RADIOACTIVE WASTE MANAGEMENT PROGRAMMES IN OECD/NEA MEMBER COUNTRIES

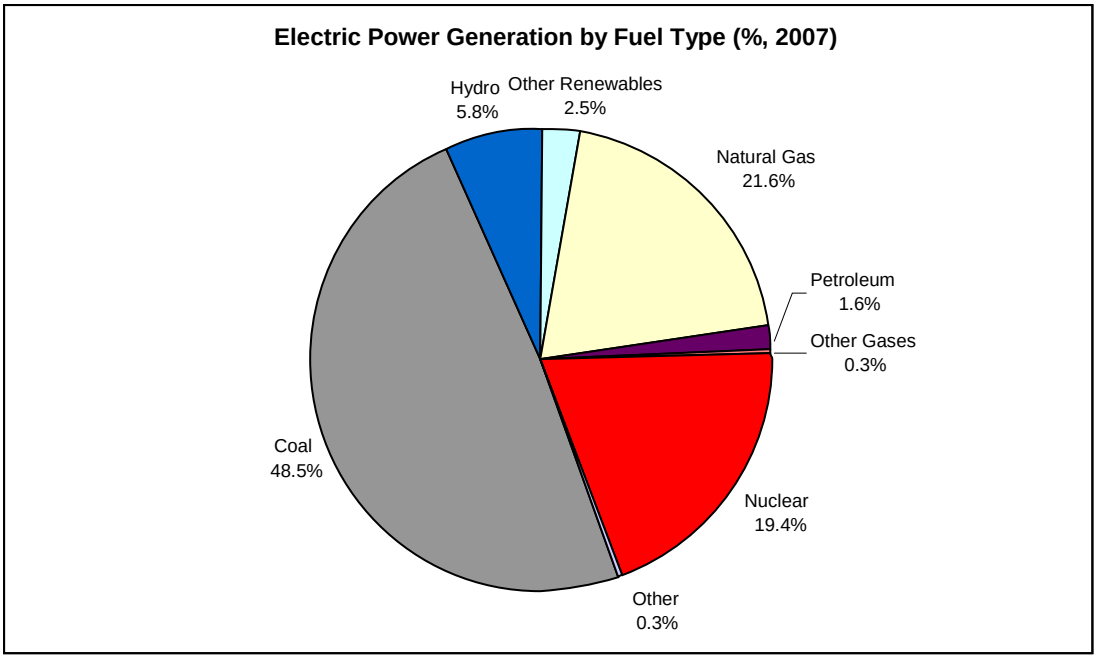
UNITED STATES

NATIONAL NUCLEAR ENERGY CONTEXT

Commercial utilisation of nuclear power in the U.S. started in 1960; as of 2007 there are 104 nuclear power units in operation. In 2008, these plants generated 806 TWh of electricity, about 20% of the total electricity generated in the U.S. that year. Globally, the U.S. reactor fleet generates about 30% of the world's nuclear electricity.

Nuclear fuel for these reactors is fabricated at six plants in the U.S., with total capacity over 4 000 tonnes heavy metal per year (tHM/yr) in 2007. The amount of spent fuel generated in 2008 was projected to be about 2 300 tonnes HM. By the end of 2008, the total amount of discharged spent fuel was projected to be about 60 000 tonnes HM, of which about 48 000 tonnes HM is in pool storage and the rest in at-reactor dry storage.

According to the U.S. Department of Energy's (DOE) Energy Information Administration's 2007 reference case, U.S. nuclear electricity generating capacity is expected to increase from 101 GWe in 2007 to approximately 113 GWe by 2030. This increase includes capacity expansion at existing plants (3.4 GWe), new plant capacity (13.1 GWe), and the retirement of seven older units by 2030 (4.4 GWe). The other existing units are expected to continue operating through 2030, based on the assumption that they will all receive 20-year reactor license renewals. Projected capacity may change significantly in the future; a total of 17 applications to build and operate new reactors have been received (for a total of 26 new reactor units).



Source: DOE/EIA, 2007

SOURCES, TYPES AND QUANTITIES OF WASTE

Radioactive waste is solid, liquid, sludge, or gaseous waste that contains radionuclides. The U.S. radioactive waste classification system has two separate subsystems, one applied to commercial-origin waste as defined by Nuclear Regulatory Commission (NRC) regulations, and the other to government-owned waste as defined by DOE. These waste definitions are broadly explained below.

Spent nuclear fuel

Spent nuclear fuel (SNF) is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. SNF inventories from commercial nuclear power plants are growing at an annual rate of approximately 2 100 tonnes HM. By end-2008, approximately 60 000 tonnes HM of SNF has accumulated. Assuming that all 104 U.S. commercial reactors receive 20-year life extensions, it is projected that by the completion of the total life cycle of the current 104-reactor fleet, the total SNF inventory will be about 130 000 tonnes HM by the year 2055. This does not take into account any future new reactor build in the U.S. DOE also manages about 2 500 tonnes HM of unreprocessed spent nuclear fuel from defence-related activities.

High-level radioactive waste

High-level radioactive waste (HLW) is the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations and other highly radioactive material that the NRC, consistent with existing law, determines by rule to require permanent isolation.

The DOE currently stores approximately 340 000 m^3 of highly radioactive waste in

230 large underground steel tanks. (An additional 4400 m^3 of granular solid calcine HLW is stored in bin sets.) Since the mid-1990s, DOE has been treating liquid and sludge tank HLW using the vitrification treatment method to immobilize (i.e. solidify) and place the HLW glass inside of stainless steel canisters for interim storage, pending final disposition. By the end of April 2009, the DOE had produced over 2 980 canisters of HLW glass. By approximately 2055, an estimated 22 500 to 36 000 canisters of vitrified HLW will have been produced and stored in the interim pending final disposition.

Low-level radioactive waste

Low-level waste (LLW) is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, uranium or thorium mill tailings, discrete sources of radium-226, or naturally occurring radioactive material, as defined by existing law. Low-level waste is generated from nuclear reactor operations, uranium enrichment processes, isotope production, medical procedures, nuclear medicine and research, and biotechnological research.

Commercial low-level waste is classified by NRC into three categories (class A, class B, and class C), which are based on the concentration limits of long-lived radionuclides and their shorter-lived precursors, and the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effected. Low-level waste exceeding the class C concentration limits is termed Greater-than-Class-C (GTCC) waste and is not generally acceptable for near-surface disposal without NRC approval.

DOE does not use the NRC LLW classification system for its near-surface disposal systems. DOE only disposes of LLW from its generators, not from commercial generators. It manages waste from its operations using procedures and requirements comparable to those used by NRC for commercial wastes.

As of the end of September 2007, a total of about 13 million m^3 of LLW and mixed LLW (MLLW) have been disposed of. Of this total, about 4.4 million m^3 of commercial LLW and MLLW has been disposed of at commercial disposal facilities (3 are currently operating and 3 are closed). The remaining 9 million m^3 of DOE-owned LLW and MLLW have been disposed of at DOE sites, with a majority of the volumes resulting from cleanup activities.

Transuranic waste

DOE uses the transuranic (TRU) waste nomenclature for its long-lived, alpha-emitting wastes (similar NRC-regulated commercial wastes fall in the GTCC LLW category). TRU waste is a form of low-level waste which is contaminated with alpha-emitting radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g (3700 Bq). Transuranic waste is generated during reactor fuel assembly, weapons fabrication, and chemical processing operations. The current transuranic waste inventory in storage totals approximately 114 000 m^3. From March 1999 through September 2008, DOE has disposed of over 56 000 m^3 of defence-related TRU wastes at the Waste Isolation Pilot Plant (WIPP) in New Mexico.

Mixed waste

Mixed low-level waste is waste that contains radioactive constituents under the purview of the *Atomic Energy Act* and other constituents that are hazardous as

defined and regulated by the *Resource Conservation and Recovery Act*. Many government-owned transuranic and low-level waste streams are mixed wastes because of their hazardous components.

The types and amounts of radioactive waste are summarised in the table below:

Radioactive waste	Description	Quantity
Spent fuel	Cumulative quantity discharged (as of end-2008)	60 000 tonnes HM
High-level radioactive waste	Total liquid waste stored in 230 large underground tanks	350 000 m^3
	Total number of vitrified canisters (as of April 30, 2009)	2 820 canisters
	Total number of canisters to be produced (by 2050)	22 500 canisters (up to 36 000)
Transuranic waste	Total stored	114 000 m^3
	Total disposed of (1999 - September 30, 2008)	56 000 m^3
Government-owned low-level and mixed low-level waste	Total in stored inventory	About 97 000 m^3
	Total disposed of (as of 2007) including waste derived from cleanup sites	About 9 million m^3

RADIOACTIVE WASTE MANAGEMENT POLICIES AND PROGRAMMES

WASTE management policies

The primary objective of radioactive waste management policy in the United States is to provide for the management, treatment, storage, transportation, and ultimate disposal of radioactive wastes generated during past and future activities in a manner that assures public and worker health and safety, and protects the environment.

PROGRAMMES and projects

Commercial spent nuclear fuel and high-level radioactive waste

Storage of commercial SNF and HLW is the responsibility of the waste generator until the Federal government takes title. At nuclear reactor sites, spent nuclear fuel is temporarily stored in specially designed, water-filled pools and aboveground, dry storage facilities.

The *Nuclear Waste Policy Act* of 1982 established the Federal government's responsibility to provide for the permanent disposal of commercial spent nuclear fuel

in a geologic repository, and designated the DOE Office of Civilian Radioactive Waste Management (DOE-OCRWM) to manage the program. The Act also assigned roles to EPA (public health and environmental standards) and NRC (licensing). The President subsequently determined in 1985 that a separate repository for disposal of defence spent nuclear fuel and high-level waste was not necessary, and decided that these wastes would be disposed in the commercial repository. The waste generators and owners fund the commercial portion of the system through a fee on the commercial generation of nuclear power. The portion of the cost for the disposal of waste generated or owned by the Federal government is paid for by the government.

In response to the NWPA, DOE-OCRWM undertook an intensive national screening process for candidate sites for the geologic repository for the nation's SNF and HLW. Between 1983 and 1986, DOE narrowed the number of potential sites for consideration from nine to three. In 1987, Congress directed DOE to discontinue studying the other sites, and to study the volcanic tuff site at Yucca Mountain, Nevada exclusively to determine its suitability as a potential repository. The strategy for evaluating Yucca Mountain relied on engineered barriers, geologic features, and natural processes to delay and minimize the release of radionuclides to the environment and minimize exposure to the public.

In 2002, after more than 20 years of site characterization activities at Yucca Mountain, the site was approved by the U.S. President after a joint resolution was passed by Congress for development of a repository. DOE submitted the license application (LA) to the NRC on June 3, 2008, and it was docketed on September 8, 2008. The NRC has a 3 to 4 year review period before making its decision whether to grant a license to authorize construction of a repository. In 2009, the Administration announced its intention to terminate the Yucca Mountain program and to convene a "blue ribbon" panel of experts to evaluate alternative approaches for meeting the Federal responsibility to manage and ultimately dispose of spent nuclear fuel and high-level radioactive waste from both commercial and defense activities.

DOE spent nuclear fuel

Historically, spent nuclear fuel generated by the DOE was stored for a short time and reprocessed to recover fissile materials. In April 1992, the United States phased out reprocessing for defence purposes. Most of the DOE's inventory of spent nuclear fuel, about 2 500 tonnes HM, is stored at three sites. These are the Hanford Reservation, Washington; the Idaho National Laboratory (INL), Idaho; and the Savannah River Site, South Carolina.

Foreign research reactor spent nuclear fuel

From the late 1950s, the U.S. began taking back foreign research reactor spent fuel containing U.S.-supplied enriched uranium. Starting in 1996, the current version of this programme was authorized to receive up to 20 tonnes HM of highly enriched uranium and low enriched uranium spent nuclear fuel, from 41 countries over a 23-year period, consisting of aluminium-based and TRIGA (Training, Research, Isotope, General Atomics) research reactor spent fuels. The DOE is responsible for the management and storage of these materials, and has completed 47 shipments of spent nuclear fuel from foreign research reactors in 27 countries.

Transuranic waste

The transuranic waste generated from DOE activities is stored either at the

respective waste generating facility or at a designated DOE storage facility. Storage methods include retrievable burial, below-ground bunkers, concrete caissons, above-ground concrete pads, and inside buildings.

In 1979, Congress authorised construction of the Waste Isolation Pilot Plant (WIPP), a facility for the safe disposal of defence-related transuranic waste. WIPP, located in the New Mexico desert, is designed to store transuranic waste in salt deposits approximately 650 m beneath the desert surface. WIPP is managed by the DOE Office of Environmental Management (DOE-EM). After 20 years of scientific study, public input, and regulatory challenges, WIPP began operations in March 1999; it was recertified in 2006 as having met environmental standards, and DOE submitted the second recertification application in March 2009. Over a 35-year period, WIPP is expected to receive about 19 500 shipments of transuranic waste. As of October 2008, WIPP had received over 6 900 shipments from eight DOE sites, comprising over 56 000 m^3 of contact-handled transuranic waste. In January 2007, DOE received approval to dispose of waste that is more highly radioactive, requiring remote (automated) handling. As of October 2008, DOE has disposed of 75 m^3 of remote-handled waste.

Low-level waste

Low-level waste ranges from low activity waste that can be disposed of by shallow land disposal techniques to high-activity waste that requires greater confinement. Generators usually store the wastes onsite for short time periods, e.g. for a few weeks to a few months, until enough waste is available for a full shipment to a disposal site.

The *Low-level Radioactive Waste Policy Act* of 1980 established two major national policies:

1. Each state is responsible for assuring adequate licensed disposal capacity for commercial low-level waste generated within its own borders.
2. Regional groupings of states, called compacts, could be formed to provide the disposal facilities.

DOE low-level waste is stored at generator sites while awaiting treatment and disposal. DOE currently operates low-level waste disposal facilities at six sites. There are also three commercially available LLW disposal sites, with an application submitted for a fourth regional facility currently being reviewed in 2008. One of the three operating LLW disposal sites for commercial LLW in the U.S., the Barnwell facility in South Carolina, closed to out-of-region waste in mid-2008. DOE waste generators without an onsite waste disposal facility ship waste to a DOE operating site for disposal and in some instances to commercial facilities when practical and economical.

DOE also has responsibility for ensuring the safe disposal of GTCC low-level radioactive waste, which must be disposed of in a facility licensed by the NRC. In July 2007, DOE issued a Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for GTCC LLW disposal. Development of a draft EIS is now in progress.

RESEARCH and development

Both industry and the Federal government conduct research and development to understand and improve waste management science and technology. Work in association with WIPP and Yucca Mountain is conducted by the DOE through several national laboratories, the United States Geological Survey (USGS), and private sector contractors.

Site characterisation activities were conducted through the 1970s, 1980s, and 1990s in support of the certification of WIPP and of site designation of Yucca Mountain. Scientific and engineering activities continue at WIPP, focused on performance confirmation, monitoring, and waste characterisation.

As part of its responsibility to clean up 114 geographic sites around the U.S. of radioactive and chemically hazardous wastes, DOE-EM in 2002 completed a comprehensive review to find greater efficiencies and cost effectiveness in its cleanup programmes, emphasising risk reduction to workers, the public, and the environment. Cleanup schedules at virtually all the contaminated DOE facilities have been revisited and accelerated after working with local regulatory agencies and citizens. The cleanup of three major DOE sites was completed in 2006; an additional eleven sites or areas are projected to be completed in the 2007 to 2009 timeframe.

DECOMMISSIONING AND DISMANTLING POLICIES AND PROJECTS

Over the last 40 years, operations at licensed nuclear facilities have caused radiological contamination at a number of sites. This contamination must be reduced or stabilised in a timely and efficient manner to ensure protection of the public and the environment before the sites can be released and the licence terminated. NRC has regulatory and oversight authority for decommissioning activities, which involve removing NRC-licensed facilities safely from service and reducing residual radioactivity to a level that permits the properties to be released for unrestricted or restricted use. This action is taken by a licensee before termination of the licence. In other cases, non-NRC licensed facilities may also be required to decontaminate and decommission the site in order to meet NRC release limits. This activity includes associated research, rulemaking efforts, and the technical interface with EPA for resolution of issues of mutual interest, in accordance with the March 1992 and October 2002 Memoranda of Understanding.

TRANSPORT

The Federal government and the states have a joint role in ensuring the safety of transport of radioactive materials. At the Federal level, the NRC and the Department of Transportation (DOT) regulate transportation. The NRC regulates the packaging, preparation, and transfer of commercial nuclear materials, while the DOT has regulatory authority over the transportation of all hazardous materials, including radioactive material. The DOT approves highway routing of nuclear materials. In addition, the DOE is responsible for transporting DOE-managed nuclear materials and will be operationally responsible for spent fuel shipments to the appropriate designated facility. The Department of Homeland Security (DHS) has an oversight role regarding the security and safeguards of nuclear materials.

State, local, and tribal governments also participate in the regulation of nuclear

material transportation through their law enforcement and emergency-response agencies.

Transportation of commercial low-level waste is the responsibility of the commercial waste generator. These wastes are usually transported by truck under contract with commercial carriers using equipment that meets NRC and DOT regulations.

Since the 1960's, more than 3 000 spent nuclear fuel shipments have been made within the U.S. without any release of radioactive material. More than 6 000 shipments of transuranic wastes have also been made to the WIPP site since 1999. In addition, the DOE makes thousands of low-level waste shipments a year to its disposal sites.

COMPETENT AUTHORITIES

Various Federal agencies are responsible for radioactive waste management, as described below:

The **Department of Energy (DOE)** is responsible for helping the nation meet energy, scientific, environmental, and national security goals, including the mitigation of risks and hazards associated with disposing of nuclear materials, and deactivating and decommissioning facilities no longer needed to support DOE's mission. The **DOE Office of Civilian Radioactive Waste Management (DOE-OCRWM)** has specific responsibility to provide for the permanent disposal of the spent nuclear fuel and high-level radioactive waste. The **DOE Office of Environmental Management (DOE-EM**) has responsibility for cleanup of the DOE weapons production and nuclear research sites across the U.S., and also manages the nuclear materials on those sites until they are ready for disposition. The Department also has regulatory authority over health, safety, and environmental protection regarding radioactive waste generated at its facilities.

The **Nuclear Regulatory Commission (NRC)** regulates the storage and disposal of commercial nuclear waste, as well as the packaging aspects of the transport casks. The NRC safety role is to ensure that the spent fuel packages meet strict regulatory design rules, and includes approving packaging designs and Quality Assurance Programmes. The NRC is responsible for setting technical standards and criteria, and for implementing overall offsite release standards set by the Environmental Protection Agency.

The **Environmental Protection Agency (EPA)** promulgates applicable standards for protection of the general environment from offsite releases of radioactive material in repositories, including the proposed repository at Yucca Mountain in Nevada and the Waste Isolation Pilot Plant in New Mexico.

The **Department of Transportation (DOT)** has authority over transportation of all hazardous materials, including radioactive materials.

The **Nuclear Waste Technical Review Board (NWTRB)** was established by Congress to provide independent oversight of the activities of OCRWM in its efforts to develop a national geologic repository.

The **Defense Nuclear Facilities Safety Board (DNFSB)** was also established by

Congress to provide safety oversight of the nuclear weapons complex operated by the DOE.

FINANCING

Costs of radioactive waste programmes

Congress appropriates funds for the Department of Energy waste management programmes. These appropriations are made in two accounts: Nuclear Waste Disposal and Defense Nuclear Waste Disposal.

Spent nuclear fuel and high-level radioactive waste

Under the *Nuclear Waste Policy Act*, as amended, the civilian portion of the radioactive waste management programme must be funded by the waste generators and owners through a fee on the commercial generation of nuclear power. This fee, which is assessed at 1/10 US-cent per KWh, is deposited in the Nuclear Waste Fund to be used for waste management. Utility fees and investment income together amounted to approximately US$1.8-billion in fiscal year 2008. The U.S. Congress makes an annual appropriation from the Nuclear Waste Fund, plus a separate annual appropriation to cover disposal costs for defence SNF and HLW. Since the Fund's inception in 1983, it has accumulated over US$30.5 -billion and expended approximately US$7.3-billion, leaving a net balance by June 2009 of approximately US$23.2-billion. The latest total system life cycle cost estimate for the Yucca Mountain repository system was produced in 2008, and estimated to be US$96.2-billion. The fees paid into the Nuclear Waste Fund were determined to be adequate to cover the costs.

Low-level waste

To facilitate the establishment of a reliable, nationwide, low-level radioactive waste management system, Congress assigned specific responsibilities to the DOE, including the provision of technical and financial assistance to states or compacts in meeting their responsibilities under the Low-level Radioactive Waste Policy Amendments Act of 1985. The act provided financial incentives for states and/or compacts to establish low-level radioactive waste management capabilities by specific dates. There are currently three commercially available LLW disposal sites. The states can assess user fees for these facilities to generators.

Each generator of commercial LLW provides the funds for storage from its operating budget. Disposal site operators levy fees on waste generators upon receipt of the wastes for disposal. The initial cost for developing low-level waste disposal facilities is paid by waste generators, or through some type of assessment or tax fee imposed by the state or compact region.

PUBLIC INFORMATION

The following sources of information on radioactive waste management are available:

Government

Department of Energy
Washington, DC

- **Department of Energy**
  Website: http://www.energy.gov

- **Office of Environmental Management**
  Website: http://www.em.doe.gov

- **Office of Civilian Radioactive Waste Management**
  Website: http://www.ocrwm.doe.gov

Nuclear Regulatory Commission
Washington, DC
Website: http://www.nrc.gov

Environmental Protection Agency
Washington, DC
Website: http://www.epa.gov

Oversight Organisations

Nuclear Waste Technical Review Board
Washington, DC
Website: http://www.nwtrb.gov

Defense Nuclear Facilities Safety Board
Washington, DC
Website: http://www.dnfsb.gov

Industry

Nuclear Energy Institute
(The Nuclear Energy Institute is the nuclear energy industry's Washington-based policy organisation.)
Washington, DC
Website: http://www.nei.org