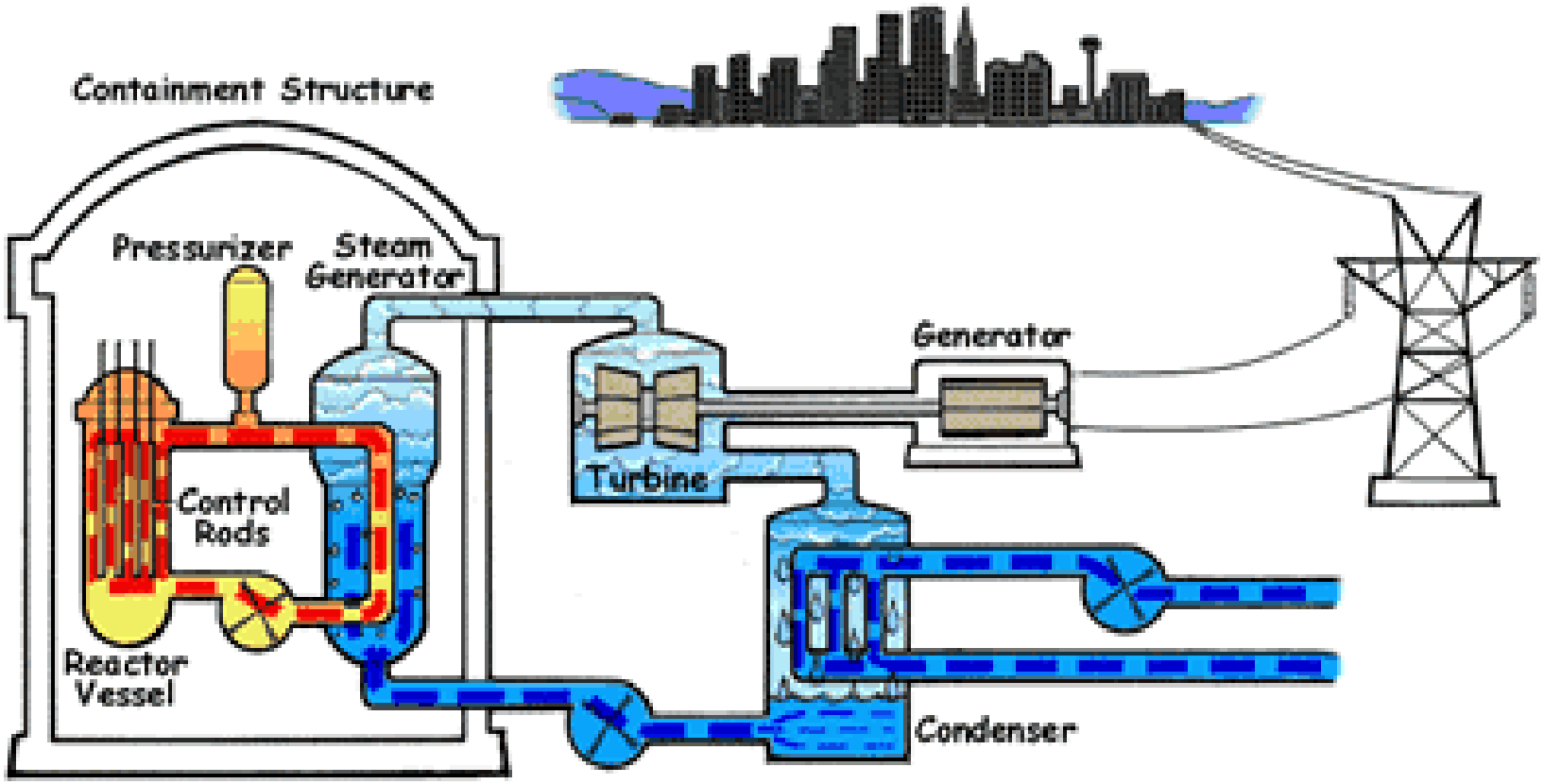
- Boiling Water Reactors (BWR)
- Pressurized Water Reactors (PWR)

# Boiling Water Reactor




Source: U.S. Nuclear Regulatory Commission

# Pressurized Water Reactor

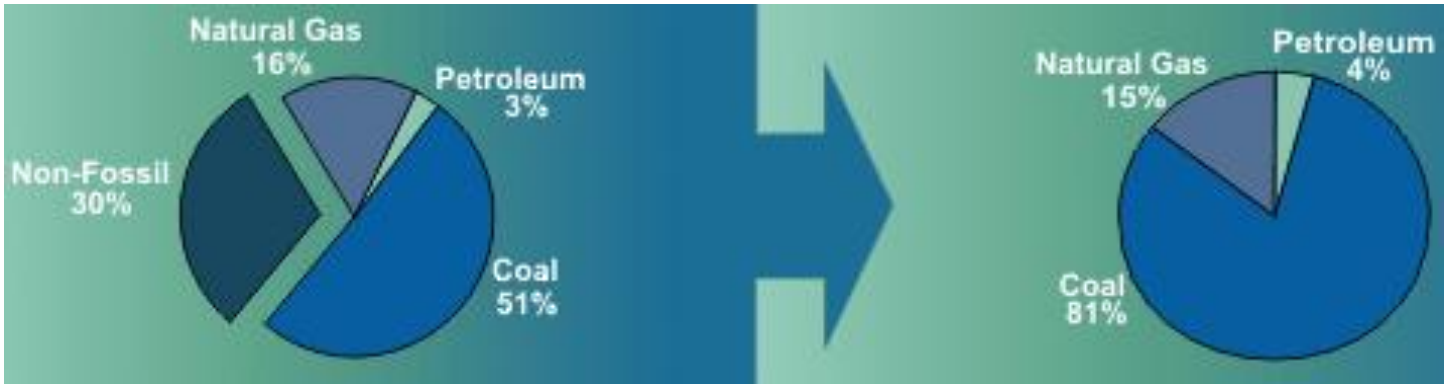


# Impact of Nuclear on the Energy Mix & Environment

Nuclear energy provides about 20 percent of the electricity in the U.S., and does not produce greenhouse gases during generation.

Concerns about climate change related to human-made greenhouse gas emissions is growing. As more than 80 percent of emissions are carbon dioxide from fossil fuel combustion, many countries are seeking to shape the energy mix to be less dependent on fossil fuels.

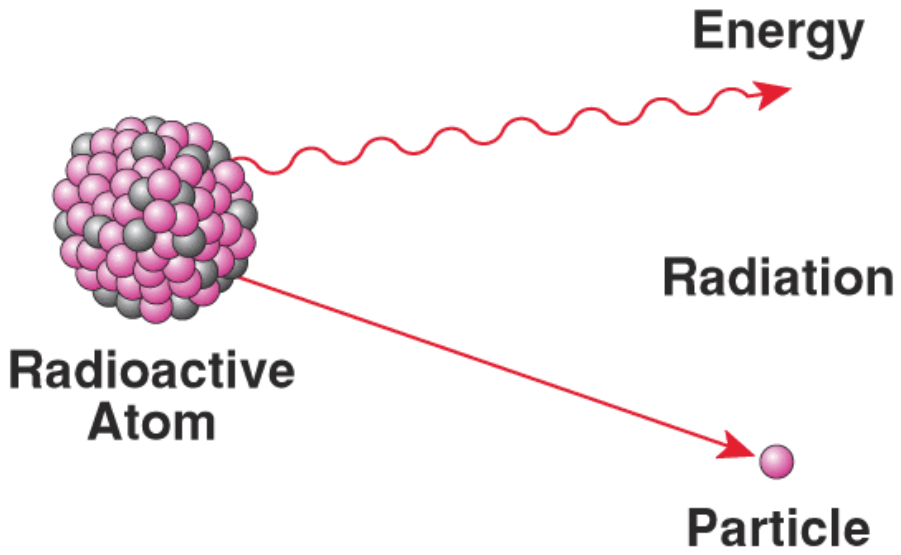
**U.S. Electricity Consumption** **Carbon Dioxide Emissions**




Source: U.S. Energy Information Administration

# What is Radiation?

Elements that are radioactive have unstable atoms. Their nuclei undergo spontaneous transformation to achieve a more stable state.




As the atoms of radioactive elements decay, they give off excess energy - or **radiation** - that travels through space in the form of waves or high-speed sub-atomic particles.

Source: U.S. Nuclear Regulatory Commission

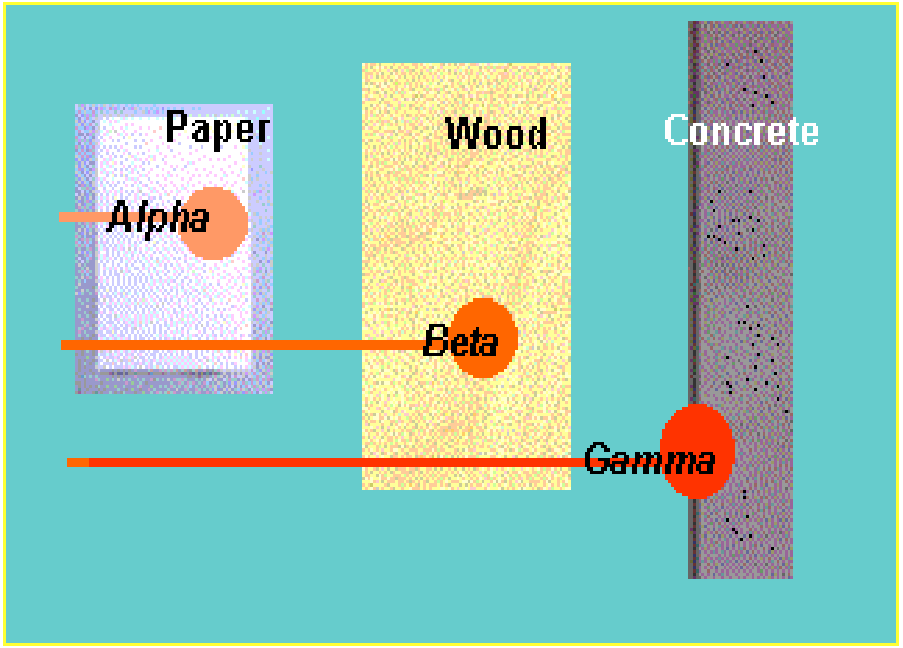
# Ionizing Radiation

**Ionizing Radiation** has enough energy to break chemical bonds in atoms or dislodge electrons, causing the atoms to become charged (ions). This type of radiation is used to generate electric power or kill cancer cells.

The three main types of ionizing radiation are:

- Alpha particles
- Beta particles
- Gamma rays

(with varying strengths of penetration shown at right)



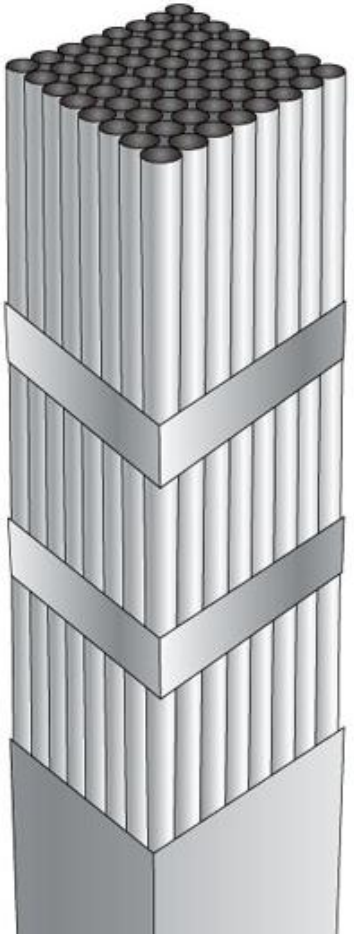

Source: Argonne National Laboratory

# Radioactive Waste

Activities that use radioactive materials generate radioactive waste.

Nuclear fission at a power plant results in waste:

- When a uranium-235 atom absorbs a stray neutron and splits, it releases binding energy and neutrons, which strike more atoms and cause an exponential chain reaction.
- As the splitting takes place and neutrons are absorbed by uranium-238 atoms (which make up the majority of the nuclear fuel), the chain reaction stops.
- At this point the nuclear fuel (steel rods containing pellets of uranium - see assembly at right) is considered "spent" and must be replaced. Spent nuclear fuel is one type of radioactive waste.



Source: Oracle ThinkQuest

# Types of Waste

The Environmental Protection Agency (EPA) defines five general types of radioactive waste:

- **Spent nuclear fuel (SNF)** from reactors and **High-level waste (HLW)** Spent reactor fuel and other highly radioactive wastes generated at reprocessing plants.
- **Transuranic waste (TRU)** from the production of nuclear weapons.
- **Uranium mill tailings** from the mining and milling of uranium ore.
- **Low-level waste (LLW)** - contaminated industrial or research waste that does not fit into any of the above categories.
- **Naturally occurring radioactive materials (NORM)** or accelerator-produced radioactive materials.

Radiation levels differ for and within each type of waste, requiring different levels of protection in the way they are managed (exposure time, physical distance, and shielding).

Source: U.S. Environmental Protection Agency

# Waste Management Techniques

Spent nuclear fuel (SNF) and high-level radioactive waste (HLW) are stored at 125 sites in 39 states.

More than 161 million people reside within 75 miles of stored nuclear waste.


Source: U.S. Department of Energy, Office of Civilian Radioactive Waste Management

# Storage - Spent Fuel Pools

**Spent Fuel Pools**

- After three to four years in a reactor core, spent nuclear fuel is moved to a pool located on-site (all U.S. reactors store SNF in pools).

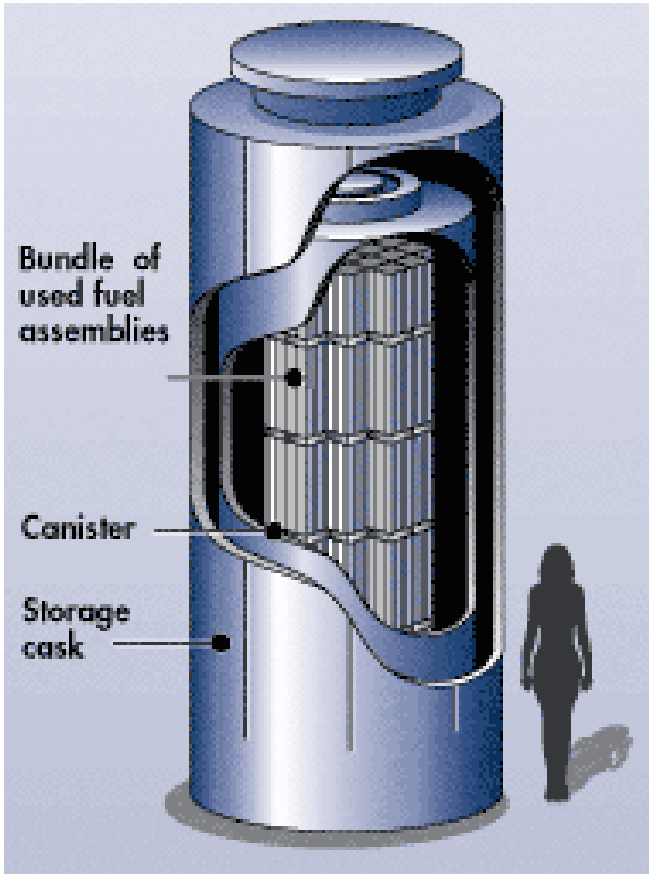
- SNF is highly radioactive and extremely hot. The water in the pools allows the fuel to cool, and acts as a barrier to protect workers, the public, and the environment.

- Nuclear reactors continue to generate energy, and as no repository has yet been built to dispose of the waste byproduct, power plants are reaching full capacity in their pools. Many have had to find additional means of storage.

Source: U.S. Department of Energy, Office of Civilian Radioactive Waste Management

# Storage - Dry Casks

- Many reactor sites supplement the storage capacity of their pools with on-site dry cask storage.
- After cooling in the pool for at least one year, spent fuel may be placed into a steel canister where all water and air is removed and the canister is back-filled with inert gas before being sealed. The canister is then surrounded by additional material (steel, concrete, etc.) to help shield radiation.
- NRC has approved dry cask storage licenses for 51 sites in 33 states.
- State officials understand that this type of storage will become more prevalent until a national repository is ready to accept the waste.




Source: U.S. Nuclear Regulatory Commission

# Reprocessing/Recycling Waste

The purpose of reprocessing spent nuclear fuel is to separate out its byproducts, either for reuse or disposal. Current processes involve dissolving spent fuel pellets in nitric acid. Some of the separated elements may be enriched or mixed for reuse as fuel (uranium, plutonium). Others are vitrified into glass logs for final disposal in a repository.

The Department of Energy's National Laboratories are researching ways to further separate elements based on their potential future use as fuel (americium, curium) or their short half-lives which may render permanent geologic disposal unnecessary (cesium, strontium).

Sources: Almanac of Policy Issues
Argonne National Laboratory

# Yucca Mountain

The Office of Civilian Radioactive Waste Management was established within the U.S. Department of Energy (DOE) to develop and manage a federal system for disposing of the nation's spent nuclear fuel and high-level defense wastes.

In 2002, Yucca Mountain in southwest Nevada was designated the permanent geologic repository for the disposal of these wastes.

In 2010, DOE suspended its license application for Yucca Mountain, putting the future use of the site in question.


Source: U.S. Department of Energy, Office of Civilian Radioactive Waste Management

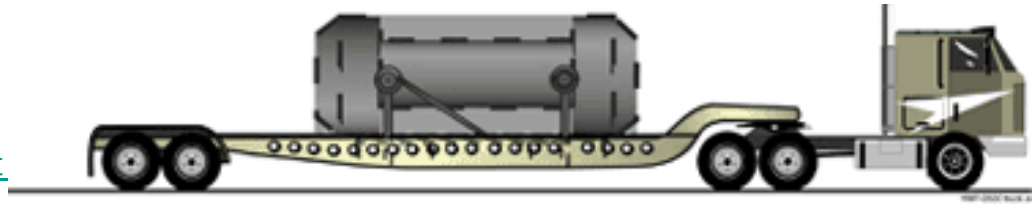
# Nuclear Waste Transportation

As nuclear waste is currently stored at sites around the country, moving that waste to a final repository will require transporting it through most states. The spent fuel and high-level wastes for transport are solid (not liquid), cannot cause an explosion, and are not flammable.

**Safety Record**

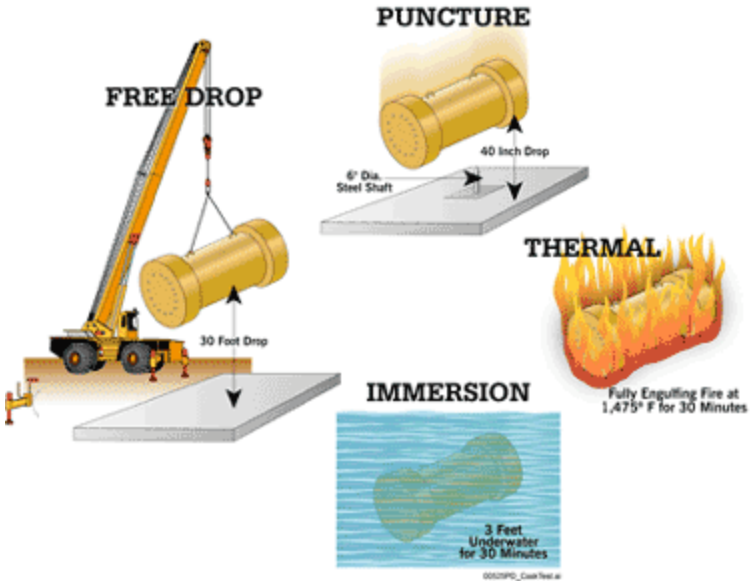
- More than 3,000 shipments of spent nuclear fuel have traveled across America's highways, railroads, and waterways over the past 45 years without any harmful release of radioactive material.
- More than 9,500 shipments of wastes have been safety transported to the Waste Isolation Pilot Plant in Carlsbad, NM since 1999.

Source: Department



# Transportation Packaging

- Spent fuel and high-level waste transportation casks are the most robust containers in the shipping industry.
- These casks use multiple layers of shielding to protect people and the environment from the effects of radiation.
- The casks go through rigorous testing procedures including: free drop, puncture, thermal, and water immersion - all performed consecutively on the same cask.




Source: U.S. Nuclear Regulatory Commission

# State Role

Legislators and State Officials play an important role in overseeing nuclear issues by:

- Assisting with development of interagency agreements;
- Commenting on DOE budgetary and other project decisions;
- Participating in a variety of working groups and local advisory boards; and
- Passing legislation to ensure the adequate safety and security of their citizenry.

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