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Radioactive Waste Management Programmes in OECD/NEA Member Countries

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International co-operation at the OECD/NEA concerning the management of radioactive waste and materials

The role of the NEA Radioactive Waste Management Committee (RWMC)

Radioactive waste and materials exist in countries with and without nuclear power programmes and need to be managed in a manner that is responsible to present and future generations. Significant progress has been achieved and considerable experience is available in NEA member countries on waste and materials processing, conditioning, storage, transport and disposal. An important experience and knowledge base has also been developed as regards decommissioning and dismantling nuclear installations. Special efforts are being expended in the area of long-term management of radioactive waste in order to continue to integrate technical advances and societal demands in decision making as well as to understand and develop consensus views on regulatory and policy issues. International co-operation amongst implementers, regulators, policy makers and R&D specialists is key to fostering a broader understanding of the issues at hand and formulating more widely accepted solutions. The NEA Radioactive Waste Management Committee (RWMC) brings together those four constituencies.

Broad approach

The RWMC contributes to promoting a broad approach to waste management issues through:

- the provision of multidisciplinary fora for the exchange of information and experience and for promoting a frank interchange in open dialogue amongst its various constituencies;
- the provision of specialised fora, e.g. implicating regulators in identifying and addressing future regulatory challenges;
- preparing and disseminating brochures and databases on national waste management and decommissioning frameworks and management approaches, with a view to reaching opinion formers and the wider public.

Strategies

In particular, the RWMC facilitates the elaboration of strategies for waste management and decommissioning, including regulatory approaches, at the national and international levels by:

- reviewing strategies adopted by member countries with a view to identify and analyse emerging technical, policy and regulatory issues and to forge consensus views;
- reviewing regulatory bases, requirements and criteria, and licensing processes, in addition to proposing regulatory approaches;
- developing methodologies for evaluating long-term safety;
- examining and developing criteria for stepwise decision making;
- organising peer reviews of national programmes for such activities as research and development, performance assessment and safety cases, as requested;
- preparing good-practice documents.

Scientific and technical knowledge base

The RWMC contributes to the scientific and technical knowledge base for the management of radioactive waste and materials, and assists in the resolution of relevant issues by:

- reviewing the scientific and technical knowledge of geological disposal concepts and decommissioning technology for nuclear facilities with a view to identifying the state of the art and areas where additional efforts are required;
- promoting co-operative efforts to compile internationally applicable data and information, and benchmarking exercises;
- promoting joint technical initiatives in support of repository development and decommissioning technologies.

Major contributions

There is today a broad international consensus on the merits of the final disposal of long-lived radioactive waste in deep and stable geological formations. This type of solution is essentially passive and permanent, with no requirement for further intervention or institutional control, although it may be assumed that siting records and routine surveillance would in practice be maintained for many years, as long as society evolves in a stable manner. The Radioactive Waste Management Committee has contributed significantly to achieving this consensus, in particular through the formulation of two international "collective opinions" and through the harmonisation of the basic pillars of long-term safety demonstrations (safety case). The Committee has also made major contributions to better understanding and resolving the governance issues that long-term radioactive management projects raise. In particular, it has been the catalyst for establishing international positions on the retrievability of waste and the reversibility of decisions, as well as for the implementation of a stepwise approach to decision making.

Radioactive waste management trends

Modern societal demands on risk governance and the widespread adoption of stepwise decision-making processes with stakeholder involvement have created a new working environment in radioactive waste management. The RWMC has formally acknowledged this by creating the Forum on Stakeholder Confidence (FSC) to identify, discuss and promote the new set of approaches required from all parties involved in radioactive waste management. The FSC has created a neutral ground where interested parties meet and discuss long-term waste management issues.

Decommissioning issues are becoming increasingly important with the ageing of nuclear facilities in member countries. The decommissioning of nuclear facilities is closely linked with radioactive waste management, as the strategy for dealing with one cannot be totally separated from the other. Social aspects – due to the impacts on communities – are very important, but regulatory, technical and economic issues exist as well. The RWMC created the Working Party on Decommissioning and Dismantling (WPDD) to address such issues with the help of international expertise.

Finally, an area of traditional strength of the Committee is the safety case for final disposal of long-lived waste deep underground. Technical and managerial aspects of these activities are addressed by the Integration Group for the Safety Case (IGSC). Through the expertise assembled in this group, the NEA is able to provide timely and highly regarded peer reviews of national safety studies. National requests for peer reviews have been increasing over the years, and now represent a well-established trend.

Future work

The RWMC will continue its activities concerning the management of radioactive waste and materials and the dismantling of nuclear facilities, in particular:

- the formulation and support of long-term waste management solutions that meet both technical and social approval;
- the stepwise approach to decision making;
- guiding principles and best practice for stakeholder involvement;
- the role of regulation and the formulation of regulations that are proportionate and practical;
- the technical case for long-term safety;
- the consideration of management of radioactive waste and materials in the more general environmental and sustainable development perspectives.

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

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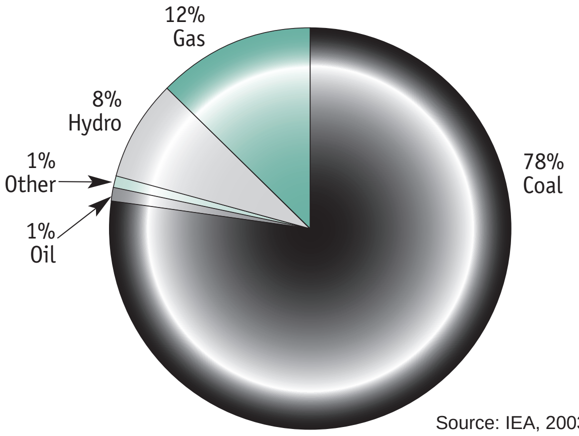
Australia

National nuclear energy context

- Australia is practically the only developed country that does not use electricity, either indigenous or imported, produced from nuclear energy.
- A proposal to build a 500 MWe nuclear power plant at Jervis Bay, NSW was abandoned in 1972. Since then, Australia has pursued a policy of non-reliance on nuclear power.
- Australia uses radioactive materials in medical, research and industrial processes. These beneficial uses of radioactivity generate small amounts of radioactive waste.
- The High Flux Australian Reactor (HIFAR) is the only operational nuclear reactor in Australia. It is used for materials research, to produce radioisotopes for medicine and industry and to irradiate silicon for the high-performance computer industry. It is at the heart of almost all the research activities of the Australian Nuclear Science and Technology Organisation (ANSTO) and supports those of several other organisations on the Lucas Heights site near Sydney. HIFAR, which has operated at Lucas Heights since 1958, was installed initially to support development of an Australian nuclear electricity generating capability.
- In July 2000, ANSTO signed a contract with the Argentinean company INVAP S.E. and its Australian partners, John Holland Construction and Engineering Pty Ltd and Evans Deakin Industries Limited, for the design, construction and commissioning of a replacement reactor for HIFAR. The Government budgeted $ 286.4 million (at 1997 value) for the replacement reactor, and the project is on track to meet that figure. In April 2002 the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA – the national nuclear safety and radiation protection regulatory body) issued a licence for construction of the reactor, and it is currently expected that its commissioning will take place in 2005.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

In Australia, radioactive waste is subdivided into four different categories, i.e. A, B, C and S. This classification scheme was developed by the National Health and Medical Research Council (NHMRC) in the Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia (1992), which is based on international recommendations for radioactive waste management but specifically describes and caters for the types of radioactive waste generated in Australia.

Categories A, B and C: Low-level and short-lived intermediate-level radioactive waste

Wastes in categories A, B and C are low-level and short-lived intermediate-level radioactive wastes under the scheme described in the International Atomic Energy Agency (IAEA) Safety Guide on the Classification of Radioactive Waste. The NHMRC Code defines category A, B and C wastes as suitable for near-surface disposal. Near-surface repositories may include sub-surface trenches and caverns at depths of up to some tens of metres, with or without engineered barriers, and may include above- and below-ground vaults. Repository design is determined by the geography and geology of the site and the types of waste to be disposed of in the facility.

Australia's inventory of category A, B and C wastes arises primarily from medical, research and industrial applications of radioactive substances but also includes domestic smoke detectors.

Category S: Long-lived intermediate-level waste

Category S wastes are long-lived intermediate-level wastes under the IAEA classification. The amount of long-lived intermediate-level radioactive waste generated in Australia is small, some 500 m^3, with an annual generation rate of less than 5 m^3/year. It includes spent or disused radiation sources from medical, research and industrial applications and wastes from production of radiopharmaceuticals and processing of mineral sands. In due course, it will also include long-lived intermediate-level radioactive waste returned to Australia after treatment of spent fuel from the ANSTO's HIFAR research reactor and from its proposed replacement. These wastes are not suitable for disposal in a near-surface repository, but they can be safely stored in a purpose-built facility above ground.

High-level waste

Australia does not generate any high-level waste and the Australian Government has indicated that Australia will not accept high-level waste from other countries.

Australia's radioactive waste

Categories	Cumulative quantity	Annual arisings
Low-level and short-lived intermediate-level radioactive waste	Approximately 3 700 m^3	Approximately 40 m^3 *
Long-lived intermediate-level radioactive waste	Approximately 500 m^3 (The volume of an average house.)	< 5 m^3

* An additional 500 m^3 of low-level waste is expected to arise in 2035 from the decommissioning of the HIFAR research reactor at Lucas Heights in Sydney.

Low-level radioactive waste drum facility at ANSTO, the Australian Nuclear Science and Technology Organisation.

Radioactive waste management policies and programmes

Proposed national radioactive waste repository

Almost half of Australia's radioactive waste is stored typically at hospitals and universities in more than 50 different locations around Australia, and often in the middle of capital cities. There are also a number of regional storage areas.

Currently, the producers of radioactive waste are responsible for looking after this waste. Although the waste has been stored under supervision, and in accordance with Acts and Regulations applied by the Commonwealth and State governments, these circumstances are not ideal and there is no guarantee of continuity of these arrangements. The States and Territories are responsible for monitoring the use, transport and disposal of radioactive materials under their control and Federal agencies are responsible for managing radioactive waste under their control.

Given the small amounts of radioactive waste generated in Australia, it is technically and economically inefficient, as well as impractical, for all of these jurisdictions to establish their own storage and disposal facilities. It has therefore been proposed to establish national, purpose-built facilities for the storage and disposal of radioactive waste as the safest and most effective option for the Australian community to manage its radioactive waste.

The proposed repository for radioactive waste disposal, which is still to be licensed by ARPANSA, will only accept low-level and short-lived intermediate-level radioactive waste. Under the NHMRC classification scheme, low-level radioactive waste includes such things as lightly contaminated clothing, laboratory equipment and soil as well as smoke detectors. It contains only very small amounts of radioactive material. (A smoke detector, for example, contains only about 40 kBq of activity.) It does not require shielding during handling and transport, it presents a very low radiation hazard, and it is suitable for shallow land burial.

Intermediate-level radioactive waste may include spent or disused radiation sources from industry or hospitals, resins, chemical sludges and metal nuclear fuel cladding. Such waste may require radiation shielding to allow safe handling. An industrial radiation source containing about 20 GBq of activity would be classified as intermediate-level radioactive waste. Under the NHMRC classification scheme, if it has a short half-life, about 30 years or less, it is classified as short-lived intermediate-level radioactive waste and may be accepted by the proposed national repository if other considerations are met.

The Australian Governments started discussing siting and selection criteria for a national repository in 1985. The process of site selection continued until 24 January 2001, when the Commonwealth Minister for Science announced that a preferred site (the so-called Site 52a) and two alternatives (the so-called Sites 45a and 40a) had been identified. The sites are located in South Australia in stony desert country, in an area of deep, saline ground water (shown by the grey, shaded area in the map below).

On 9 May 2003, the Commonwealth Minister for the Environment and Heritage gave environmental approval, subject to conditions, for construction of the proposed national low-level radioactive waste repository at either of the Sites 45a and 40a. The Minister ruled out construction of the facility at Site 52a because of the perceived risk associated with its close proximity to a proposed commercial satellite launch facility and an existing weapons testing facility. The Minister for Science then announced, on the same date, that the national repository for the safe disposal of Australia's low-level radioactive waste would be constructed at Site 40a, 20 km east of Woomera in South Australia.

The Australian Government, represented by the Department of Education, Science and Training (DEST) will own the proposed repository but it is expected that a contractor will manage the facility on a day-to-day basis.

Construction and operation of the repository are subject to the Australian Government obtaining legal title to the land comprising Site 40a. In July 2003, DEST acquired legal title to the site under Commonwealth lands acquisition legislation, but the Government of the State of South Australia and an indigenous community group challenged the legality of this acquisition in the Federal Court of Australia. The Federal Court dismissed the challenge; however the South Australian Government and the indigenous group appealed. The appeal was expected to be heard in mid-2004.

Siting, construction and operation are also subject to issue of the necessary licences by ARPANSA, who are responsible for authorisation of site preparation and repository construction and operation. DEST applied to ARPANSA in August 2003 for the relevant licences, and the application is subject to consideration by ARPANSA. Commencement of operations was not expected until after late 2004 subject to issue of the necessary licences.

National store for long-lived intermediate-level waste

On 8 February 2001, the Australian Government announced that it would establish a safe, purpose-built facility, above ground on Commonwealth land, for the storage of national long-lived intermediate-level waste produced by Australian Government agencies. Co-location of the national intermediate level radioactive waste store with the planned national low-level radioactive waste repository in South Australia has been ruled out. The search for a site for the national store will be a comprehensive and transparent process, based on scientific and environmental criteria. A site will be selected following the advice of scientific experts, and an independent, expert advisory committee, the National Store Advisory Committee (NSAC).

A public discussion paper entitled "Safe Storage of Radioactive Waste, The National Store Project: Methods for Choosing the Right Site", was released for comment in July 2001. A further paper responding to public comments, and defining the final methodology and selection criteria, was released in May 2002.

The NSAC has provided a list of potentially suitable sites to the Australian Government. Further assessment of these sites is required before the Australian Government announces those sites that will be short-listed for detailed investigation.

As for the waste disposal repository, any national store will require the relevant licences from ARPANSA for site preparation and for construction and operation of the facility.

Research and development

The development of ceramic waste forms for the immobilisation of high-level and long-lived radioactive waste is continuing in Australia. ANSTO is currently installing a process to immobilise its own radioactive wastes arising from radiopharmaceutical production.

Following preparation of its Waste Management Action Plan (WMAP) in 1996, ANSTO has developed processes and technologies for managing its radioactive wastes. These include the so-called legacy wastes that have accumulated over the 40 years of ANSTO operations. The WMAP comprised a number of integrated tasks that have provided ANSTO with modern waste management facilities that enable legacy waste issues to be addressed. The proposed National Waste Repository for low-level and short-lived intermediate-level waste will provide ANSTO with a route for disposing of much of the radioactive waste currently stored on its premises and the construction of its multi-purpose Waste Treatment & Packaging Facility will allow it to prepare the waste in forms that comply with the repository waste acceptance criteria.

Decommissioning and dismantling policies and projects

Australia has one operating research reactor (HIFAR), one shutdown research reactor (MOATA), and one research reactor under construction. MOATA was an ARGONAUT 100 kW type reactor operated by ANSTO between 1961 and 1995, when it was permanently shut down. ANSTO now has a licence from ARPANSA to decommission this reactor.

The MOATA decommissioning studies were finalised in 1999 and a decision taken to adopt a long-term storage option. Stage 1 of this option, involving removal of fuel and coolant from the reactor, had already been carried out in 1996. The main reactor structure is now in Stage II, which involves care and maintenance for a period presently estimated at 30 years. The reactor structure is enclosed, and measures are in place to prevent unauthorised access. The facility is subject to periodic inspection and radiation measurement, and is incorporated into ANSTO's plans and arrangements for accidents and incidents on its site. Financial provision has already been made for the cost of the current stages of decommissioning.

It is expected that HIFAR will be shut down in 2006, subject to the replacement research reactor meeting licensing requirements and becoming operational.

Transport

How often will transport take place?

Because Australia produces only a very small amount of radioactive waste each year, transport of radioactive material to the repository will be infrequent. Initially, a number of shipments will be required for disposal of Australia's existing inventory of low-level radioactive waste. However, more than half of this inventory is currently stored near Woomera, which means it will have to be transported only a short distance. Once the existing national inventory is removed to the repository, disposal campaigns are expected to take place every one to three years.

Is transporting radioactive waste safe?

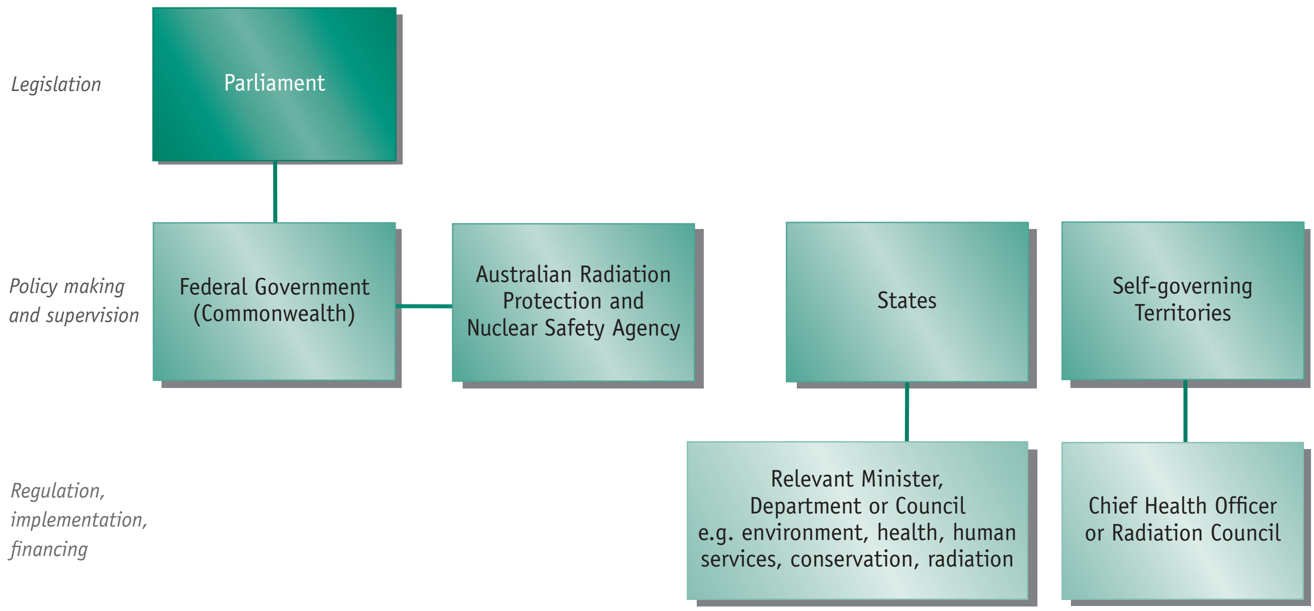
It is estimated that 20 million packages of radioactive material are routinely and safely transported throughout the world each year. More than 30 000 of these movements take place within Australia. In fact, there are fewer risks associated with transporting radioactive waste than there are with flammable and corrosive substances such as fuel and acid, which are routinely transported in and around major cities on a daily basis. Like any other vehicles carrying hazardous materials, those vehicles transporting radioactive waste are appropriately marked.

Competent authorities

Australia is a federation of six States (i.e. New South Wales, Queensland, Victoria, South Australia, Western Australia and Tasmania), with three self-governing Territories (i.e. the Northern Territory, the Australian Capital Territory and Norfolk Island), each with its own constitution, government and laws. The Australian Constitution originated as an agreement under which the former British colonies came together as States in a federation. It established the form of the federal government (i.e. the Australian Government or Commonwealth) and set out the legal basis for relations between the Commonwealth and the States and Territories.

The list below shows the regulatory bodies established by the States and Territories for regulation of the safe use of radioactive material and equipment and, in the case of the Commonwealth, it shows the body responsible for regulation of: nuclear installations such as the HIFAR reactor and proposed national radioactive waste storage and disposal facilities, and prescribed radiation facilities such as the National Medical Cyclotron.

Main bodies involved in radioactive waste management in Australia



Financing

The Commonwealth, State and Territory Governments each finance their own radioactive waste management schemes and associated research and development programmes. These schemes and programmes are generally financed through direct government funding, except in Western Australia and Queensland where the established radioactive waste management facilities are partly financed by fees charged for accepting waste. The Commonwealth also intends to charge for disposal of waste in its proposed national low-level radioactive waste repository.

Public information

For more information, the websites of the relevant authorities and organisations are listed below.

Government

Department of Education, Science and Training (DEST)
The Information Officer Radioactive Waste Management
Department of Education, Science and Training, Canberra
E-mail: Repository@dest.gov.au – for information about the proposed National Repository
E-mail: Store@dest.gov.au – for information about the proposed National Store
Website: http://www.radioactivewaste.gov.au/

Research

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)
Public Affairs Officer
Miranda NSW 1490
E-mail: arpansa@health.gov.au
Website: http://www.health.gov.au/arpansa/index.htm

Australian Nuclear Science and Technology Organisation (ANSTO)
Government and Public Affairs Unit
PMB 1 Menai NSW 2234 Australia
E-mail: enquiries@ansto.gov.au
Website: http://www.ansto.gov.au

Regulatory bodies

Commonwealth
Chief Executive Officer
Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)
E-mail: arpansa@arpansa.gov.au
Website: http://www.arpansa.gov.au

Australian Capital Territory
Director Radiation Safety Section
ACT Health
E-mail: radiation.safety@act.gov.au
Website: http://www.health.act.gov.au/c/health?a=da&did=10054021&pid=1074210066

New South Wales
Director Radiation Control Section
New South Wales Department of Environment and Conservation
E-mail: radiation@epa.nsw.gov.au
Website: http://www.epa.nsw.gov.au/radiation/index.htm

Northern Territory
Manager - Radiation Health
Radiation Health Section
Northern Territory Department of Health and Community Services (DHCS)
E-mail: envirohealth@nt.gov.au
Website: http://www.health.nt.gov.au

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Director Radiation Health
Queensland Department of Health
E-mail: radiation_health@health.qld.gov.au
Website: http://www.health.qld.gov.au/phs/ehu/

South Australia
Director Radiation Protection Division
Environment Protection Authority
E-mail: radiationprotection.branch@state.sa.gov.au
Website: http://www.environment.sa.gov.au/epa/radiation.html

Tasmania
Senior Health Physicist
Health Physics Branch
Department of Health and Human Services
E -mail: health.physics@dhhs.tas.gov.au
Website: http://www.dhhs.tas.gov.au/publichealth/radiationcontrol/index.html

Victoria
Manager
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Department of Human Services
MELBOURNE VIC AUSTRALIA
E-mail: radiation.safety@dhs.vic.gov.au
Website: http://www.dhs.vic.gov.au/phd/radiationsafety/index.htm

Western Australia
Secretary, Radiological Council
NEDLANDS WA AUSTRALIA
E-mail: radiation.health@health.wa.gov.au

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Belgium

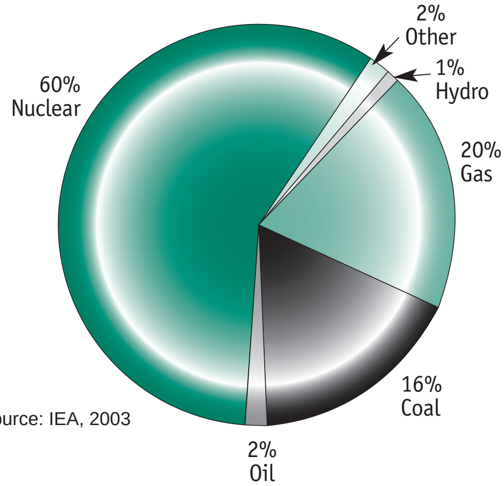
National nuclear energy context

Commercial utilisation of nuclear power in Belgium started in 1975 and by 2002 there were 7 nuclear power units connected to the electricity grid. In 2002 they generated 47.7 TWh of electricity, 57.2% of the total electricity generated in that year.

Also in 2002, the capacities for nuclear fuel fabrication were 400 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors and 37 tonnes HM/year of mixed oxide (MOX) fuel also for use in light water reactors. Spent fuel storage capacity was 3 830 tonnes HM, and the amount of spent fuel arising in 2002 was 108 tonnes HM.

On 16 January 2003, the Belgian federal parliament voted in favour of a bill that requires gradual phase-out of commercial nuclear power plants in Belgium from 2015. This is when the first of four units at the Doel nuclear power plant will be closed down after a 40-year lifetime. (Doel started operation in 1974 and was the first commercial nuclear power plant in Belgium.)

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

Sources

About 70% of the radioactive waste produced in Belgium comes from the nuclear industry, the largest producer. Nuclear industry waste is generated during nuclear power plant operation, reprocessing of spent fuel (carried out by Cogema in France), uranium and MOX fuel fabrication, decommissioning of the Eurochemic pilot spent fuel reprocessing plant and by various nuclear facilities at the Nuclear Energy Research Centre (SCK•CEN).

Approximately 10% of Belgian radioactive waste is generated by nuclear research. The remainder arises from production of radioisotopes by the National Institute for Radioisotopes (IRE), from the use of such isotopes in medicine, industry and in private laboratories, and from the Euratom Institute for Reference Materials and Measurements (IRMM).

Types and quantities

In Belgium, radioactive wastes are classified by way of three categories:

1. Category A: Low- and medium-level short-lived waste. This waste contains small amounts of beta and gamma emitters with half-lives of under 30 years. It arises mainly from the operation of nuclear power plants, but also from reprocessing, research, and from production of radioisotopes and their use in nuclear medicine and industry.

2. Category B: Low- and medium-level long-lived waste. This waste contains mainly alpha emitters, with half-lives exceeding 30 years, together, in some cases, with intermediate amounts of beta and gamma emitters. It arises mostly from the fabrication of nuclear fuels, from nuclear research and the reprocessing of spent nuclear fuel.

3. Category C: Long-lived high-level waste. This waste contains substantial amounts of beta and gamma emitters with short and medium half-lives, together with longer-lived alpha emitters. It arises mostly from research and from the reprocessing of spent nuclear fuel.

The projected total volumes of waste in each of these three categories are given below. They are estimated on the basis of assumptions about the continuing operation of nuclear power plants, reprocessing of all spent fuel, and nuclear facility dismantling by 2050. (Given current trends, the figures below are likely to be an overestimate.)

Category A. The estimated total volume of conditioned waste in this category is 72 000 m^3. At the end of 2002, a total of 12 439 m^3 of this type of conditioned waste was in store at the Belgoprocess site in Dessel. By the year 2015, when the first unit of the Doel nuclear power plant will be closed down, this will have risen to about 22 500 m^3. Of the estimated total volume of waste in this category about 39 200 m^3

will be generated from nuclear facility dismantling activities.

Category B. The estimated total volume of conditioned waste in this category is 7 900 m^3. At the end of 2002, 3 908 m^3 of this type of conditioned waste were in store at the Belgoprocess site in Dessel. Most of this was produced during dismantling of the former Eurochemic pilot reprocessing plant at Dessel. Another 4 000 m^3 or so will arise progressively from the reprocessing of Belgian spent fuel by Cogema in France, from decontamination of nuclear facilities at Dessel and at Mol, the site of the former Waste Department of SCK•CEN, and from nuclear facility dismantling.

Category C. The estimated total volume of conditioned waste in this category is between 2 100 m^3, if only 630 tonnes of spent fuel are reprocessed, and 5 000 m^3, if all of the spent fuel is reprocessed. At the end of 2002, about 236 m^3 of vitrified high-level waste were in store at the Belgoprocess site at Dessel. If reprocessing ceased immediately, the volume of vitrified waste in store would increase by about 55 m^3 and about 4 700 m^3 of conditioned spent fuel would have to be stored.

These figures are summarised in the table below:

Belgium's radioactive waste

Radioactive waste type	Description	Volume
Category A: Low- and medium-level short-lived waste	Projected total volume of conditioned waste	72 000 m^3
	Volume of conditioned waste at end 2002	12 439 m^3
Category B: Low- and medium-level long-lived waste	Projected total volume of conditioned waste	7 900 m^3
	Volume of conditioned waste at end 2002	3 908 m^3
Category C: Long-lived high-level waste	Projected total volume of conditioned waste*	2 100 m^3
	Projected total volume of conditioned waste**	5 000 m^3
	Volume of vitrified high-level waste at end 2002	236 m^3

* 630 tonnes of spent fuel reprocessed.
** All spent fuel reprocessed.

Radioactive waste management policies and programmes

Waste management policies

Radioactive waste generated during routine operation of nuclear facilities in Belgium is processed and conditioned on-site by the operator of the relevant facility, or by the National Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS) in central processing and conditioning facilities located in Dessel and Mol. The Dessel and Mol sites also accommodate central facilities for storage of all conditioned Belgian waste, of all categories, awaiting disposal. The associated operations are carried out by Belgoprocess, the industrial auxiliary company of ONDRAF/NIRAS, which manages these central processing and interim storage facilities.

Conditioned low-level and short-lived waste is stored in engineered surface facilities, awaiting the results of research designed to establish whether near-surface disposal is an acceptable option for Belgium.

The current plan for conditioned high-level and long-lived, alpha-bearing waste is disposal in deep geological formations, and an extensive R&D programme, started in 1974, is concerned with assessing the use of a clay formation as host rock for a repository.

Three decommissioning projects are currently in progress in Belgium. These involve decommissioning and dismantling of the Eurochemic pilot reprocessing plant, the facilities of the former Waste Department of the SCK•CEN, and some other installations of the SCK•CEN including the BR3 reactor. The wastes arising from these decommissioning projects is processed and conditioned in the same way as wastes arising from routine operation of nuclear facilities. During decommissioning particular importance is attached to minimising the amount of radioactive waste produced. This involves techniques such as decontamination of concrete by removal of the contaminated surface layer and abrasive or chemical decontamination of metal items, so that the bulk of the residual materials may be released from regulatory control and does not have to be treated as radioactive waste.

Programmes and projects

Details of existing plants and storage sites

Low-level solid waste is either incinerated or compressed in a facility called CILVA, which began industrial operation in 1994. Low-level liquid waste is treated chemically by flocculation and precipitation. After processing, the waste is encapsulated in cement or bitumen in 400-litre drums and then stored in a building designed specifically for the purpose. The CILVA facility cost 57 million euro, and its operation was certified to the ISO 9001 quality management standard in 1995. The capacity of the low-level waste storage building is 14 000 m^3. By the end of 2002 it contained 10 039 m^3 (over 25 000 drums) of conditioned low-level waste, which constitutes almost

72% of its capacity. The rest of the total of 12 439 m^3 is stored elsewhere on the Belgoprocess site. At the present rate, the building will be full by 2010. If, by that time, no provision has been made for disposal of low-level and short-lived waste, additional interim storage capacity for this type of waste will have to be built.

Medium-level and long-lived alpha-bearing waste is treated chemically, encapsulated in cement or bitumen in 400-litre drums, and then stored in a shielded building. By the end of 2002 this building contained 3 908 m^3 (nearly 16 000 drums) of conditioned waste, which constitutes almost 87% of its capacity.

Reprocessing of Belgian spent fuel, by Cogema in France, generates both high-level waste and very high-level waste. High-level waste is encapsulated in cement and very high-level waste is vitrified. These wastes are, or will be, stored in a specially designed shielded building with 1.5 m to 1.7 m thick concrete walls and roofs, lead shielding, forced ventilation, remote control equipment and air-cooled storage pits. The building cost 55 million euros and was commissioned in 1995. It has storage capacity for 600 containers of vitrified high-level waste and 1 000 m^3 of cemented medium- and high-level waste. By the end of 2002, it contained 21 m^3 (140 containers) of vitrified, heat-producing, high-level waste, which constitutes about 24% of its capacity for this type of waste. The figure of 600 vitrified high-level waste containers derives from the assumed reprocessing of 630 tonnes of spent fuel and return of the resulting waste over a period of 10 years. A similar storage building was commissioned in 1991 and contains almost 215 m^3 of vitrified high-level waste generated on the Belgoprocess site, where some 1 000 m^3 of high-level, liquid waste resulting from the activities of the former Eurochemic reprocessing plant were vitrified.

Disposal

All radioactive waste of Belgian origin will be disposed of on land. In accordance with a federal government decision of 16 January 1998, research into disposal of low-level and short-lived radioactive waste is focussed on the existing Belgian nuclear sites of Mol (which hosts SCK•CEN, the Belgian Nuclear Research Center), Dessel (the location of the central interim stores for conditioned radioactive waste of all types), and Fleurus-Farciennes (which hosts IRE, the Institute for Radio-Elements). Local partnerships have been created in the localities of these nuclear sites by the local authorities in co-operation with ONDRAF/NIRAS. The first partnership was created in Dessel in September 1999 under the name STOLA, the second in Mol in February 2000 under the name MONA, and the third in Fleurus-Farciennes in February 2003 under the name PaLoFF.

The aim of these partnerships is to involve the local authorities and members of the public in the development of preliminary concepts for surface or deep underground disposal that can be integrated into larger, economically and socially acceptable regional development concepts. Current progress suggests that these local partnerships will complete their final reports and conclusions by 2004-2005, including final decision by the respective municipal councils on whether to accept the concept developed. The reports will then be submitted to the federal government for its decision on whether disposal of low-level and short-lived radioactive waste is feasible in Belgium and, if so, at which site, in which form and by way of which concept.

In the early 1970s, an inventory of potential deep geological formations for disposal of conditioned high-level and alpha-bearing waste was performed by SCK•CEN and site characterisation was started in 1974. Geophysical investigations led to the decision to build an underground research laboratory, called the High Activity Disposal Experimental Site (HADES), in the so-called Boom clay layer of the Mol-Dessel area. It is located on the SCK•CEN site, at a depth of 220 m, and comprises an access shaft and two galleries in which numerous measurements and in situ experiments have taken place since 1984 when work in the laboratory started.

The principal areas of research include the geology and hydrogeology of the formation; definition of the deep underground repository concept; backfilling material; interaction between the waste and the host rock and, in particular, the retention of radionuclides by clay minerals; the assessment of spent fuel disposal techniques; the improvement and definition of the various disposal scenarios; and the safety and performance assessment of a potential repository in the deep clay. Several of these experiments are conducted in co-operation with other research organisations and universities, both national and international. An important experiment, conducted in close collaboration with the French waste disposal organisation, ANDRA, deals with the lining of the galleries of a future repository.

In 1999, as part of the PRACLAY project (a preliminary demonstration test of high-level radioactive waste disposal in clay) a second access shaft to the Boom clay was created. This was followed, in 2002, by the excavation of an 80 m-long gallery connecting the new shaft to the HADES underground research laboratory. For the excavation, the so-called Wedge Block System was used. This is a tunneling technique that uses a boring machine equipped with a segment erector and which allowed important data on clay convergence to be gathered. It was an innovative experiment, being the first time anywhere that the technique had been used at a depth of 225 m in poorly indurated clay like the Boom clay at Mol. It was very successful, with an excavation rate of 2 to 3 m/day. In the near future, the laboratory will be extended to include a full-scale disposal gallery for study of the response of the clay formation to heat. A number of mock-up heat-generating packages (representing high-level waste canisters) will be placed in the clay in order to observe the clay behaviour. The experiment will also provide an opportunity to implement and demonstrate technologies for use in the construction and operation of the future repository. This will be co-financed by the European Commission within the framework of its shared-costs research programme for radioactive waste management.

In July 2002, the SAFIR 2 report (Safety Assessment and Feasibility Interim Report), was published. It presents the results of R&D on disposal of high-level and long-lived waste performed in the period 1989-2000. The three main objectives of the report are: (1) To provide a structured synthesis of the technical and scientific studies carried out on the disposal of category B and C waste in a poorly indurated argillaceous formation. (2) To promote interaction with the nuclear safety authorities in order to reach closer agreement on the outstanding requirements for R&D on the principles of safety assessment. (3) To offer a technical and scientific base for dialogue with all stakeholders in the long-term management of radioactive waste.

The report concludes that the research finds nothing to prohibit disposal of high-level waste in the Boom clay. It reinforces confidence in the concept studied and confirms that, for the wastes under consideration, disposal in poorly indurated clay remains a viable option. By establishing an inter-disciplinary R&D programme that incorporates aspects of social sciences, it will be possible to further enhance confidence in the concept studied. In particular, considering management alternatives, developing repository designs, allowing for non-radiological environmental effects and considering societal aspects, will increase confidence. The SAFIR 2 report was evaluated by way of NEA peer review during October 2002, the results of which were published in March 2003 ("SAFIR 2: Belgian R&D Programme on the Deep Disposal of High-level and Long-lived Radioactive Waste – An International Peer Review by NEA").

The underground and surface facilities of HADES and PRACLAY, and the research performed in them, are managed by the European Underground Research Infrastructure for Disposal of Radioactive Waste in a Clay Environment (EURIDICE), a European economic interest group of which ONDRAF/NIRAS and SCK•CEN are the founding members.

In connection with the process of vitrifying very high-level waste for geological disposal, and in accordance with a decision of the Belgian federal government, ONDRAF/NIRAS is coordinating a complementary programme of active glass sample characterisation currently being undertaken by the Belgian government, Synatom and Cogema. This includes destructive and non-destructive sample analysis. Results are not expected before 2006.

Research and development

Functions

ONDRAF/NIRAS has the main responsibility for research and development on radioactive waste management, and on disposal in particular. The research is undertaken by the Nuclear Research Centre (SCK•CEN) in Mol, universities and other research institutes, as well as at engineering companies.

Contents of R&D plans

Most of the R&D work is related to the disposal of radioactive waste and addresses the following subjects: (a) Development of technical solutions for the long-term management of low-level and short-lived waste. (b) Geological disposal of long-lived and high-level waste in clay, as described above under programmes and projects.

Decommissioning and dismantling policies and projects

Programmes concerned with decommissioning of nuclear facilities have been in progress in Belgium since 1987. They started with R&D and small pilot projects on dismantling and decontamination, with the aim of defining and developing suitable techniques, and providing information on their performance and costs.

The first main project involved extensive preparatory work for decommissioning of the former Eurochemic spent fuel reprocessing plant. The plant had been jointly operated by a consortium of 13 European countries but after final shutdown, responsibility for its decommissioning, and the largest part of the associated financing, passed solely to the Belgian State. The waste management and decommissioning company Belgoprocess, a subsidiary of ONDRAF/NIRAS, started by developing dismantling and decontamination techniques that could be used effectively by operators working in protective clothing under severe conditions, and that had improved performance under real industrial conditions. Decommissioning of the BR3 nuclear reactor, on the SCK•CEN site at Mol, started in 1989. The BR3 reactor was the first pressurised water reactor installed in Western Europe. It was commissioned in 1962 and finally shut down in 1987. In 1989 the European Commission selected it as a pilot dismantling project in the framework of the third European Union five-year research programme on decommissioning of nuclear installations. In addition, several other buildings on the SCK•CEN site, and in which physical, chemical and biological nuclear R&D had been carried out, were decontaminated and released from radiological surveillance in 1995-96. They are now used for conventional technological research by a Flemish research institute. Finally, in 1991, remediation and decommissioning of the former waste management site of the SCK•CEN started with the cleanup of historic waste. This site had become the property of ONDRAF/NIRAS who subcontracted the work to its subsidiary Belgoprocess. The industrial scale decommissioning of redundant process and storage facilities began in 1998 and some facilities have now been returned to green field status.

The final target of all these programmes is re-use of sites or facilities on an unrestricted or restricted basis.

Transport

The transport of radioactive materials in Belgium is governed by the Royal Decree of 20 July 2001 which sets out general regulations for protection of the public, workers and the environment against the hazards of ionizing radiation. All shipments, by whatever means, must be authorised in advance by the Federal Agency for Nuclear Control, under the supervision of the federal Minister of the Interior. In general, these regulations follow the technical requirements of the IAEA Regulations for the Safe Transport of Radioactive Substances but, for certain types of shipment, the transport license may specify special conditions, such as provision of escorts.

Radioactive waste in non-conditioned form, awaiting processing and conditioning, or in conditioned form, awaiting interim storage, is generally removed from the site where it was generated. Non-conditioned waste is transported to the central processing and conditioning facilities and conditioned waste to the central storage facilities, both on the Belgoprocess site in Dessel. These transport operations are mostly performed by Transnubel and Transrad who act as subcontractors for ONDRAF/NIRAS. This type of transport is carried out exclusively by road. The type of transport container and vehicle used depends on the nature and radiation level of the radioactive waste. Specially shielded transport containers have been designed for the safe transport of waste packages. In 2002, 269 shipments of unconditioned waste and 37 shipments of conditioned radioactive waste were carried out.

Spent nuclear fuel is transported by road and rail from the Belgian nuclear power plants to the Cogema reprocessing plant at La Hague in France. The waste resulting from reprocessing is shipped back to Belgium by road and rail using specially designed, shielded transport canisters. In 2002, two such return shipments, containing a total of 56 canisters of vitrified high-level waste, were carried out without difficulty. Another shipment took place on 10 September 2003, bringing the number of such shipments that have already taken place to 6, out of the total of 15 planned over a period of 10 years.

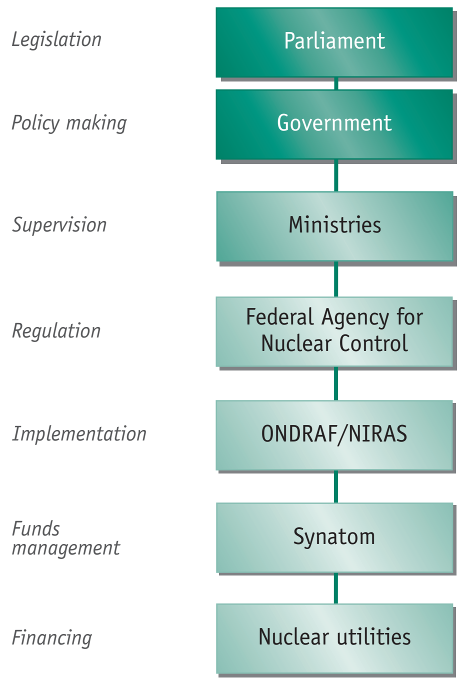
Competent authorities

Organisation of radioactive waste management in Belgium is the responsibility of ONDRAF/NIRAS, a public body set up by way of a law enacted in 1980. A Royal Decree of 30 March 1981 defined its missions and duties, and it operates under supervision of the federal Minister in charge of energy policy. Its mission was extended by way of a law enacted on 11 January 1991 to include certain aspects of the management of enriched fissile materials and the decommissioning of nuclear facilities other than nuclear power plants, the procedures for which were defined in a Royal Decree of 16 October 1991. Under a further law, of 12 December 1997, ONDRAF/NIRAS is also responsible for establishing and updating an inventory of all Belgian nuclear facilities and sites containing radioactive substances. The first inventory report, covering the period 1998-2002, was published in January 2003.

All nuclear activities in Belgium are subject to the general regulations for the protection of the public, workers and the environment against the hazards of the ionising radiation. This includes the technical activities associated with processing, conditioning and interim storage of radioactive waste, and with decommissioning the nuclear facilities at the former Eurochemic pilot reprocessing plant in Dessel and the former Waste Department of SCK•CEN in Mol.

Licensing, control and surveillance under these regulations is the duty of the Federal Agency for Nuclear Control (FANC), which was created in 1994 and is supervised by the federal Ministry of the Interior. The interface between the responsibilities of FANC and of ONDRAF/NIRAS is controlled by way of a formal, protocol agreement.

Main bodies involved in radioactive waste management in Belgium



Financing

The law under which ONDRAF/NIRAS was created requires the costs associated with radioactive waste management to be paid by those who produce it. This law also specifies that the costs of all ONDRAF/NIRAS activities, including applied research and investment, have to be estimated at cost price and financed by the radioactive waste producers in proportion to their share of the overall volume of radioactive waste generated. Long-term operations, mainly those associated with future radioactive waste disposal, will be financed by way of a special fund to which waste producers contribute annually according to the volume and type of radioactive waste they produce.

The same law provides for creation of an insolvency fund whose aim is to guarantee the necessary financial means for ONDRAF/NIRAS to take over responsibility for radioactive waste management from any waste producer who becomes bankrupt or insolvent. The radioactive waste producers also finance this fund.

ONDRAF/NIRAS activities concerned with establishing and updating the inventory of nuclear facilities and sites in Belgium are financed by way of licence fees, paid by the owners or operators of these facilities or sites and imposed by Royal Decree on 31 May 2000. Its activities associated with decommissioning the nuclear facilities at the former Eurochemic pilot reprocessing plant in Dessel and the former Waste Department of SCK•CEN in Mol are financed by way of a federal charge on electricity supply, imposed by Royal Decree on 24 March 2003. R&D on radioactive waste disposal is also financed by the waste producers, mainly Electrabel the owner and operator of the nuclear power plants of Doel and Tihange, and Synatom the organisation in charge of the nuclear fuel cycle in Belgium. These funding arrangements are agreed with ONDRAF/NIRAS by way of five-year plans.

Public information

In addition to its illustrated annual report, ONDRAF/NIRAS publishes a bulletin entitled "ACTUA" on its website at www.nirond.be. This bulletin describes major events concerning radioactive waste and, in each issue, presents a special topic with the aim of improving public understanding of the subject. Other publications deal more specifically with surface and geological disposal projects, and with the return shipment of waste resulting from the reprocessing of Belgian spent fuel in France. ONDRAF/NIRAS also has a radioactive waste information centre, called "Isotopolis", on the Belgoprocess site in Dessel. This centre is open to the public and is aimed primarily at secondary school students.

Belgoprocess organises visits to its processing, conditioning and interim storage facilities for the press, professional visitors and occasionally for the public. It also publishes an annual report and information leaflets on its activities. The Belgian Nuclear Forum, comprised of companies from the nuclear industry, publishes a quarterly bulletin entitled "Actualité Nucléaire", which provides the general public with details of major events that have taken place in the nuclear sector, including those in the area of radioactive waste management.

For more information, the websites of the relevant organisations are listed below.

Government

Federal Agency for Nuclear Control (FANC)
Brussels
Website: http://www.fanc.fgov.be
E-mail: info@fanc.fgov.be

Industry

ONDRAF/NIRAS
Brussels
Website : http://www.nirond.be
E-mail: webmaster@nirond.be

Belgoprocess
Dessel
Website : http://www.belgoprocess.be
E-mail: info@belgoprocess.be

Belgian Nuclear Forum
Brussels
Website : http://www.belgatom.com
E-mail: belgatom@tractebel.be

For further information, please contact:

OECD Nuclear Energy Agency
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Fax: +33 (01) 45 24 11 10, Internet: www.nea.fr

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Canada

National nuclear energy context

A total of 22 CANDU reactors are operated by public utilities and private companies in the provinces of Ontario (20), Quebec (1) and New Brunswick (1). Of the 22 reactors installed, 17 reactors are currently in full commercial operation, and they generate on average around 12.5% of Canada's electricity, mostly in Ontario where 40% of the electricity produced in the province comes from nuclear energy.

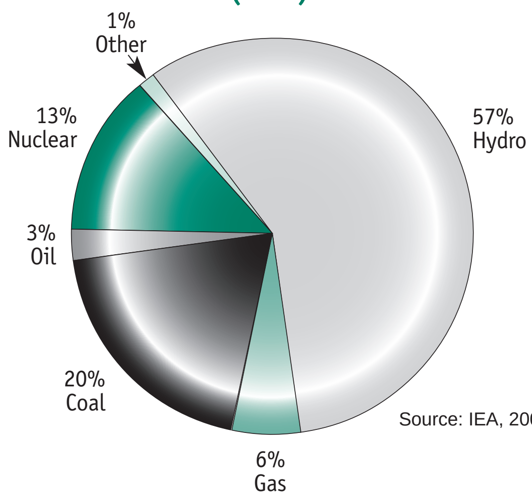
Also in 2002, the capacity for nuclear fuel fabrication was 2 750 tonnes heavy metal per year (HM/year) of uranium fuel for heavy water reactors.

In Canada the nuclear fuel cycle comprises uranium mining and processing, nuclear fuel fabrication and production of nuclear power, based on Canadian CANDU technology.

Canada is the world's leading producer of uranium, accounting for about 30% of global production. It has the world's third largest resource of uranium, including the two largest high-grade deposits.

The currently identified economic resources, about 439 000 tonnes of uranium, are sufficient for nearly 40 years of production at present rates of extraction.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

In Canada, radioactive waste is generated from uranium mining and processing, nuclear fuel fabrication, operation of nuclear reactors, and radioisotope manufacture and use. These radioactive wastes are divided into three categories: nuclear fuel waste, low-level radioactive waste, and uranium mine and mill tailings.

Nuclear fuel waste (NFW)

In Canada, nuclear fuel waste refers to the nuclear fuel bundles discharged from CANDU power reactors, the prototype and demonstration power reactors, and research and isotope production reactors. There are no plans to reprocess and recycle the spent fuel removed from nuclear reactors. It is therefore described as nuclear fuel waste and current plans are based on its long-term management as a waste. Ontario Power Generation (OPG) is the largest nuclear utility with 12 reactors, 9 of which are presently in operation. Bruce Power, which leased the Bruce nuclear generating station from OPG in 2001 for a period of 18 years, has 6 of the 8 reactors at that site in operation. New Brunswick Power and Hydro-Québec each operate one reactor, at Point Lepreau and Gentilly respectively. Together, the four nuclear utilities generate, on an annual basis, a few hundred cubic metres (~ 250 m^3 in 2002) of nuclear fuel waste from the operation of these reactors. To the end of 2002, the inventory of nuclear fuel waste stored on site by the utilities in wet and dry storage was 5 568 m^3 and 990 m^3 respectively. In addition, a small amount of nuclear fuel waste comes from the research and radioisotope production reactors of Atomic Energy of Canada Ltd (AECL), a federal Crown corporation, and research reactors in operation at universities. The estimated volume of these wastes to the end of 2002 was 208 m^3.

Low-level radioactive waste (LLRW)

Low-level radioactive waste is defined by exception. It comprises all forms of radioactive waste except for nuclear fuel waste and uranium mine and mill tailings. LLRW is divided into two broad categories:

- Waste from ongoing activities where an owner or producer remains responsible for its management.

- Waste from historic activities where no owner or producer exists to take responsibility for it, leaving government as the manager of last resort.

Ongoing LLRW is currently being produced from Canada's nuclear reactors, nuclear fuel processing and fabrication facilities, and from medical research and industrial uses of radioisotopes. Operational wastes constitute most of such waste, and this trend will continue until the start of significant decommissioning of nuclear facilities. At the end of 2001, there was an estimated inventory of 186 000 m^3 of ongoing LLRW in storage. Historic LLRW consists primarily of process residues and contaminated materials mixed with soil. It is generally of low or very low activity. The volume of historic waste is approximately 1 430 000 m^3, representing the bulk of Canada's total LLRW inventory. Over 90% of the historic waste results from past operations of a radium and uranium refinery and is located at interim waste management sites in the Port Hope area of southern Ontario. In addition, there are some 83 000 m^3 of contaminated soil stored at the AECL Chalk River Laboratories, which were produced by nuclear activities during the early years of nuclear research and development and by associated cleanup activities.

Uranium mine and mill tailings

Uranium mine and mill tailings are a specific type of radioactive waste generated during the mining and milling of uranium to produce uranium concentrate, which is used in fabrication of nuclear fuel. These wastes are generally held in containment areas close to the milling sites. Because of their large volumes, the tailings are usually decommissioned where deposited. This is typically in mined-out, open pits that have been engineered to create tailings management facilities, or in above-ground tailings ponds. Most of the existing uranium mine and mill tailings are located in the provinces of Ontario and Saskatchewan. Of the total of twenty-four tailings sites in Canada, only three in Saskatchewan continue to receive such waste. At the end of 2003, the inventory of uranium mine and mill tailings at operational mine sites was 12.7 million tonnes dry mass. The total quantity of all Canadian uranium mine and mill tailings, from both operational and inactive or shutdown mines, is about 225 million tonnes.These figures are summarised in the table below.

Aerial view of the JEB mill and of the JEB tailings management facility (TMF) at McClean Lake, Canada. Cogema Resources Inc.

Canada's radioactive waste

Radioactive waste type	Description	Quantity
Nuclear fuel waste	In wet storage	5 568 m^3
	In dry storage	990 m^3
	From research and radioisotpe production reactors	208 m^3
Low-level radioactive waste	From ongoing activities	About 186 000 m^3 *
	From historic activities	About 1 430 000 m^3 *
Uranium mine and mill tailings	At operating and inactive or shutdown mines	About 225 million tonnes

* Estimated inventory.

Radioactive waste management policies and programmes

Waste management policies

In July 1996, the Government of Canada announced its Policy Framework for Radioactive Waste. This set the stage for further development of the institutional and financial arrangements required for implementation of long-term management of radioactive waste in a safe, environmentally sound, comprehensive, cost-effective and integrated manner. The federal government has responsibility to develop policy, to regulate, and to oversee the activities of radioactive waste producers and owners to ensure that they meet their operational and funding responsibilities, in accordance with approved long-term waste management plans. It is recognised, however, that there will be variations in the general approach to management of the different types of waste.

Health, safety, security and environmental aspects of the management of all radioactive wastes, whether ongoing or historic, are regulated under the *Nuclear Safety and Control Act* by the federal regulatory body, the Canadian Nuclear Safety Commission (CNSC).

Programmes and projects

Nuclear fuel waste

As required by the federal government, a deep geological disposal concept for nuclear fuel waste was developed by AECL and Ontario Hydro, the precursor of OPG. In October 1988, this was referred for review to an independent, federal Environmental Assessment Panel. Guidelines for preparing an Environmental Impact Statement (EIS) were published in 1992, and the EIS was duly submitted by AECL in 1994. In March 1998, the Panel published a report with conclusions and recommendations on the acceptability of the proposed concept. They found that, on balance, the concept was technically sound but not socially acceptable, and the Panel proposed further steps to remedy the situation.

In 1998, the Government of Canada responded to the Panel recommendations, in line with the 1996 Policy Framework for Radioactive Waste, and set the stage for developing institutional and financial arrangements for implementing long-term nuclear fuel waste management. The challenge was to ensure that the public would be confident that long-term management of nuclear fuel waste would be carried out in the best interest of Canadians. An important part of the answer to this challenge was the development of the *Nuclear Fuel Waste Act (NFW Act)*, which came into force on 15 November 2002.

The *NFW Act* requires nuclear utilities to create and maintain a waste management organisation with a mandate to propose to the Government of Canada alternative approaches for the long-term management of nuclear fuel waste, and to implement the approach that is selected by Government. The *NFW Act* also requires the utilities and AECL to establish trust funds to finance the implementation of the selected long-term nuclear fuel waste management approach.

Used fuel dry storage containers stored at Pickering Nuclear. OPG, Canada.

The Nuclear Waste Management Organisation (NWMO) was established by the nuclear utilities in late 2002. The *NFW Act* requires it to submit to the Government, by 15 November 2005, a study setting out alternative approaches for the long-term management of nuclear fuel waste, and its recommendation on which approach should be adopted. The NWMO study is required to include approaches based on on-site storage, centralised storage and on disposal. In carrying out this study, the NWMO must consult the general public on each of the alternative approaches. It must also create an Advisory Council whose role is to examine and provide written comments on the NWMO programme activities. The Advisory Council membership must reflect technical and social sciences expertise and, when the Government of Canada has selected the general approach, it must include representatives from relevant local and regional governments and aboriginal organisations.

Low-level radioactive waste

All ongoing low-level radioactive waste from nuclear power production is presently stored at reactor sites. OPG, Hydro-Québec, New Brunswick Power and AECL all operate on-site storage facilities. AECL also provides a waste storage facility for smaller producers on a fee-for-service basis. To date there has been no pressing need for early disposal of LLRW as waste volumes are small and the interim storage is judged to be safe.

The major nuclear utility in Canada, OPG, and AECL together produce about 70% of the annual volume of low-level radioactive waste in Canada. OPG's low-level radioactive waste is safely stored on an interim basis at the Western Waste Management Facility at Bruce Nuclear Power Development (BNPD). In April 2002, OPG and the Municipality of Kincardine signed a Memorandum of Understanding to jointly study options for the long-term management of the wastes at the BNPD site. The year 2015 is considered an achievable target date for bringing a long-term management facility into service.

The other major ongoing producer of low-level radioactive waste, AECL, stores the waste it generates in in-ground and above-ground structures. Natural Resources Canada and AECL are assessing organisational approaches and long-term waste management strategies for dealing with the AECL inventory of low-level radioactive waste, in support of future government decisions about management of those wastes.

The bulk of historic LLRW in Canada is located in the area of Port Hope in Ontario. In March 2001, the Government of Canada entered into an agreement with the municipalities in whose localities the historic wastes are located. This agreement, termed the Port Hope Area Initiative (PHAI), addresses the cleanup and long-term management of these wastes. The Government proponent for the PHAI is the Low-Level Radioactive Waste Management Office (LLRWMO). This body was established in 1982 as the Government of Canada agent for the management of historic waste and is responsible for implementation of the PHAI.

The PHAI will involve long-term management of these historic wastes in newly constructed, above-ground mounds in the local communities. The $ 260 million project will take about ten years to complete. The first phase of the Initiative involves environmental assessment and regulatory review and is expected to be complete in 2007. Ongoing public consultation remains a priority and municipal consent will be necessary to move into the next phase. Cleanup, waste facility construction and waste emplacement would take place in the following five years, after which the facilities would continue to be monitored and maintained for the long-term.

Uranium mine and mill tailings

All currently active uranium mining sites are situated in northern Saskatchewan. Most of the inactive sites are in the Elliot Lake area of northern Ontario, which was the major uranium-mining centre in Canada for over 40 years. Since the last facility closure in 1996, uranium mining companies have committed over $ 75 million for decommissioning of all mines, mills and waste management areas.

The CNSC has recently embarked on a programme to bring all inactive sites in Canada under regulatory control where appropriate and necessary.

Research and development

AECL maintains a comprehensive R&D programme of underlying research in support of existing and ongoing CANDU reactor designs, with the specific objectives to ensure the continuing safe and effective operation of CANDU reactors, including radioactive waste management; to develop new products and services to enhance AECL business opportunities; to provide the basis for specific enhancements to AECL's CANDU 6, CANDU 9 and MAPLE reactor designs; to support the pre-commercial development of advanced CANDU designs; and to support Canadian government policy.

Regarding R&D related to uranium mine and mill tailings, the mining industry, in co-operation with provincial and federal governments, has funded a comprehensive research programme over the past two decades on acid rock drainage and the stability of engineered barriers. Technologies developed under this program have been successfully applied to the decommissioning of uranium tailings in Ontario and Saskatchewan and at other sites across Canada.

Decommissioning and dismantling policies and projects

The *Nuclear Safety and Control Act*, together with supporting Regulations, explicitly addresses the decommissioning of nuclear facilities. Amongst other things, the Act requires that the shutdown and decommissioning of facilities licensed by the CNSC must be carried out according to plans approved by the CNSC. It also includes provisions for ensuring that applicants provide such financial guarantees for funding the decommissioning of their facilities as CNSC may require.

Decommissioning projects are under way on the AECL research facilities at Whiteshell and Chalk River, and on the AECL demonstration/prototype power reactor sites at Douglas Point and Rolphton in Ontario, and at Gentilly in Québec. These reactors, and the NRX reactor at Chalk River and the WR-1 reactor at Whiteshell, are now partially decommissioned and are in a state of "storage-with-surveillance". This surveillance period is to allow for the decay of radioactivity in the reactors, thus reducing the radiation dose to workers involved in their final dismantling. AECL is continuing to submit preliminary and detailed decommissioning plans for components of its research facilities.

Monitoring the decommissioned uranium mining facilities in the Elliot Lake area of Ontario is continuing. These facilities include the Stanrock and Denison facilities of Denison Mines Limited and the Quirke, Panel and Stanleigh facilities of Rio Algom Limited. On 16 August 2002, the CNSC issued a Radioactive Waste Facility Operating Licence to Rio Algom Limited for the remaining other idle uranium mining facilities in the Elliot Lake area (Spanish American, Milliken, Lacnor, Nordic/Buckles, and Pronto). These mine sites have not been operational for almost 40 years, and were not previously licensed.

Indian and Northern Affairs Canada is conducting decommissioning work, under CNSC licence, at the idle Rayrock mine site in the Northwest Territories.

The University of Toronto has completed the decommissioning of its sub-critical assembly and its Slowpoke research reactor.

Transport

In Canada, radioactive material is routinely transported by road, rail, sea and air. The CNSC regulates the safe transport of nuclear substances under the *NSC Act* and cooperates with the federal department, Transport Canada, under the *Transportation of Dangerous Goods Act*. The requirements for transport of such materials are based largely on the *Regulations for Safe Transport of Radioactive Material* developed by the International Atomic Energy Agency.

Most shipments are of radioactive materials destined for use in medicine, science and industry and they generally involve routine deliveries of materials with very low levels of activity, but other more radioactive materials, such as spent fuel from nuclear reactors, are also transported within Canada.

Competent authorities

Regulation and licensing

The Government of Canada recognises the important contribution of the nuclear industry as well as the need to ensure safety, security, public health and the protection of the environment. Against this background, policies, legislation and regulations have been put in place in order to provide appropriate direction and oversight of radioactive waste management in Canada. The Canadian Nuclear Safety Commission (CNSC) is the leading federal body for regulation and oversight of operations conducted by the nuclear industry. Natural Resources Canada also provides oversight, particularly through its Nuclear Fuel Waste Bureau, which administers the *Nuclear Fuel Waste Act*. Health Canada, Transport Canada and the Canadian Environmental Assessment Agency also contribute to federal oversight.

Public bodies

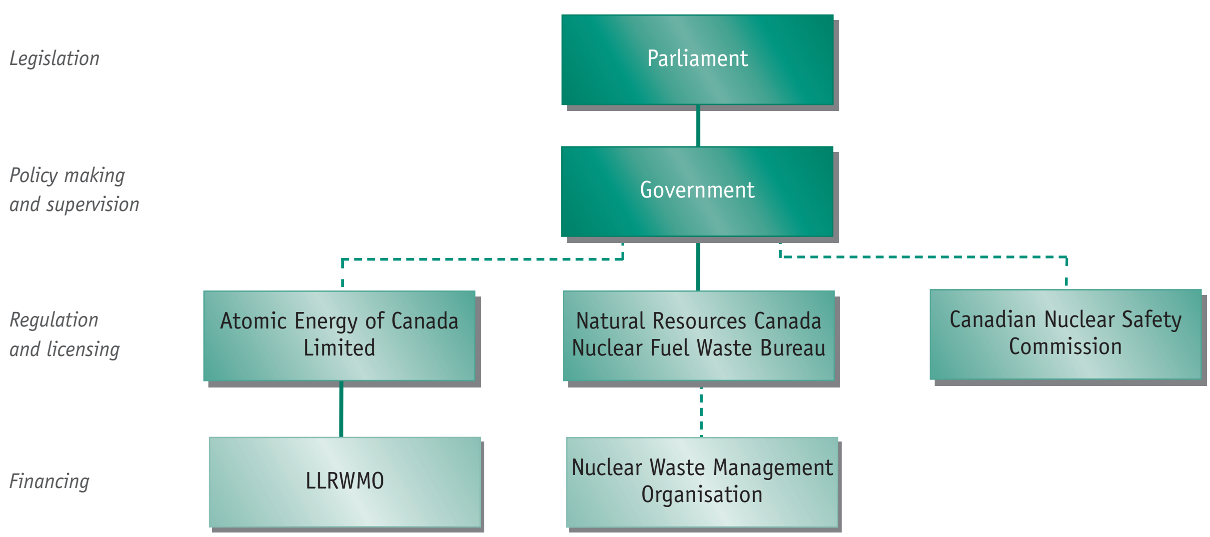
AECL is a federal Crown corporation and is responsible for CANDU design, engineering and marketing as well as nuclear research and development. It has both a public and commercial mandate and is a radioactive waste producer in its own right.

The Low-Level Radioactive Waste Management Office (LLRWMO) is the federal body charged with carrying out cleanup operations for historic waste. The LLRWMO is operated as a separate division of AECL, but receives its funding and policy direction from Natural Resources Canada.

Operators

The key companies currently responsible for operating elements of the nuclear fuel cycle are the power-producing utilities, Hydro-Québec, Ontario Power Generation, Bruce Power and New Brunswick Power, together with their Nuclear Waste Management Organisation, the companies involved in uranium mining, milling, processing or refining, Cameco Corporation and Cogema Resources Inc, and the nuclear fuel fabrication companies, Canada General Electric and Zircatec Precision Industries.

Main bodies involved in radioactive waste management in Canada



Financing

In general, regarding financial responsibility for radioactive waste management, the CNSC requires existing operators to provide financial guarantees designed to ensure that operations take place in a responsible and orderly manner, in both the short and long term. Where a producer or owner cannot be identified, cannot be located, or is unable to pay, responsibility rests with the federal and/or provincial governments, as managers of last resort. Specific provisions are as follows.

Nuclear fuel waste

The requirements for financial guarantees set out in the *Nuclear Safety and Control Act* take into account the related requirements of the *Nuclear Fuel Waste Act*. This requires a specific guarantee in the form of trust funds into which nuclear utilities and AECL deposit money annually to cover the costs of long-term nuclear fuel waste management operations. Money in these funds can only be withdrawn by the Nuclear Waste Management Organisation, and only after a construction or operating licence for a long-term waste management facility has been granted by the CNSC. To date a total of $ 660 million has been deposited into the trust funds.

Low-level radioactive waste

Financial guarantee requirements under the *Nuclear Safety and Control Act* apply to the ongoing production of low-level radioactive waste. Financial guarantees sufficient to cover the full costs of radioactive waste management are now being put into place for all nuclear facilities in Canada, including nuclear power reactors, research reactors, fuel fabrication facilities, uranium processing facilities, isotope processing facilities, and waste management facilities. With respect to the management of historic low- level radioactive waste, the LLRWMO receives its policy direction and funding from Natural Resources Canada.

Uranium mine and mill tailings

The CNSC requires the owners of uranium mine sites to post financial guarantees to cover the costs of decommissioning. Where an owner cannot be identified, cannot be located, or is unable to pay, responsibility for decommissioning rests with the federal and provincial governments. The 1996 Canada-Ontario Memorandum of Agreement (MoA) on cost-sharing for the long-term management of abandoned uranium mine sites recognises that present and past owners are responsible for all financial aspects of the decommissioning, and long-term maintenance of uranium mine sites, including the tailings. In the case of abandoned sites, however, the MoA outlines how both levels of government will share the long-term management responsibilities and associated costs. A similar agreement with the Government of Saskatchewan is under consideration.

Public information

In Canada, public participation in decision-making is of high priority and all major organisations carry out public information programs. This increasing public role is recognised in various pieces of federal legislation, which incorporate a mandatory requirement for public participation, especially in regard to social and ethical considerations. For more information, the websites of the main government and industry organisations are listed below.

Government

Canadian Nuclear Safety Commission: www.cnsc.gc.ca
Nuclear Fuel Waste Bureau: www.nfwbureau.gc.ca
Natural Resources Canada: www.nrcan.gc.ca and http://nuclear.nrcan.gc.ca
Low-Level Radioactive Waste Management Office: www.llrwmo.org
Canadian Environmental Assessment Agency: ww.ceaa.gc.ca
Transport Canada – Transport of Dangerous Goods Directorate: www.tc.gc.ca/tdg/menu.htm

Industry

Hydro-Québec: www.hydroquebec.com
Ontario Power Generation: www.opg.com
Bruce Power: www.brucepower.com
New Brunswick Power: www.nbpower.com
Atomic Energy of Canada Ltd: www.aecl.ca
Nuclear Waste Management Organisation: www.nwmo.ca
Cameco Corporation: www.cameco.com
Cogema Resources Inc.: www.cogema.ca
General Electric Canada: www.ge.com/canada
Zircatec Precision Industries: www.zircatec.ca
Canadian Nuclear Association: www.cna.ca

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

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OECD Nuclear Energy Agency
12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
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Czech Republic

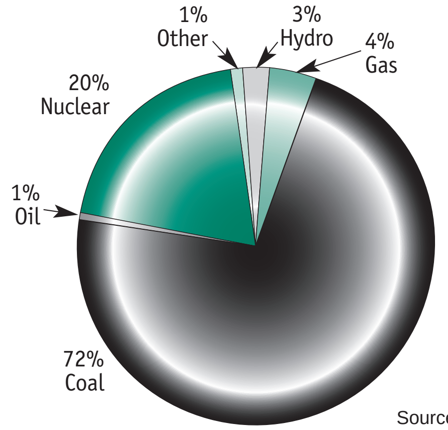
National nuclear energy context

Commercial utilisation of nuclear power in the Czech Republic started in 1985 and by 2002 there were 6 nuclear power units connected to the electricity grid. In 2002 they generated 17.6 TWh of electricity, 25% of the total electricity generated in that year.

Also in 2002, the spent fuel storage capacity was 1 431 tonnes heavy metal (HM), and the amount of spent fuel arising in that year was 39 tonnes HM.

In November 2001, the Czech Republic and Austria resolved their disagreement over start-up of the Temelin nuclear power plant, after an international expert review carried out under mediation by the European Commission. The difficulties were resolved within the framework of the "Melk Protocol" whereby Austria and the Czech Republic agreed to a safety review process before commercial operation of the plant, and a regular exchange of information thereafter.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

Low- and intermediate-level waste – short-lived (LILW-SL)

This type of waste contains small or medium amounts of radionuclides with half-lives of under 30 years and arises in liquid or solid form during the operation and decommissioning of nuclear reactors, and during the use of radioactive sources in medical, research and industrial applications.

Very low-level waste, and waste contaminated with naturally occurring radioactive material (NORM), form a specific sub-category. These wastes are created in the processing of certain metal ores or phosphate materials, during the shipment and processing of crude oil and in the water-treatment industry. Their radionuclide concentrations are below or near the limit for permitting their release into the environment without further radiological control.

The quantities of LILW-SL in the Czech Republic are summarized in the table below. This shows the quantities of operational and decommissioning waste arising from the Dukovany and Temelin nuclear power plants (NPP) over indicated time periods, together with average annual waste production rates. It also shows the quantities of waste arising from the activities of institutions outside the nuclear industry over indicated periods, also with average annual production rates.

Quantities of LILW-SL (in m^3)

Source	Operational	Decommissioning	Av. annual production
Dukovany NPP (1985-2025)	10 250	–	256
Dukovany NPP (2025-2035)	–	3 640	364
Dukovany NPP (2085-2094)	–	2 385	239
Temelin NPP (2000-2042)	12 000	–	285
Temelin NPP (2040-2047)	–	620	78
Temelin NPP (2090-2095)	–	4 012	669
NPP total	**32 907**		
Institutions (1958-2000)	2 800		67
Institutions (2000-2095)	5 700		60
Institutions total	**8 500**		

Low- and intermediate-level waste – long-lived (LILW-LL)

This type waste contains mainly radionuclides with half-lives exceeding 30 years, together in some cases with medium amounts of shorter-lived radionuclides. About 90% of it arises from the operation and decommissioning of nuclear facilities with the remainder coming from the use of radioactive sources in the institutions outside the nuclear industry and from decommissioning of their equipment and facilities.

Spent nuclear fuel and high-level waste

According to the *Atomic Act*, spent nuclear fuel is not considered to be waste until it is declared as such by its owner, or by the State Office for Nuclear Safety. The company that operates the nuclear power plants in the Czech Republic is CEZ, which has adopted the open nuclear fuel cycle concept. Under this concept spent fuel is not reprocessed for recovery of reusable material. For this reason, the management of reprocessing residues in the form of vitrified high-level radioactive waste is not currently an issue of direct concern to CEZ.

High-level waste contains substantial amounts of radionuclides with short and medium half-lives, together with longer-lived radionuclides. It would arise mainly from the reprocessing of spent nuclear fuel but only if the CEZ policy was changed.

The quantities of LILW-LL and spent nuclear fuel in the Czech Republic are summarised in the table below. This shows the quantities of operational and decommissioning waste and spent nuclear fuel arising from the Dukovany and Temelin nuclear power plants over indicated time periods, together with analogous figures for the waste and spent fuel arising from the activities of institutions outside the nuclear industry. The table excludes information about waste and spent fuel that may arise from any new nuclear facilities, as well as information about any high level waste that would be generated if any decision were made to reprocess spent nuclear fuel. Spent nuclear fuel from the FJFI ČVUT university reactor is included under the entries for 'Institutions'.

Quantities of LILW-LL (post-processing volume in m³) **and spent nuclear fuel** (in tonnes HM)

Source	Operational	Decommissioning	Spent nuclear fuel
Dukovany NPP (1985-2025)	50	–	1 937
Dukovany NPP (2025-2094)	–	2 000	–
Temelin NPP (2000-2042)	50	–	1 787
Temelin NPP (2090-2095)	–	624	–
NPP total	**2 724**		**3 724**
Institutions (1958-2000)	80	5	0.2
Institutions (2000-2050)	150	50	0.3
Institutions total	**285**		**0.5**

Radioactive waste management policies and programmes

Waste management policies

The collection, transportation and storage of radioactive waste and spent nuclear fuel, and the processing of radioactive waste, is carried out in the Czech Republic by licensed private bodies. The state-owned Radioactive Waste Repository Authority (RAWRA) is responsible for disposal of radioactive waste and for the future processing and disposal of spent nuclear fuel. If necessary, RAWRA can also provide extended services to the generators of these materials.

LILW-SL will be safely disposed of in the Czech Republic in existing near-surface repositories whose operations will be continually assessed and optimised and whose associated safety documentation will be kept up-to-date.

One possible method for the disposal of LILW-LL, and any high-level waste, would involve emplacement in a deep geological repository but, in the absence of such a facility, these materials will be stored by the waste generators on their own sites, or by RAWRA. Conditions will be stipulated for its treatment, and adequate storage capacity will be reserved or built.

The technical procedures for disposal of radioactive waste and for the preparation of a deep geological disposal facility in the Czech Republic will draw upon the results and experience of foreign research and technical developments. In addition, the options for reprocessing spent nuclear fuel, and for reducing its volume or toxicity, will also be pursued.

Programmes and projects

Low- and intermediate-level waste management

The largest volume of radioactive waste is comprised of LILW-SL. After two or three hundred years, the activity of this waste decays to a very low level and, hence, it can be deposited in near-surface repositories. The techniques for processing and treating such radioactive waste for disposal are well developed and are implemented in the Czech Republic. Some of these radioactive wastes contain radionuclides with very short half-lives and their activity decays to a very low level in a short time. Such transient waste is processed, treated and stored in the same way as other low-level wastes but, after its activity decreases to below a stipulated level, the waste is released for recycling or disposal at secure, non-radioactive waste sites.

Production of very low-level waste, and waste contaminated with naturally occurring radioactive material (NORM), takes place at specific facilities and could potentially endanger the local area. Hence particular attention has also been paid to these materials. The collection, sorting and processing of such waste is currently carried out on an ad-hoc basis although a system for its collection and assessment has now been partially implemented. A legal framework for the management of such materials has not yet been established in the Czech Republic, but arrangements concerning the commercial management of waste contaminated with NORM, which arises from certain operations in the uranium industry, are currently being discussed.

A LILW-SL disposal facility is located on the site of the Dukovany NPP. It is intended for the disposal of operational waste produced by both the Dukovany NPP and the Temelín NPP. The disposal capacity of 55 000 m^3 is large enough for both plants, including their decommissioning.

The Richard disposal facility, located near the town of Litomerice, is designated for disposal of institutional LILW-SL. It is constructed on the premises of a former mine and is designed for disposal of radioactive waste containing artificial radionuclides. Its disposal capacity is 8 500 m^3, which is sufficient for disposal of all the institutional LILW-SL expected to be generated up to 2070.

The quantities of LILW-LL are relatively small, but it is not suitable for disposal in the existing near-surface repositories. The requirements for processing, storage and subsequent deep geological disposal of this waste will be stipulated in due course. These requirements are well-established elsewhere, and the associated techniques are already used commercially, so implementation is more a matter of time and finance than a technical issue. For the time being, most of this kind of waste is stored without processing, where it arises and by its generators. A small amount is stored by RAWRA.

It is planned that the LILW-LL from NPP operations will continue to be stored at the NPP until its decommissioning, when the waste will then be disposed of into a deep geological repository (DGR).

As regards institutional LILW-LL, the Bratrství repository, located in a former uranium mine near the town of Jáchymov, is designed for disposal of waste containing naturally occurring long-lived nuclides such as ^{226}Ra and uranium. Its capacity is 1 200 m^3, which is expected to be sufficient for disposal of all waste of this type. The institutional LILW-LL containing artificial long-lived nuclides such as ^{241}Am and ^{239}Pu will be stored at the Richard repository until the DGR is in operation.

It is planned to support the systematic management of low- and intermediate-level waste by establishing a central collection and processing facility. Procedures will be also be established for making decisions about the release of very low-level wastes into the environment without further regulatory control under the Atomic Act, and waste disposal sites, at which such waste can be accepted, will be identified.

Depending upon the results of ongoing safety analysis, a time schedule and technical specifications will be prepared for the final disposal of radioactive waste accepted at the Bratrství and Richard repositories before the Atomic Act was passed.

Management of high-level waste and spent nuclear fuel

High-level waste, and spent nuclear fuel if it is declared as waste, constitute the most hazardous category of radioactive waste. The volume of this waste is low, and is less than a tenth of the volume of all radioactive waste generated in the Czech Republic. Because the levels of activity and concentrations of long-lived radionuclides are high, this kind of waste is currently destined for disposal in a deep geological repository. Techniques for the processing of such waste are available and are already used industrially in spent nuclear fuel reprocessing plants elsewhere. In fact the vitrification process was developed in the Czech Republic. Containers are currently being designed for the direct disposal of spent nuclear fuel or processed high-level waste, and suitable structures and insulation materials are being analysed. The techniques for spent nuclear fuel and high-level waste processing, and for production of repository containers and insulation materials, will be further developed and final selection made when the geological and hydrogeological conditions at the site selected for the deep repository are known.

Currently, spent nuclear fuel from the Dukovany NPP is stored on the premises of the plant itself, and CEZ has adopted a concept of dry storage in dual-purpose, transport/storage containers. Spent fuel from research reactors is stored at the Nuclear Research Institute at Řež. Spent nuclear fuel from the Temelín NPP will be stored at a storage facility that is planned to be in operation in about 2010, but whose location has not yet been decided.

The final decision about management of high-level waste and spent nuclear fuel depends on the outcome of current research and development for a deep geological repository in the Czech Republic, as described below. At the present time, the option of high-level waste and spent nuclear fuel disposal in an international regional repository has not been excluded. For the time being, however, it seems unrealistic but the knowledge acquired in development of a deep geological repository in the Czech Republic would be invaluable in the construction of a regional repository, if such a project became feasible in future.

Also in connection with management of high-level waste and spent nuclear fuel, certain advanced studies will be financially and scientifically supported. These include studies of methods for separating the small quantities of long-lived radionuclides from spent nuclear fuel for their separate treatment and disposal or for their transmutation into short-lived species. These studies have the potential to reduce the toxicity of the residual waste for disposal and, in the case of transmutation, to realise the energy potential of the material remaining in spent nuclear fuel.

Research and development

Geological repository development

The generic, conceptual design for a deep geological repository in a non-specific site has been completed, including Environmental Impact Assessment and a time schedule and budget for its implementation. Current work involves selection and confirmation of the suitability of a repository location.

Waste management

RAWRA is coordinating a study of methods for retrieving spent ion exchange resins from the storage tanks at the Dukovany NPP, and of methods for their treatment.

A conceptual system design has been completed for management of spent sealed radioactive sources that are unacceptable for disposal in the existing repositories. These sources mainly contain the long-lived radionuclides Am, Pu, Am/Be and Pu/Be. The conceptual design involves conditioning them for interim storage at the Richard repository until a deep geological repository is completed. RAWRA will be developing and implementing the necessary equipment and procedures on the basis of this work.

Decommissioning and dismantling policies and projects

Concept for decommissioning of Dukovany NPP and Temelin NPP

The option adopted for decommissioning of the Dukovany and Temelin nuclear power plants, operated by CEZ, may be described as gradual decommissioning with deferred site clearance.

In this option, all spent nuclear fuel will be removed from the reactors soon after final shutdown. After removal of peripheral equipment, the reactor structures will then be left in place under protective closure for a period of about 50 years. By this time the radiation levels within them will have fallen naturally to levels at which operators may enter the reactors safely in order to carry out the main activities of decontamination, dismantling and site clearance and then to process the resulting radioactive wastes.

These decommissioning wastes will be processed using the same techniques as currently applied to operational wastes from the nuclear power plants, i.e. bituminisation and cementation. The estimated volumes of processed LILW-SL and LILW-LL arising from these decommissioning projects are shown in the tables above.

Transport

The Czech Republic has implemented all the international treaties and conventions on transport of hazardous goods by road, rail and air, by which it is bound. It has also transposed into its own law the EC regulations concerning transportation of radioactive material. These in turn are based on the Regulations for the Safe Transport of Radioactive Substances published by the International Atomic Energy Agency. These regulations apply to radioactive material in general and are not specific to radioactive waste. Nevertheless some licensees under the Atomic Act have their own systems for internal approval of radioactive waste transportation arrangements specifically and some companies specialise in such transportation.

Competent authorities

The Czech Republic has developed a "Concept of Radioactive Waste and Spent Nuclear Fuel Management". This is a fundamental document that records the strategy of Government and State Authorities in regard to the organisations concerned with generation and management of radioactive waste and spent nuclear fuel. It covers the period up to 2025, approximately, but is likely to affect policy up to the end of the 21st century. The Concept recognises the roles of various organisations and interest groups and provides information relative to their specific responsibilities or interests, as follows:

The Czech Government and State Authorities in general: By adopting the Concept the government declares the principles, objectives and priorities for achieving optimum radioactive waste and spent nuclear fuel management, to be implemented by individual ministries, including the ministries of Industry and Trade, the Environment and Finance.

The State Office for Nuclear Safety: Under the *Atomic Act* this is the body responsible for nuclear safety and radiation protection supervision. The Concept sets out the specific content of those activities subject to legal regulation, thereby providing support for the state supervision of radioactive waste and spent nuclear fuel management.

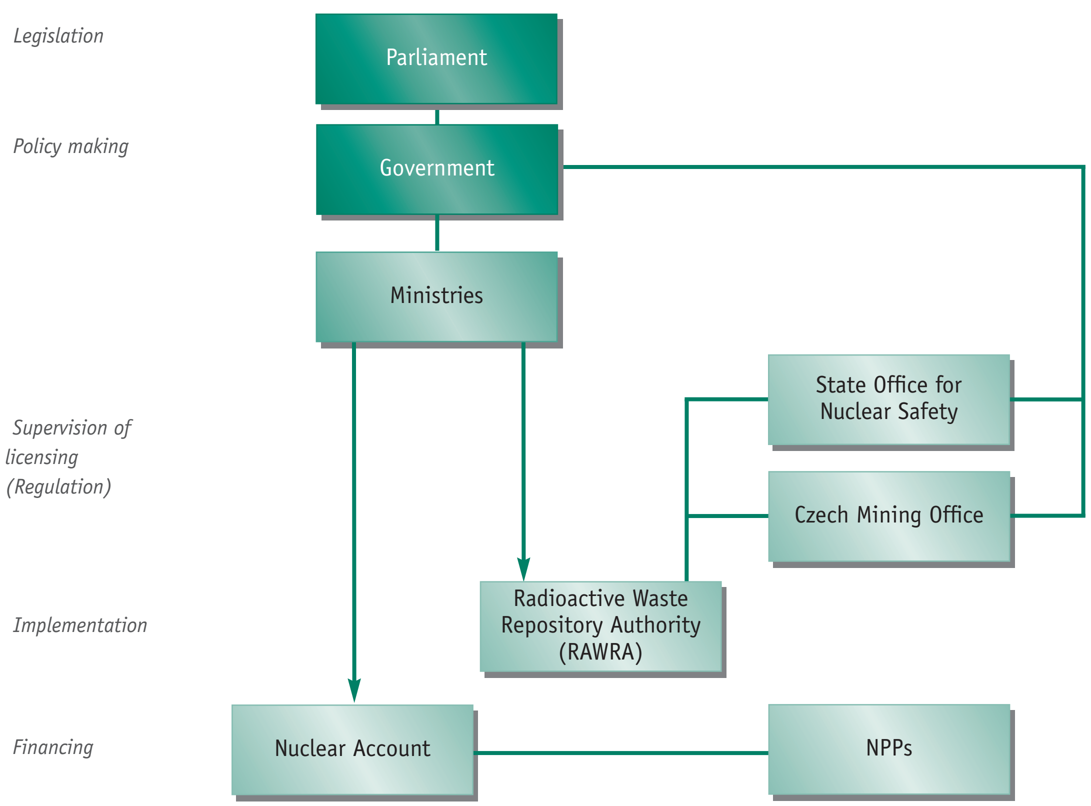
The Radioactive Waste Repository Authority and its Supervisory Board (RAWRA): The Concept is a fundamental, strategic document, which will be used as a basis for the preparation of annual, three-yearly and long-term action plans to be presented on an annual basis, together with RAWRA's budget, to the government for approval. These plans will allow RAWRA's Board to evaluate the performance of RAWRA and the fulfilment of targets, and ensure the efficient use of funds from the nuclear account.

Generators of Radioactive Waste and Spent Nuclear Fuel: The Concept provides a decision-making framework for generators of radioactive waste and spent nuclear fuel concerning their business or production strategies.

Institutions Involved in the Development of Methods for the Disposal of Radioactive Waste and Spent Nuclear Fuel: Using the Concept, research and scientific institutions, universities and other organisations can allocate capacity and systematically prepare for the fulfilment of any requirements arising from the implementation of the concept.

The General Public: The Concept contains basic information about future intentions and priorities concerning radioactive waste and spent nuclear fuel management in the Czech Republic.

Main bodies involved in radioactive waste management in the Czech Republic



Financing

In compliance with internationally acknowledged principles, the Atomic Act requires that the radioactive waste generator bear all the costs of radioactive waste management from production to disposal of such waste, including the cost of monitoring repositories after their closure and the cost of the associated research and development. The processing of radioactive waste for disposal is paid for by the generator in the form of direct payments to specialist organizations that carry out such activities on the generator's behalf. Radioactive waste disposal and spent nuclear fuel processing and disposal are the responsibility of RAWRA. The generator pays for these services in the form of payments to a nuclear account.

Nuclear account

The nuclear account is controlled by the government and nuclear account funds may only be used through RAWRA for tasks specified in the Atomic Act. Nuclear account funds come from several different sources. The distribution of nuclear account funds and amounts and methods of payment are stipulated by certain government decrees. RAWRA administers payments to the nuclear account and prepares documentation on the level of payments.

Cost of waste disposal in near-surface repositories

The costs of operation and closure of existing repositories will be covered by nuclear account funds. Individual generators of radioactive waste deposited will pay into the nuclear account depending on the character and amount of waste being deposited. The level of payments required to cover these costs will be determined according to relevant methodology and made in compliance with current government decree either in the form of one-off payments or regular instalments.

Cost of high-level waste and spent nuclear fuel disposal

The costs of design, construction, operation and closure of a deep geological repository as well as the cost of spent nuclear fuel processing into a form suitable for disposal, and that of high-level waste or spent nuclear fuel disposal itself, will be settled by direct one-off payments or in regular instalments from high-level waste or spent nuclear fuel generators.

Provisions for decommissioning

Under the provisions of the Atomic Act, licensees are obliged to make financial provision for decommissioning nuclear facilities or workplaces with significant or very significant sources of ionising radiation. Funds should be available for both the preparation for decommissioning and decommissioning itself at the required time, and in an amount commensurate with the proposed method of decommissioning as approved by the State Office for Nuclear Safety. Such financial provisions are tax-deductible and are maintained by respective licensees. The estimated cost of decommissioning is verified by RAWRA and licensees are obliged to update their estimates every five years.

Public information

For more information, the websites of relevant organisations are listed below.

Government

State Office for Nuclear Safety – SUJB
Prague
E-mail: emergency@erc-cr.cz
Website: http://www.sujb.cz/

Radioactive Waste Repository Authority – RAWRA
Prague
E-mail: info@rawra.cz
Website: http://www.surao.cz/english/index.php

Industry

CEZ (The joint-stock, nuclear operating company)
Prague
E-mail: info@mail.cez.cz
Website: http://www.cez.cz/cze/

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Finland

National nuclear energy context

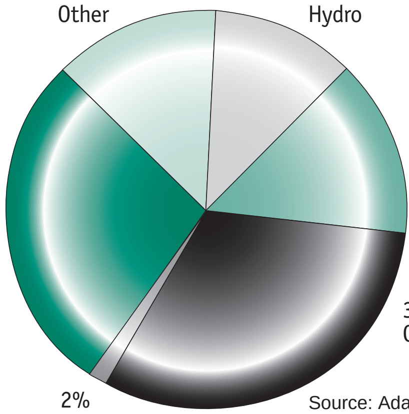
Commercial utilisation of nuclear power in Finland started in 1977 and there are 4 nuclear power units connected to the electricity grid. In 2003 they generated 21.8 TWh of electricity, 27.3% of the total electricity generated in that year.

Also by the end of 2003, the spent fuel arising was about 1 350 tonnes heavy metal (tHM) while the effective storage capacity was about 2 100 tHM.

In May 2001, the Finnish Parliament accepted a decision in principle for deep geological disposal of spent nuclear fuel in the bedrock at Olkiluoto, near the site of the existing nuclear power plant operated by Teollisuuden Voima Oy (TVO).

In January 2002, the Government made a positive decision in principle for the construction of another nuclear power unit and the Parliament ratified that decision in May 2002. Thus, by the time of the parliamentary elections in March 2003, nuclear energy was not a contentious political issue in Finland.

Breakdown of electricity sources (in %)



Source: Adato Energia Oy, 2004

Olkiluoto 3,
in April 2004.
TVO, Finland.

Sources, types and quantities of waste

Nuclear waste in Finland arises from the two nuclear power plants at Olkiluoto and Loviisa, together comprising four units, and from a small research reactor (FiR 1) operated by the Technical Research Centre of Finland (VTT), at Otaniemi, Espoo. There was a small uranium mining and milling facility in Finland but the site is now restored. Other radioactive wastes arise from a number of facilities using radioisotopes in medical, research and industrial applications. No major decommissioning projects giving rise to waste are foreseen within the next two decades.

Waste is classified in Finland according to its disposal route. Spent nuclear fuel contains very high levels of activity and is destined for disposal in a deep geological repository. Low and intermediate level waste (LILW) is of much lower activity and is destined for disposal in rock caverns at intermediate depth. Waste described as "small user radioactive waste" arises from medical, industrial and research sources and generally falls within this latter category. Very low-level waste (VLLW) is characterized by radionuclide concentrations near or below the limit for permitting their release into the environment without further radiological control.

The quantities of radioactive waste in storage at the end of 2002 are shown in the table below. The information is taken from the Finnish Report on the Safety of Spent Fuel and Radioactive Waste Management for the Joint Convention on Spent Fuel Management and on the Safety of Radioactive Waste Management.

Finland's radioactive waste

Waste type	Quantity (activity)	
Spent nuclear fuel from NPPs (at end 2002)	Loviisa	303 tonnes HM
	Olkiluoto	973 tonnes HM
	Total	**1 276 tonnes HM**
Spent fuel from FiR 1 research reactor		4 kg HM
LILW from NPPs (including waste disposed on-site, but excluding VLLW and activated metal waste)	Loviisa	2 446 m^3 (17.5 TBq)
	Olkiluoto	4 190 m^3 (66.6 TBq)
	Total	**6 636 m^3 (84.1 TBq)**
Small user radioactive waste	Central storage	44 m^3 (25 TBq)
	STUK buffer storage	2.3 m^3 (2 TBq)
	Total	**46.3 m^3 (27 TBq)**

Radioactive waste management policies and programmes

Waste management policies

The Finnish *Nuclear Energy Act* states that nuclear waste generated in Finland shall be handled, stored and permanently disposed of in Finland. It also states that nuclear waste generated elsewhere than in Finland shall not be handled, stored or permanently disposed of in Finland. There are only minor exemptions from these principles.

Nuclear waste is defined as radioactive waste in the form of spent nuclear fuel or some other form generated in connection with or as a result of the use of nuclear energy. Producers of nuclear waste are responsible for all aspects of nuclear waste management and for their associated costs. The Ministry of Trade and Industry (MTI) has issued a long-term schedule for the implementation of nuclear waste management.

There is no specific policy for dealing with radioactive waste other than nuclear waste. Each user of radioactive substances is required to take all the measures needed to render harmless the radioactive waste arising from its operations.

In any situation where a producer of nuclear waste, or other radioactive waste, is incapable of fulfilling its waste management obligations the responsibility for doing so will fall to the State.

Spent nuclear fuel management

Spent fuel will be stored in water pools for some decades and thereafter encapsulated and transferred to an underground repository at a depth of about 500 m in crystalline bedrock. There has been good progress in complying with a 1983 Government decision on policy for spent nuclear fuel management in Finland, and key milestones concerned with development of the deep geological repository are described below under programmes and projects.

As regards interim storage, extension of the storage capacity for spent fuel was completed at the Olkiluoto NPP in 1987 and at the Loviisa NPP in 2000. At both sites, there is now enough storage capacity until 2010.

LILW management

Low and intermediate level wastes from reactor operations are disposed of in the bedrock of the power plant sites. The repositories at the Olkiluoto NPP site and at the Loviisa NPP site were commissioned in 1992 and 1998, respectively.

Waste from decommissioning of nuclear power plants

The nuclear power utilities must update their NPP decommissioning plans for regulatory review every five years. According to these plans, wastes from the decommissioning of the reactors will be disposed of in underground repositories co-located with those for operational wastes at the power plant sites.

Programmes and projects

Storage systems

National policy is based on storing spent fuel and other nuclear wastes at the power plant sites until they are disposed of in Finland. The amount of spent fuel from the Loviisa NPP during its planned lifetime of 40 years will be about 1 070 tonnes HM. Because about 330 tonnes HM has already been shipped to Russia, a storage capacity of approximately 740 tonnes HM is needed. The spent fuel arising at the Olkiluoto NPP is estimated to be 1 870 tonnes HM, based on 40 years' operation. At the Loviisa plant, the effective storage capacity is about 520 tonnes HM. In addition to the spent fuel cooling pools in the reactor buildings, there is further basket-type and rack-type pool storage. At the Olkiluoto plant the spent fuel cooling pools in the reactor buildings have an effective capacity of about

370 tonnes HM. After cooling, spent fuel is transferred to a separate on-site facility with three storage pools, each of 400 tonnes HM capacity and with high-capacity fuel racks. The total effective storage capacity at Olkiluoto is 1 570 tHM.

At Loviisa NPP, wet waste is stored in tanks, and some solid waste is kept in storage rooms on the plant. At Olkiluoto NPP, reactor waste is kept in buffer stores inside the plant before transfer to the disposal facility.

Disposal systems

The estimated total amounts of different types of waste employed in the safety analyses for the disposal repositories at Olkiluoto NPP and Loviisa NPP are shown in the table below. They relate to the volume of waste as packaged for disposal.

Spent fuel repository development

The process of selecting a site for a spent fuel disposal repository has included the following steps.

- In 1985, after a site screening exercise, 102 potentially suitable areas were identified.
- In 1987, five areas, including the Olkiluoto area, were selected for preliminary site investigations.
- In 1992, the three most appropriate sites, Romuvaara, Kivetty and Olkiluoto, were included in a shortlist of sites subjected to detailed investigation.
- In 1997 site investigations were started also at the Loviisa NPP site on the island of Hästholmen.
- The environmental impact assessment process was launched in the four municipalities in 1997, and was completed in the autumn of 1999.
- In May 1999, the company responsible for spent fuel disposal, Posiva, submitted an application to the Government for a Decision in Principle (DiP) in which Olkiluoto was proposed as the site of a deep disposal facility for spent fuel.
- In January 2000, the Radiation and Nuclear Safety Authority (STUK) submitted its preliminary safety appraisal of the DiP application.
- In January 2000, the host municipality of the Olkiluoto site, Eurajoki, gave its approval to the DiP application.
- In December 2000, the Government made the Decision in Principle for disposal of spent fuel from the existing four reactors at the Olkiluoto site, and the Parliament endorsed it in May 2001.
- In May 2002 the Parliament endorsed another DiP concerning the disposal of the spent fuel from the fifth reactor unit in Finland.

It is expected that construction of an underground rock characterisation facility will commence in 2004. The submission of the application for the construction license is scheduled for 2012 and the repository should be operational in 2020.

Repository site	Dry maintenance waste	Solidified waste	Decommissioning waste	
			Activated	Contaminated
Olkiluoto NPP	5 600 m^3	3 100 m^3	4 400 m^3	22 000 m^3
Loviisa NPP	2 400 m^3	5 400 m^3	4 000 m^3	9 300 m^3

Olkiluoto 3, in June 2004. TVO, Finland.

Research and development

The Finnish research programmes

The Finnish research programme on nuclear waste management (KYT) was launched two years ago with the general goal to maintain and increase national know-how in the area of nuclear waste management. The total annual budget of the programme is approximately one million euros. In order to ensure stable financing for the program the *Nuclear Energy Act* was amended in 2003 such that the financial source is a special fund which is augmented by annual charges from the owners of nuclear facilities.

The producers of nuclear waste carry out R&D for the safe management of their own wastes. The total budget for this work amounts to about 10 million euros annually. The programme is focused on spent fuel disposal. Extensive geological investigations as well as development of the disposal concept and performance assessment have been carried out for about 15 years. Most of the practical work has been contracted to Governmental research institutes and to private consulting and geotechnical companies. From 2003 onwards the R&D programmes are prepared for three-year periods and the programme and results are reviewed by the regulatory authorities.

Underground research

Presently, there is no large-scale underground research laboratory in Finland in support of the spent fuel disposal repository development. However, some experiments are done in a research tunnel co-located with the LILW repository at Olkiluoto and a deep underground rock characterisation facility, ONKALO, will be established at the Olkiluoto site as part of the site confirmation investigation.

In 2001, Posiva renewed its co-operation agreement with SKB of Sweden on the research in the Swedish Äspö Hard Rock Laboratory. It also maintains bilateral co-operation agreements with the analogous bodies in Switzerland, Japan, Canada, and the Czech Republic.

ONKALO underground repository. Posiva Oy, Finland.

Decommissioning and dismantling policies and projects

Decommissioning plans were last updated in 2003. The plan for the Loviisa NPP is based on immediate decommissioning while for the Olkiluoto NPP a safe storage period of about 30 years prior to dismantling is envisaged. The disposal plans for the decommissioning waste are based on extension of the on-site LILW repositories. Activated metal components accumulated during the operation of the reactors would also be disposed of in those repositories. The engineered barriers will be selected taking account of the radiological and other safety related characteristics of each waste type. A special feature of the decommissioning plans is the emplacement of large components, such as pressure vessels and steam generators, into the disposal vaults without cutting them into smaller pieces.

Transport

All transport of radioactive waste in Finland is licensed and supervised by the regulatory authorities according to well-established national and international regulations for the transport of radioactive materials and dangerous goods.

Between 1981 and 1996, fifteen shipments were sent by rail from the Loviisa NPP to Russia, with about 330 tonnes HM of spent fuel in total. As a result of the Amendment of the Nuclear Energy Act, these shipments ceased at the end of 1996.

Spent nuclear fuel at the Olkiluoto site is currently moved from the storage pools in the reactor buildings to the on-site interim storage facilities by means of a purpose-designed cask. In due course, transport of spent fuel from the Loviisa NPP to encapsulation and disposal facilities at Olkiluoto will have to be arranged, but the mode of transport and detailed technical arrangements are still open.

As the other operational and decommissioning nuclear wastes are stored on-site, and are likely to continue being disposed of on-site, there is no need for off-site transport of these wastes.

Competent authorities

Regulation and Licensing

The key organisations involved in regulation and licensing of radioactive waste management, and their specific roles, are as follows:

The Government grants licenses for nuclear facilities and issues general safety regulations.

The Ministry of Trade and Industry (MTI) oversees implementation of waste management and related R&D to ensure that it complies with national policy and, together with the State Nuclear Waste Management Fund, that provisions for future waste management are adequate. MTI is advised by an Advisory Committee on Nuclear Energy.

The Radiation and Nuclear Safety Authority (STUK) is responsible for the control of radiation and nuclear safety, for issuing detailed safety regulations and for the technical and safety-related review of licence applications and other important documents, such as the submission for a Decision in Principle for the spent fuel repository. STUK is advised by an Advisory Committee on Nuclear Safety.

Operators

The key bodies responsible for carrying out the activities associated with radioactive waste management are as follows:

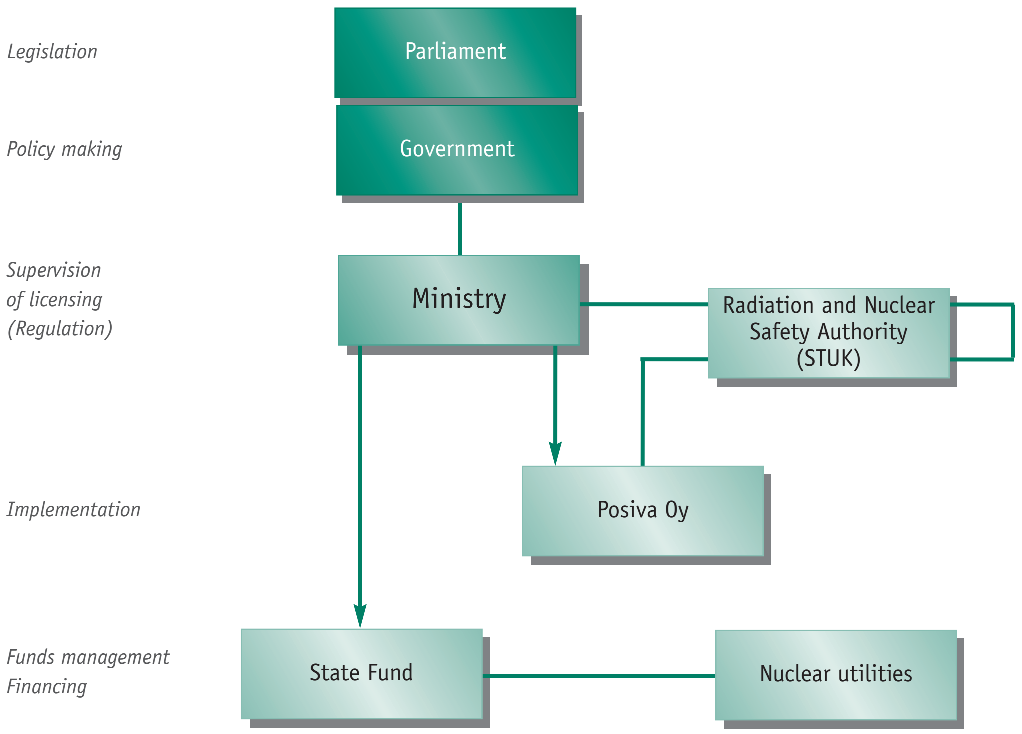
Fortum Power and Heat Oy (FPH) and Teollisuuden Voima (TVO) are the utilities responsible for operation of the Loviisa NPP and the Olkiluoto NPP respectively. They are responsible for interim storage of spent fuel, for the conditioning and disposal of operating LILW, and for planning of the decommissioning of their NPPs.

Posiva Oy is a company owned jointly by FPH and TVO and is responsible for the preparations for, and subsequent implementation of, spent fuel disposal.

As well as being a regulatory body, **the Radiation and Nuclear Safety Authority (STUK)** also has administrative control of a central interim storage facility for Small User Radioactive Waste.

All of these bodies, in the discharge of their responsibilities, call on the services of relevant research institutes, universities and consultants.

Main bodies involved in radioactive waste management in Finland



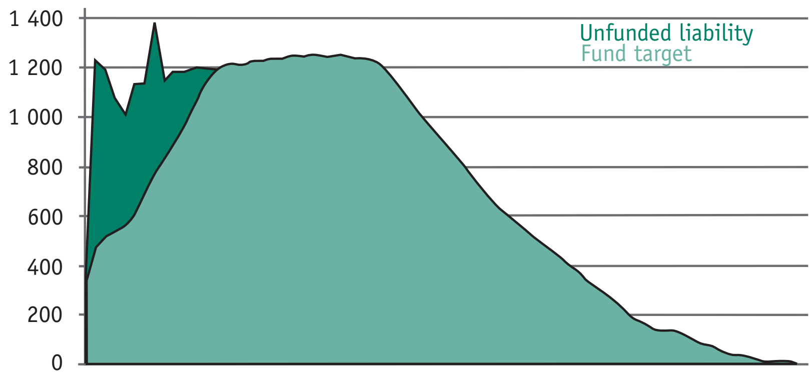
Financing

Costs and funding

The operators of nuclear facilities are responsible for financing the management of the wastes that they generate. In order to ensure that their financial liability is covered, they must present annual estimates of the costs for their future waste management commitments. The current estimates, including costs for management of existing wastes and those expected to arise from decommissioning of NPPs, amount to about 1 338 million euros, without discounting. The utilities are obliged to set aside a certain amount of money each year to the State Nuclear Waste Management Fund, and at the end of 2003 the fund covered the whole liability.

Unfunded liabilities and fund targets for the period up to 2060 are shown in the figure below.

The sum of fund targets and unfunded liabilities of the utilities (Teollisuuden Voima Oy and Fortum Power and Heat)



Public information

For more information, the websites of the relevant organisations are listed below.

Government

Radiation and Nuclear Safety Authority of Finland
Helsinki
Website: http://www.stuk.fi
E-mail: stuk@stuk.fi

Ministry of Trade and Industry (MTI)
Helsinki
Website: http://www.ktm.fi
E-mail: kirjaamo@ktm.fi

Research

VTT Technical Research Centre of Finland
Espoo
Website: http://www.vtt.fi
E-mail: kirjaamo@vtt.fi

Industry

Posiva Oy
Olkiluoto
Website: http://www.posiva.fi
E-mail:

Teollisuuden Voima Oy (TVO)
Olkiluoto
Website: http://www.tvo.fi
E-mail:

Fortum Power and Heat Oy
Espoo
Website: http://www.fortum.com/main.asp?path=14022
E-mail: communications@fortum.com

For further information, please contact:

OECD Nuclear Energy Agency
12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
Tel.: +33 (01) 45 24 10 15,
Fax: +33 (01) 45 24 11 10, Internet: www.nea.fr

(66 2005 12 1 P)
ISBN 92-64-01210-9

France

National nuclear energy context

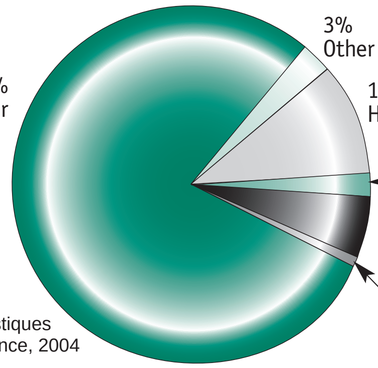
Commercial utilisation of nuclear power in France started in 1959 and by 2002 there were 59 nuclear power units connected to the electricity grid (including the Phenix FBR). In 2003 they generated 441 TWh of electricity, 77.8% of the total gross electricity generated in that year.

Also in 2002, the capacities for nuclear fuel fabrication were 750 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors and 140 tonnes HM/year of mixed oxide (MOX) fuel also for use in light water reactors. Spent fuel storage capacity was 24 450 tonnes HM, and the amount of spent fuel arising in 2002 was 1 135 tonnes HM.

Three new nuclear power units have been commissioned since 1997 and, in 2002, the average availability factor of French nuclear power plants was 82.5% with net electricity exports increasing by 12% to the record level of 76.9 TWh.

In France, spent nuclear fuel is not considered to be waste and is reprocessed for recovery of reusable materials. Commercial reprocessing is carried out at the La Hague plant operated by Cogema. The two facilities at this plant have the combined capacity to reprocess up to 1 700 tonnes HM/year of spent fuel and they supply commercial services to national and foreign customers.

Breakdown of electricity sources (in %)



Source: Statistiques énergétiques France, 2004

Sources, types and quantities of waste

Most of the radioactive waste in France is generated as a result of electricity production. The remainder arises from the use of radioactive materials in medical, research, defense and industrial applications. It is classified into four categories according to the requirements for its safe management, having regard to both level of activity and to the half-lives of the radionuclides it contains.

Reflecting first the levels of activity, these categories are: very low-level waste (VLLW), low-level waste (LLW), intermediate-level waste (ILW) and high-level waste (HLW). For each of these four categories, a further distinction is made between the waste containing radionuclides with a short half-life (less than 30 years) and those with a long half-life (more than 30 years). The rate of generation of VLLW is estimated to be about 25 000 t/year for the next 30 years. These wastes contain various radionuclides and have an average activity of around 10 Bq/g. They are disposed of in a new surface repository at the Centre de Morvilliers facility, a few kilometres from the existing Centre de l'Aube disposal facility.

The short-lived, LLW and ILW waste are disposed of in engineered, surface disposal structures at the Centre de l'Aube disposal facility. More than 80% of these wastes are generated by front end cycle plants, nuclear power plants and reprocessing plants. About 15% comes from the research centres of the Commissariat à l'énergie atomique (CEA), and the remainder from small generators such as hospitals and universities. The amount of waste disposed of at the Aube disposal facility in 2002 was 12 556 m^3. At the end of 2002 and since the beginning of its operation the Aube Center had received 136 650 m^3. The management of long-lived LLW is currently the subject of studies performed by Andra, concerned especially with radium-bearing waste and graphite waste.

Long-lived ILW is presently kept in interim storage at the sites where it is generated, awaiting the availability of a dedicated disposal facility. HLW arising from spent fuel reprocessing is vitrified. The resulting canisters are stored in dedicated facilities at the production sites, at La Hague and Marcoule. They will remain there for a few decades, until their ultimate destination is decided. The related vitrified HLW production to be derived from French reactors spent fuels is about 600 glass canisters per year out of the La Hague plant.

Quantities of waste presently in interim storage facilities

The volume of radioactive waste in the interim storage facilities at the end of 2001, by individual category, was as follows: Short-lived ILW (tritiated waste): 1 800 m^3; long-lived ILW: 46 000 m^3; vitrified HLW: 1 500 m^3. These figures exclude those wastes arising from the reprocessing of foreign spent fuel which, in compliance with Law 91-1381 of 30 December 1991, are returned to their foreign owners after an interim storage period. They also exclude long-lived LLW containing radium and graphite.

Radioactive waste inventory

An annual inventory of radioactive waste in France has been published by Andra for the last ten years. This identifies all the sites on which radioactive waste is present, including contaminated sites. New work is currently under way on compilation of an inventory of potential radioactive waste, which would take account of all the waste that will inevitably be generated by the existing facilities, reflecting the concept of so-called "pending" waste. This predictive inventory work should be completed in 2004 and then periodically brought up to date. Current estimates of the annual quantities of waste produced and total quantity expected by 2020 are shown in the table below. This is based on the assumptions of 59 power reactors operating, 21 of which use MOX fuel, and the reprocessing of 850 tonnes HM/year of spent fuel. As above, these figures exclude those wastes arising from the reprocessing of foreign spent fuel.

France's radioactive waste

Waste type	Estimated annual production (m^3)	Cumulative volume in 2020 (m^3)
VLLW	10 000 to 50 000	300 000
Short-lived LLW and ILW	13 000 to 20 000	1 000 000
Long-lived ILW	300 to 500	53 000
Vitrified HLW	100	38 000

Radioactive waste management policies and programmes

Waste management policies

Management of radioactive waste, and other industrial waste, is subject to the legal framework defined by Law n° 75-633 of 15 July 1975 (article L.541 of the Environment Code), and the associated decrees covering retrieval of materials and disposal of waste. The basic principles enshrined in this law are prevention of waste production, the responsibility of waste producers for their waste until it is safely disposed of, the traceability of waste, and the need for public information. In addition it is only when waste cannot be reused or recycled under current technical and economic conditions that it may be disposed of.

The underlying concept is that facilities should be designed with all aspects of waste management in mind, from generation to reuse, recycle or safe disposal, and with regard to the interactions between inter-dependent waste management operations. In this way a system may be created that is optimised as part of an overall approach to waste management and which takes account of safety, traceability and volume reduction issues.

As regards the policy for research into management of high level and long-lived radioactive wastes, broad guidelines were set out in article L.542 of the Environment Code, following the law of 30 December 1991, as follows:

- High-level and long-lived radioactive waste must be managed in a manner compatible with the protection of nature, the environment and health, while at the same time considering the rights of future generations.
- Work will be conducted into:
  - *The search for solutions for separating and transmuting the long-lived radioactive elements present in these wastes.*
  - *Study of the possibility of reversible or irreversible disposal in deep geological formations, in particular by building underground laboratories.*
  - *Study of packaging processes and long-term surface storage for these wastes.*

Also following the law of 30 December 1991, and the associated articles L.542-1 of the Environment Code, Andra was constituted as an industrial and commercial public establishment. It had been created in 1979 as part of the CEA, with responsibility for the long-term management of radioactive waste generated in France. This new status gives it more independence from the producers of waste and places it under the supervision of the ministries of Industry, the Environment and Research.

Programmes and projects

Radioactive waste treatment, packaging and tracking

In the interests of optimising the management of short-lived LLW and ILW, both technically and economically, Andra and the waste generators have jointly developed an integrated waste management system that covers all phases of waste processing and conditioning, transportation and disposal. In this context, and for compliance with safety regulations, Andra has a further responsibility to develop technical specifications for waste packages. Under this arrangement, waste generators are required to submit, for Andra's approval, a waste acceptance file on each type of package they plan to produce.

A major component of this integrated waste management system involves tracking the waste from its production through to its final disposal. This is based on a computer network linking waste generators to the Andra headquarters, which records the characteristics of each package, checks compliance, authorises shipment, and then tracks the packages to their final location.

Radioactive waste disposal facilities

The Centre de la Manche, adjacent to the La Hague reprocessing plant, was commissioned in 1969 for disposal of short-lived LLW and ILW and received 527 000 m^3 of waste up until June 1994 when disposal operations were terminated. It was covered with a multi-layer, engineered cap and has been actively monitored since 1997. In January 2003, it was licensed for a period of institutional control expected to last for 300 years. The transition from operation to institutional control was the subject of a licensing process similar to that for construction and commissioning of a nuclear installation, including a set of public inquiries.

In the mid-1980s, in preparation for closure of the facility at La Manche, Andra designed a replacement facility, the Centre de l'Aube, located 250 km east of Paris. Its design benefited considerably from experience of the Centre de La Manche facility and it was commissioned in January 1992. It comprises waste conditioning facilities and a disposal area covering about thirty hectares. It is authorised to dispose of one million cubic metres of packaged, short-lived LLW and ILW and is expected to meet France's needs until at least 2040.

Andra subsequently proposed creation of a separate repository specifically for disposal of VLLW. After all necessary site investigations and public enquiries, the Centre de Morvilliers, in Aube Department, was constructed and eventually commissioned in summer 2003. The repository has a capacity for 650 000 m^3 of VLLW and an expected operational lifetime of 30 years. It represents another essential component of France's overall system for radioactive waste management and will accommodate most of the waste resulting from the decommissioning and dismantling of facilities in which radioactive substances have been used.

Development of new disposal systems

Andra is required to carry out investigations with a view to proposing the means for disposal of those waste categories for which no permanent solution currently exists. These include long-lived LLW, such as radium-bearing residues, and graphite and tritiated wastes. They also include long-lived ILW and HLW.

In regard to long-lived ILW and HLW, guidelines for three areas of research are set out by law, as described above, and a period of 15 years is set for completion of the work. An overall assessment of these three areas of research will then be submitted in 2006 to the French Parliament with, if appropriate, a Bill authorising the creation of a high-level, long-lived radioactive waste repository. Andra has specific responsibility for the second area of research, concerned with disposal in deep geological formations.

The site-selection process for underground research laboratories started in 1993 when the government commissioned Mr. Christian Bataille MP to explain the project to local communities and to seek their candidacies. From 1994 to 1996, Andra was authorised to carry out geological characterisation work in four departments, the Gard, the Meuse and the Haute-Marne for clay, and the Vienne for granite. In December 1998, the government decided that France should have two underground research laboratories, the first in a clay formation straddling the Meuse and Haute-Marne departments, and the second in a granite formation yet to be determined.

The disposal repository design involves three containment barriers against migration of radionuclides. Waste packages are placed in disposal cells, silos or tunnels that have been created within stable geological formations. The first two barriers are man-made. They include the waste packages themselves with any additional protection they may have. These packages are then placed within a so-called "engineered" barrier, made from containment materials such as bentonite (a swelling clay) whose purpose is to isolate the waste from the surrounding rock. Lastly, the geological environment provides a third, natural barrier measuring several tens of metres in thickness. Andra focuses its research activities on clay and granite, and on study of the possibilities for reversible or irreversible disposal in deep geological formations. The study of clay rock relies mostly on the Meuse/Haute-Marne underground laboratory where investigations are conducted in situ within a 150-million-year Callovo-Oxfordian layer of argillite.

Because a granitic site is not yet available for an underground research laboratory, the Andra programme is primarily concerned with resolving key scientific questions in regard to granite formations, proposing generic repository design options applicable in the French context of geology, waste inventory, etc. and preparing for potential land surveys. These generic designs constitute the reference basis for the studies and investigations on which Andra will report at the end of the 15-year period, in 2005.

Summary of programmes and projects

The results of the work described above are depicted in the table below, which shows the disposal routes, or "channels", for the main categories of radioactive waste.

Existing or future disposal channels for the main solid radioactive waste

<table>
<tr><th>Half-life / Activity</th><th>Very short-lived (half-life <100 days)</th><th>Short-lived (SL) (half-life <30 years)</th><th>Long-lived (LL)</th></tr>
<tr><td>Very low-level (VLLW)</td><td rowspan="4">management radioactive decay</td><td colspan="2">dedicated surface (Morvilliers repository)</td></tr>
<tr><td>Low-level (LLW)</td><td rowspan="2">surface disposal (Aube repository)</td><td>dedicated subsurface disposals being devised</td></tr>
<tr><td>Intermediate-level (ILW)</td><td>channels being divised under article L.542 of the Environment Code (law of 30 December 1991)</td></tr>
<tr><td>High-level (HLW)</td><td colspan="2">channels being divised under article L.542 of the Environment Code (law of 30 December 1991)</td></tr>
</table>

Research and development

As described under "Programmes and projects", Andra is working on the evaluation of disposal of long-lived ILW and HLW in deep geological formations, as required by the Law of 30 December 1991. The other two areas of research required by the law concern separating and transmuting the long-lived radioactive elements present in these wastes, and packaging processes and options for their long-term surface storage.

Separation and transmutation of long-lived radioactive elements in the waste is a possible means of reducing the toxicity and/or half-life of certain radionuclides contained in the waste by exposing them to a flux of high-energy particles. This so-called transmutation can only be applied to radionuclides, not to the waste itself. Hence, a preliminary chemical or physical step of separation or partitioning is necessary in order isolate the relevant radionuclides. The CEA is in charge of this research area.

The study of conditioning processes and long-term surface storage techniques for waste involves research into novel waste packaging and waste storage options. The CEA is also in charge of this third area of work.

These three research areas complement each other. The evaluation of results should lead to a decision on long-term management of radioactive waste in 2006.

Decommissioning and dismantling policies and projects

Current status

Most of the French decommissioning projects are concerned with either civilian nuclear facilities or those associated with defense activities.

There are four major civilian operators in France. Électricité de France (EDF) operates the nuclear power plants. All of its 8 gas-cooled, graphite-moderated nuclear power units and one HWGCR have been definitively shut down, as have the Superphenix fast breeder reactor and one Chooz (Ardennes) PWR. The Compagnie générale des matières nucléaires (Cogema, subsidiary of the AREVA group) operates nuclear fuel cycle plants including chemical reprocessing facilities, uranium production facilities, gaseous diffusion plants, and other facilities. The Commissariat à l'énergie atomique (CEA) operates most of the nuclear R&D facilities. Many installations such as research reactors, laboratories, pilot plants, etc. have already been dismantled, are presently being dismantled, or are on a waiting list for dismantling.

Accounting for decommissioning costs

Operators are obliged to make financial provision for facility decommissioning over the operating lifetime of their installations. These provisions are calculated for each installation on the basis of estimated decommissioning costs and on the estimated lifetime of the facility concerned. For example, the estimated lifetime of an EDF pressurised water reactor is 30 (more likely 40) years. These provisions are re-evaluated each year, taking into account the effect of inflation and, if necessary, any major changes to the estimated costs of decommissioning.

Transport

French legislation for the safe transport of radioactive materials is based on the Regulations for the Safe Transport of Radioactive Substances recommended by the International Atomic Energy Agency in 1985. Transport safety is secured by classifying materials according the hazards associated with radiotoxicity, nuclear criticality and dispersability, and by providing appropriate packaging and shipping arrangements. Radioactive waste shipment programmes are drawn up in discussion with all relevant bodies and authorities, and with due regard to the different recycling or disposal routes available. After notification of the shippers, subsequent shipment of waste is monitored by the authorities.

Radioactive waste is generally transported by road or rail from its site of production to an appropriately authorised facility, such as the melting and incineration plant operated by CENTRACO, or the disposal facilities operated by Andra at Centre de l'Aube and Centre de Morvilliers. The aim is to dispose of waste through an appropriate route, or channel, as soon as possible, in order to minimise the amounts of waste in interim storage at their production sites.

A particular feature of radioactive material transport in France is the transboundary movement of spent fuel and radioactive waste associated with spent fuel reprocessing operations carried out at La Hague on behalf of German, Japanese, Belgian, Swiss and Dutch customers. The reprocessing contracts with foreign nuclear power companies contain a clause stipulating return of the waste to its country of origin. This waste is packaged in a form suitable for safe transport and interim storage, while protecting public health and the environment. These transboundary movements are carried out in compliance with the comprehensive international, European and national regulations, and related international conventions, regarding safety, security, physical protection and public order. Transboundary movements within Europe are mainly by rail. Transport to Japan is by sea and port infrastructures complying with the requirements of nuclear safety have been built in France and Japan. There has been no significant incident compromising safety, security or radiation protection during these transport shipments in recent years.

Competent authorities

Regulatory bodies

The responsibility for supervision of the safety of basic nuclear installations, and the safety of nuclear material transportation, lies with the ministers for the Environment and for Industry. According to Decree 2002-255 of 22 February 2002, the Directorate General for Nuclear Safety and Radiation Protection (DGSNR) develops proposals for government policy on nuclear safety, under the joint supervision of those ministers, and develops proposals for radiation protection, under the supervision of the minister for Health. The DGSNR is also responsible, in particular, for preparing and implementing safety policies for the management of spent fuel and radioactive waste.

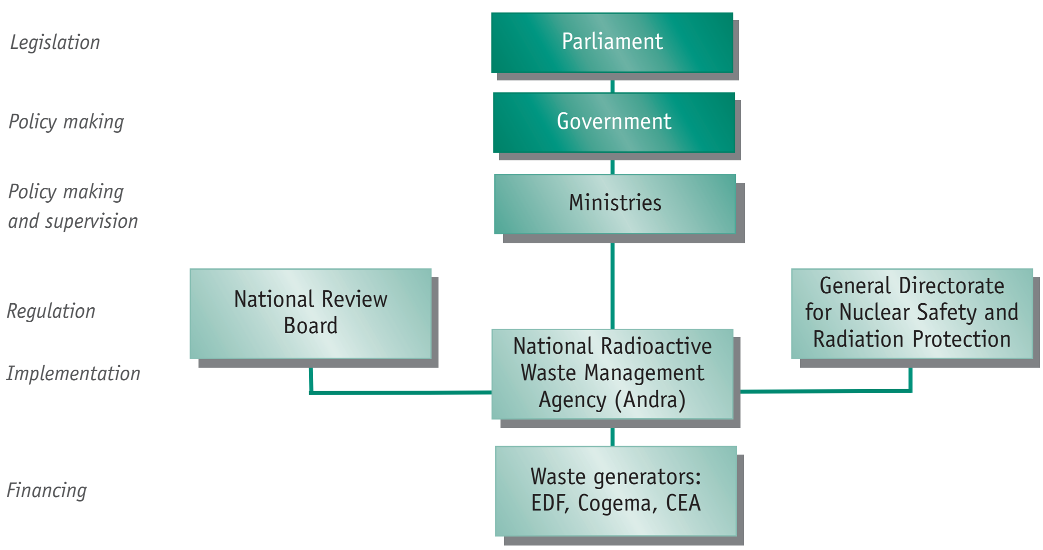
A joint authority, the Authority for Nuclear Safety (ASN), comprises the DGSNR together with the Nuclear Safety and Radiation Protection Departments (DSNR) within the Regional Directorates for Industry, Research and the Environment (DRIRE). The ASN relies on the expertise of outside technical organisations, especially the Institute for Radiation Protection and Nuclear Safety (IRSN), and seeks advice and recommendations from relevant advisory committees. In the field of nuclear safety, the dual supervision by the ministers for Industry and for the Environment guarantees the independence of the Nuclear Safety Authority from the General Directorate for Energy and Raw Materials (DGEMP), responsible for the supervision of Andra and waste producers. The DGEMP reports exclusively to the minister for Industry.

Radioactive waste management organisation

Within the framework of the Law of 30 December 1991, the *Agence nationale pour les déchets radioactifs* (Andra) fulfils three complementary missions described in the Quadrennial Contract it signed with the French State in July 2001. These are as follows: (1) an industrial mission to implement suitable management systems for each category of radioactive waste; (2) a research mission that aims primarily at conduct of feasibility studies on a potential deep geological repository for high-level long-lived waste, with the potential for reversibility; (3) an information mission to produce an inventory of the location and situation of all existing radioactive waste in France, and to disseminate clear and verifiable information to the public.

Andra has been in charge of the waste disposal centres since 1979. The first repository for short-lived low- and intermediate-level radioactive waste at Centre de la Manche was closed in 1994, as described above.

Main bodies involved in radioactive waste management in France



Waste generators

Électricité de France (EDF) is the electricity utility that owns and operates all nuclear power plants in France, and whose activities are supervised by the ministry of Industry. **The Commissariat à l'énergie atomique (CEA)** is a public body responsible for conducting research into reactor technology and the fuel cycle. It is supervised by the ministry of Industry. **The Compagnie générale des matières nucléaires (Cogema)** is a private company, linked to the AREVA Group and to CEA. It is involved in all stages of the uranium reprocessing cycle including nuclear fuel fabrication.

The relationship between all of the above bodies is shown in the figure above.

Financing

Waste generators are required by law to bear all the financial costs associated with management and disposal of their wastes. However, there is no legal requirement for them to create a specific fund for accumulation of the provisions they make for this. Nevertheless, in collaboration with their supervisory authorities, EDF, AREVA and CEA have already set up the financial tools to create such funds within their company account. Instead of making specific legislation on this subject, the French State has developed an economic approach, based on the definition of appropriate rules for governance of these companies.

In the case of CEA, a dedicated fund was created in 2001 for covering long-term liabilities associated with both decommissioning operations and long-term radioactive waste management. This fund is managed by CEA under specific accountancy rules and is supervised by a special committee whose members are independent of the organisation. This committee advises the CEA board on cost estimation, financial statements and budgets.

In the case of AREVA a specific fund, based on Cogema business revenues, has been created. Following the recent implementation of AREVA governance rules, a special committee was created to supervise the management arrangements and financial provisions for the long-term liabilities of the group. This committee advises the AREVA Supervisory Board.

In EDF, a specific fund was created as stipulated in the 1997-2000 contract between the French State and the company. The management of this fund and the further accumulation of resources have been carried forward into the present 2001-2003 contract. Currently, the most important financial issue is forecast of financial liabilities for the period 2020 and 2040 when decommissioning of the current Pressurised Water Reactor NPPs will probably start. This will enable the company progressively to set up a well-dimensioned financial fund.

Public information

For more information, the websites of the relevant authorities and organisations are listed below.

Government and Parliament

Direction générale de la sûreté nucléaire et de la radioprotection (Nuclear Safety Authority)
Paris – Website: http://www.asn.gouv.fr
Ministère de la Santé et de la Protection sociale
Paris – Website: http://www.sante.gouv.fr/
Ministère de l'Emploi, du Travail et de la Cohésion sociale
Paris – Website: http://www.travail.gouv.fr
Ministère de la Défense
Paris – Website: http://www.defense.gouv.fr/
Direction générale de l'énergie et des matières premières (DGEMP)
Paris – Website: http://www.industrie.gouv.fr/energie
Office parlementaire des choix scientifiques et technologiques
– Sénat (Paris/Website: http://www.senat.fr)
– Assemblée Nationale (Paris/Website: http://www.assembleenationale.fr)

Research

Commissariat à l'énergie atomique (CEA)
CEA/Direction de la communication
Paris – Website: http://www.cea.fr
Andra
Chatenay Malabry – Website: http://www.andra.fr
IRSN
Fontenay-aux-Roses – Website: http://www.irsn.fr
Note: (OPRI is presently a part of IRSN).

Industry

Cogema
Vélizy – Website: http://www.cogema.fr
EDF
Website: http://www.edf.fr

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Germany

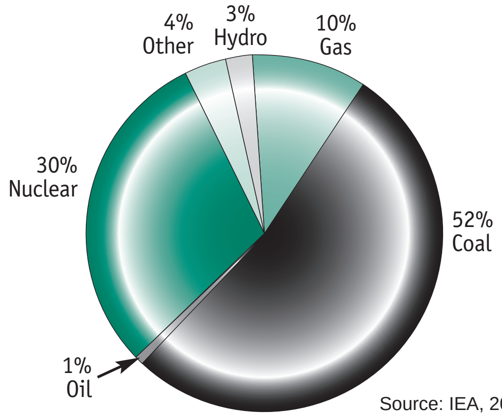
National nuclear energy context

Commercial utilisation of nuclear power in Germany started in 1961 and by 2002 there were 19 nuclear power units connected to the electricity grid. In 2002 they generated 164.8 TWh of electricity, 29.5% of the total electricity for public use generated in that year.

Also in 2002, the capacity for nuclear fuel fabrication was 650 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors. Spent fuel storage capacity was 15 350 tonnes HM, and the amount of spent fuel arising in 2002 was 410 tonnes HM.

The commitment to phase out nuclear energy production in Germany was made by law in 2002. Among the reasons for this were lack of public acceptance of nuclear energy in Germany, and the view that the residual risk associated with its use in electricity production is no longer tolerable. This phase-out is based on an agreement between the federal government and the electricity utilities, initialled on 14 June 2000 and signed on 11 June 2001. The agreement to phase out the use of nuclear power for electricity production therefore limits the standard lifetime of nuclear power plants to about 32 years from the date of commissioning.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

An annual survey of the volume of radioactive waste produced in Germany is carried out by the Federal Office for Radiation Protection (BfS) on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

The main sources of radioactive waste are nuclear fuel cycle activities, including power production, related research and development and the decommissioning and dismantling of nuclear facilities, the use of radioisotopes in medical, research, and industrial applications, and the activities of other bodies associated with transfer and removal of such wastes.

The waste is classified into two categories according to the requirements for its disposal. These categories are:

- Radioactive waste with negligible heat generation.
- Heat-generating radioactive waste.

Radioactive waste with negligible heat generation includes metals and non-metals, filters and filter elements, combustible substances, carcasses, chemical fluids, sludge, slurries and biological fluids as well as oil, solvents and emulsions.

Heat-generating radioactive waste includes those wastes that arise from the reprocessing of spent nuclear fuel elements for recovery of reusable materials. These wastes include fission-product concentrates, fuel-element cladding and related materials. Spent nuclear fuel that is not reprocessed, but is destined instead for direct disposal as radioactive waste, also falls within this category.

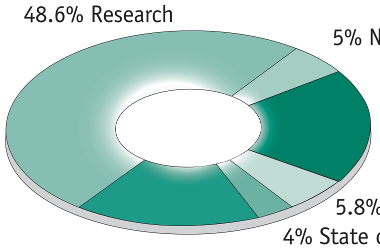
The main operations involved in preparing waste for interim storage and/or disposal include the following:

- Compaction, which is a treatment method where the bulk volume of a compressible material is reduced by the application of high external pressure.
- Immobilisation, which consists of converting waste into solid form by embedding or encapsulating it in materials such as cement, concrete, bitumen or glass.
- Incineration, which is a waste treatment process consisting of burning combustible waste to reduce its volume.
- Solidification, which is the conversion of gaseous, liquid or liquid-like materials into a solid waste form in order to produce a physically stable material. Typical processes include calcination, drying, evaporation, cementation, bituminisation or vitrification.

Collectively, these processes are termed "conditioning", and "conditioned waste" refers to processed and/or packaged radioactive waste ready for interim storage and/or disposal.

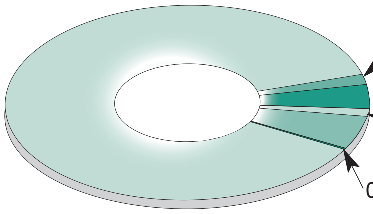
The total volume of conditioned radioactive waste with negligible heat generation, accumulated by the end of 2000, was 67 220 m^3. The percentage breakdown of this stock, by source, is shown in the figure below.

Percentage breakdown of conditioned radioactive waste with negligible heat generation



The total volume of conditioned heat-generating radioactive waste, accumulated by the end of 2000, was 1 494 m^3. The percentage breakdown of this stock, by source, is shown in the figure below.

Percentage breakdown of conditioned heat-generating radioactive waste



The accumulation of conditioned radioactive waste in Germany has been forecast up to 2080, on the basis of waste surveys and disposal plans submitted by the utilities. The figures are as follows:

- Conditioned radioactive waste with negligible heat generation: 280 000 m^3 (approx.).
- Conditioned heat-generating radioactive waste: 24 000 m^3 (approx.).

Radioactive waste management policies and programmes

Policy

The safety policy of the German Federal Government with respect to nuclear technology and radioactive waste management (RWM) gives utmost priority to the protection of man and the environment.

As a result of the 1998 Federal election a coalition of the Social Democrats and Alliance´90/The Greens came into power. The political aims of the Federal Government are given in the coalition agreement dated October 20, 1998. Since 1998, the Federal Government has made a pronounced change compared to the previous energy policy. It is intended to irreversibly phase out nuclear energy use for electricity generation.

The basic document on the future use of nuclear energy for electricity production in Germany was initialled on 14 June 2000 and signed on 11 June 2001. According to this document, the Federal Government and the utility companies agree to limit future utilisation of the existing nuclear power plants. The most important agreements refer to operational restrictions. For each installation the amount of energy it may produce is calculated starting 01 January 2000, until its decommissioning. In total, about 2 620 TWh (net) may be produced. According to this, the time of operation of a nuclear power plant amounts to 32 calendar years on average, starting at the beginning of commercial operation. The new policy is enforced by the latest amendment of the Atomic Energy Act which became effective on 27 April 2002. In particular, this act contains the following provisions:

- The purpose of the Atomic Energy Act is not (as before) to promote nuclear energy, but to phase it out in a structured manner, and to ensure on-going operation up until the date of the plant's discontinuation.
- No further licenses will be issued for commercial nuclear power plants. The authorization to operate a commercial nuclear power plant shall expire once the specific electricity volume fixed for this nuclear power plant has been produced. The electricity volumes of older nuclear power plants can be transferred to newer plants.
- All spent fuel elements from nuclear power plants are to be disposed of directly, with the exception of those delivered to a reprocessing plant until 30 June 2005. From 01 July 2005 onwards, the transportation of fuel elements from nuclear power plants for reprocessing is legally prohibited.
- Operators of commercial nuclear power plants are required to ensure that a local interim storage facility is constructed to reduce transports to the central storage in Ahaus or Gorleben and that the irradiated nuclear fuel incurred is stored until release to a final disposal site for radioactive waste.
- The required financial security for nuclear power plants has been increased tenfold to a maximum of 2.5 billion euros. This security includes the security for interim storage facilities for spent fuel rods within the enclosed site of the respective nuclear power plants.
- The disposal of radioactive waste into Morsleben will not be resumed. The licensing procedure remains restricted to decommissioning.

Programmes and projects

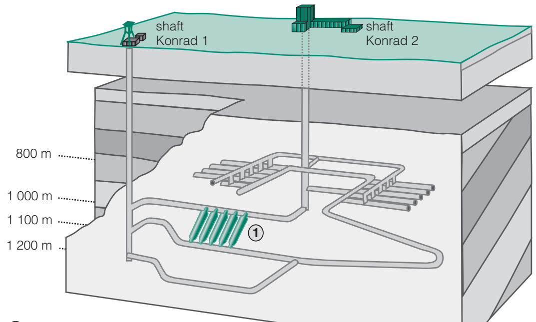
In Germany, the handling of radioactive materials and the disposal of radioactive waste are governed by the *Atomic Energy Act*. According to this act, radioactive residues must be properly disposed of as radioactive waste. Also, after waste conditioning by a method that depends on the characteristics of the waste, packaged wastes are to be placed in interim storage facilities that ensure their proper storage until disposal.

In the direct disposal concept, spent fuel elements will be packaged in containers suitable for disposal and then stored for several decades. Approval has already been given for a period of 40 years of interim storage, and it is currently envisaged that these containers will then be disposed of by emplacement in galleries or boreholes in deep geological formations. Since no repository is in operation being capable of accepting spent fuel elements, there are only conceptual considerations available on the design of such a facility.

The Bartensleben rock-salt mine near Morsleben, in Saxony-Anhalt, was chosen by the former German Democratic Republic in 1970 for disposal of low and medium-level radioactive waste with rather low concentrations of alpha-emitting radionuclides. After German re-unification in 1990 it became a Federal repository. Experimental disposal operations had started in 1971 with the first delivery of low-level radioactive waste. Following further development and licensing, the actual emplacement of radioactive waste started in 1981 in the existing rock-salt cuttings and galleries in the deepest part of the mine. By September of 1998, when disposal was stopped, a total volume of 36 753 m^3 of solid and solidified waste, and 6 617 sealed radiation sources had been disposed of in the Morsleben repository.

In addition to the above disposals, certain other items were placed in deep boreholes in the Morsleben facility for interim storage. These included sealed cobalt radiation sources, some sealed caesium radiation sources, small quantities of solid, medium-level radioactive waste containing europium and packaged in seven special steel cylinders with a volume of 4 litres each, and one 280 litre drum containing radium-226 waste. An application for disposal of these wastes has been filed within the scope of the licensing procedure for decommissioning of the Morsleben repository.

Two sites have been considered to date with respect to their suitability as disposal facilities. The abandoned Konrad iron-ore mine in Lower Saxony has been investigated for the disposal of radioactive waste with negligible heat generation, i.e. waste packages that do not increase the host rock temperature by more than 3°K on average. The licensing procedure started in August 1982 and the plan approval was issued by the licensing authority in May 2002. However, under an agreement between the Federal Government and the electricity utilities, an application for immediate enforcement of the licence was withdrawn. This withdrawal means, in effect, that conversion of the Konrad mine into a repository for all types of radioactive waste with negligible heat generation will be possible only after a final court decision referring to the licence. The court cases are expected to take about four years, then further decisions on the Konrad project will have to be taken. The general scheme for a disposal repository in the Konrad mine, as currently conceived, is shown in the diagram below.The salt dome at Gorleben, which is located in Lower Saxony, has been investigated for its suitability as a site of a repository for all types of radioactive waste, but primarily for the heat generating radioactive waste arising from reprocessing and spent fuel elements.



① Old excavations not intended for disposal of radioactive waste.

In the context of the continuing international debate, the German government considers it necessary to further develop the suitability criteria for a final repository, and to revise the concept for the final storage of radioactive wastes. In recent years, state-of-the-art science and technology and general risk assessment have developed considerably, and this has consequences for the further exploration of the salt dome in Gorleben. A number of conceptual and safety-related issues raise particular doubts. A further exploration of the Gorleben salt dome can contribute nothing to clarify these issues. Consequently, the investigation of the Gorleben site has been interrupted for a period lasting between 3 and 10 years, until 2010 at the latest, in order to allow sufficient time for the clarification of the conceptual and safety-related disposal issues. In addition, further sites in different host rock formations shall be explored. Potential sites will be identified based on site selection criteria.

In the year 1999, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety appointed the *"Arbeitskreis Auswahlverfahren Endlagerstandorte"* (Committee on a site selection procedure for repository sites) in order to develop criteria for the identification of sites, that are both suitable for safe disposal and at the same time are accepted by the general public. In December 2002, the committee made recommendations for a comprehensive and systematic and stepwise approach to a selection of disposal sites including societal and stakeholder involvement. For reasons of public acceptance and procedural fairness, the procedure is designed to include the entire territory of Germany from the beginning. No area will be selected or precluded prior to the start of the procedure; all areas are to be evaluated using the same criteria.

During the planned legal implementation, a wide scope of public participation is envisioned to assure, that the public may deliver its suggestions on the procedure. It is the objective to have a procedure implemented by the year 2006, that leads to the identification of the safest possible site and which finds broad acceptance in the public. The selection procedure should begin shortly thereafter. The start of repository operations is scheduled approximately for the year 2030. It is intended to strengthen the polluter pays principle by transferring the disposal task to the waste producers. Consequently, disposal no longer would be a Federal task.

Research and development

Organisation and funding

Research on radioactive waste management in Germany follows two distinct categories: (1) Research necessary for the construction of German waste disposal repositories. (2) Research that is independent of preparatory work on repositories, and comes under the general objective of continually improving the protection of man and his environment.

R&D on repository projects is carried out by the Federal Office for Radiation Protection (BfS) and costs are recovered from waste producers, primarily the electricity utilities.

Supplementary research is the responsibility of the Federal Ministry of Education, Science, Research and Technology (BMBF) and the Federal Ministry of Economics and Labour (BMWA). It is conducted and financed under the Energy Research Programme and consists of: (a) the long-term safety assessment of repositories in rock-salt; (b) the assessment of the suitability of geological formations, other than rock-salt, for the disposal of high-level, heat-generating radioactive waste; (c) the domestic plan for the back-end of the nuclear fuel cycle; (d) the concepts, measurement techniques, and data-recording and processing for the monitoring of fissile material.

Research projects in both of these categories are carried out mainly by the major research centres at Karlsruhe and Jülich, and by the Company for Plant and Reactor Safety (GRS), the Federal Institute for Geosciences and Natural Resources (BGR), the German Company for the Construction and Operation of Final Repositories for Waste Materials (DBE), and by universities and other bodies.

Underground laboratory studies

Between 1965 and 1978, the former Asse salt mine, near Remlingen in the Wolfenbüttel district, was used by the Environment and Health Research Centre (GSF) as an experimental repository for low and medium-level radioactive waste. The purpose of this research was to solve technical and scientific problems connected with the construction and operation of a repository for radioactive waste of all kinds. When the radioactive waste storage permit expired in 1978, about 124 500 waste drums of low-level waste and 1 300 waste drums of medium-level waste had been emplaced in the Asse facility.

Since then, R&D has continued on a salt concrete barrier system. When the Asse sealing system was designed, it was planned to erect different components serving as seal and abutment. The salt concrete plug was intended primarily as an abutment and secondarily as a seal.

Decommissioning and dismantling policies and projects

In Germany, 18 nuclear power reactors and prototype reactors, 32 research reactors and critical assemblies, and 10 fuel cycle facilities have been permanently shut down. Two of the power reactors, 21 of the research reactors and critical assemblies, and five of the fuel cycle facilities have already been dismantled. The sites of two power reactors, KKN in Niederaichbach and HDR in Großwelzheim, were restored to "green-field conditions" and released from regulatory control. Dismantling is in progress for other power reactors, and restoration to "green-field conditions" is the plan in most cases. Deferred dismantling has been chosen for two power reactors, KWL in Lingen and THTR-300 in Hamm-Uentrop, where a system of safe enclosure has been licensed. Deferred dismantling has also been selected for four research reactors, which are also in safe enclosure mode. According to the respective licenses, the concept for completing all decommissioning steps has to be submitted to the regulatory body, and no license for deferred dismantling will be granted without this.

The operator of a nuclear facility may choose between dismantling and deferred dismantling after a safe enclosure period. Recent decisions by operators of power reactors have been in favor of immediate dismantling, mainly because of cost considerations, societal aspects and the availability of qualified and trained staff.

An important aspect of nuclear facility decommissioning is disposal of the radioactive wastes generated and re-use of residual substances. Future decommissioning of nuclear power plants in Germany is expected to generate a total of about 150 000 tonnes of radioactive waste. The rate at which it is generated is expected to increase gradually over the years and to peak in about 2025. These wastes will be managed in accordance with the provisions of the *Atomic Energy Act* and the *Radiological Protection Ordinance*. The conditions for the release of materials, buildings and sites from nuclear regulatory control, the respective monitoring of such materials and the systematic approach to the management of radioactive wastes is regulated in the legal framework. Further information on decommissioning of nuclear facilities in Germany can be found via http:\www.nea.fr(html)rwm/wpdd/welcome.html.

Transport

Transport of radioactive waste and spent fuel elements from nuclear power plants involves: untreated waste for conditioning; conditioned waste to central interim storage facilities; spent fuel elements for reprocessing in France and the United Kingdom until 30 June 2005; and vitrified high-level reprocessing waste from La Hague, in France, to the Gorleben interim storage facility.

The safety regulations for these transport operations are prescribed by the *Atomic Energy Act* and the regulations on the transportation of dangerous goods, primarily the Dangerous Goods Ordinances concerning Road and Rail Transport. A transport licence has to be obtained from the Federal Office for Radiation Protection for the transport of nuclear fuels and large radioactive sources. Nuclear fuels include enriched uranium, plutonium, new fuel elements. Large radioactive sources have an activity of more than 1 000 TBq and include, for example, cobalt-60 radiation sources which are used in the medical field. The Federal State (Länder) Authorities, the Federal Railway Authority and the Federal Air Transport Authority are responsible for supervising transport operations.

Competent authorities

Responsibility for take-over and disposal of radioactive waste

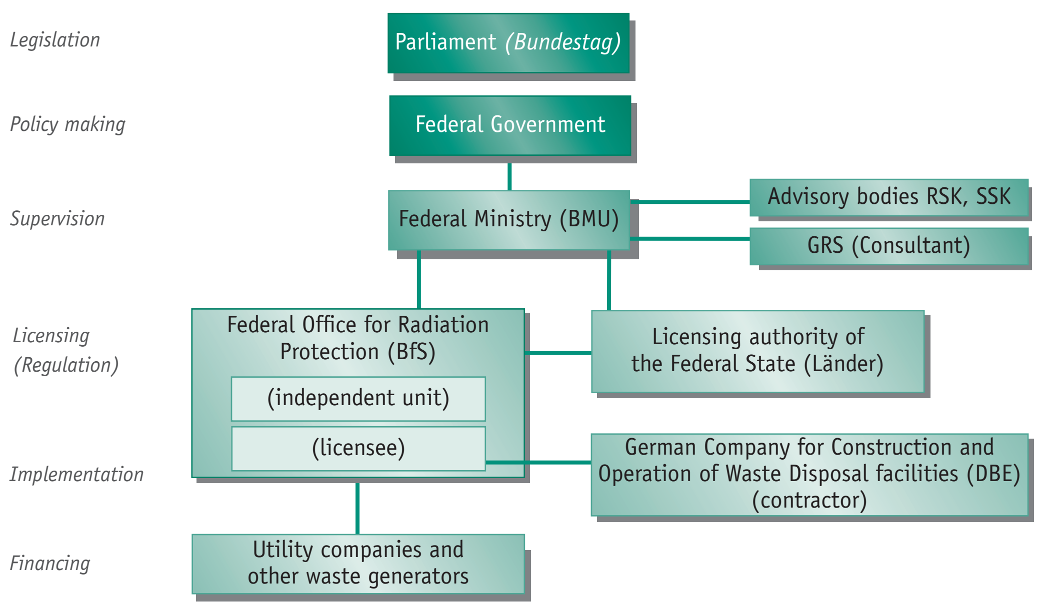
The handling of radioactive waste is regulated by the *Atomic Energy Act*. According to Section 9a of the Act, the Federal Government must set up facilities for taking over and ensuring the safe disposal of radioactive waste. The government has transferred this responsibility to the Federal Office for Radiation Protection (BfS), which is a superior federal authority under the Federal Ministry for the Environment (BMU). BfS may call on other bodies to carry out its legal tasks. The German Company for the Construction and Operation of Final Repositories for Waste Materials (DBE), which is based in Peine and was set up in 1979, acts on behalf of BfS as its main contractor. In this context, wastes from various sources, including medical establishments and universities, may be placed in interim storage at the sites belonging to research centres, nuclear fuel fabrication plants and the collection plants of regional authorities. In addition, there are central storage facilities at Gorleben, Ahaus and Mitterteich.

BMU works with the Federal Ministry of Education, Science, Research and Technology (BMBF) and the Federal Ministry of Economics and Labour (BMWA) on R&D concerned with the take-over and final storage of radioactive waste.

Licensing procedures

The *Atomic Energy Act* provides the legal framework for licensing of the construction and operation of a radioactive waste disposal site. BfS is the applicant and the licensing bodies are the regional authorities. In the case of the Konrad repository, the Lower Saxony Environment Ministry (NMU) is the licensing authority. Public participation is an important factor in the licensing procedure, and information about a project application is made available to members of the public, who may express objections. These objections are then discussed at a hearing involving the applicant and its experts, the licensing authority and its experts, and the objectors and their experts. In addition, all mining activities must also be approved by the competent mining authorities.

Main bodies involved in radioactive waste management in Germany



Institutional Framework

The Federal Government and the parliament are responsible for policy making and legislation, respectively. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is responsible for nuclear safety, radiation protection, nuclear disposal and final storage. The Reactor Safety Commission (RSK) and Radiation Safety Commission (SSK) are responsible for advising BMU on all major issues concerning nuclear reactors, nuclear fuel cycle and radiation protection.

The regulatory authority is assisted by technical safety organisation such as the Company for Plant- and Reactor Safety (GRS).

The Federal Office for Radiation Protection (BfS) is a federal authority subject to supervision by BMU. BfS has its own integrated supervisory unit (independent unit). BfS implements in particular federal administrative tasks in the field of radiation protection including radiation protection precaution as well as nuclear safety, the storage of nuclear fuel, government custody, the transport of radioactive substances and the management of radioactive waste including construction and operation of federal installations for safekeeping and final disposal. It supports BMU on a technical and scientific level in these fields.

On behalf of the Federal Government the Länder execute administrative duties (licensing and supervision) under nuclear and radiation protection law as delegated by the federal authorities. Thus, the Federal States are the competent licensing authorities for all nuclear installations within their territory, except centralised and decentralised interim storage facilities for spent nuclear fuel. They supervise all nuclear facilities, repositories excluded. To ensure the uniform implementation of the Atomic Energy Act, the Federal States are subject to federal supervision by the BMU. The BMU has the right to issue directives to the competent nuclear authority of the respective Federal State, particularly in order to get consistent and suitable regulatory decisions. Federal supervision covers both legality and expediency of the Federal States' way of proceeding. The Länder have to operate *Landessammelstellen* (regional collecting depots), i. e. interim storage facilities for radioactive waste originating in particular from isotope applications in industry, research and development as well as medicine.

For the construction and operation of repositories the BfS may make use of "third parties". In 1979, the German Company for the Construction and Operation of Final Repositories (DBE) was founded as such a third party according to the Atomic Energy Act. DBE is the main contractor of BfS with regard to construction and operation of repositories.

Financing

The costs of conditioning, interim storage and disposal of radioactive waste from nuclear power plants, including the waste from reprocessing of spent fuel elements abroad, are met by the electricity utilities and are incorporated into the price of electricity. All waste producers including the electric utilities and the Federal Government, on behalf of its research centres, finance the planning and preparation for future German radioactive waste disposal, in accordance with the Prepayment Ordinance. The actual operation of the disposal facility will be financed by all waste producers according to the provisions of Article 21a of the *Atomic Energy Act*.

Public information

In addition to the information available locally from individual companies and facilities, information is also provided by Federal Government agencies, federal authorities, individual federal state governments and their agencies, and by industry. For more information, the websites of some relevant authorities and organisations are listed below.

Government

Bundesamt für Strahlenschutz (BfS)
Salzgitter
E-mail: info@bfs.de
Website: http://www.bfs.de

Industry

GNS Gesellschaft für Nuklear-Service mbH
Hollestraße 7 A, Essen
E-mail: info@gns-gnb.de
Website: www.gns.de

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Hungary

National nuclear energy context

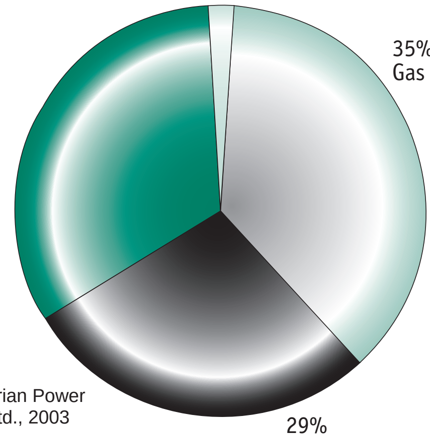
Commercial utilisation of nuclear power in Hungary started in 1983 and by 2003 there were 4 nuclear power units connected to the electricity grid. In 2003 they generated 11.01 TWh of electricity, 32.7% of the total electricity generated in that year.

As of 31 December 2003, a total of 2 129 fuel assemblies were in the spent fuel ponds in the nuclear power plant, and 3 497 fuel assemblies were stored in the Interim Spent Fuel Storage Facility.

By the end of 2003 the total capacity of the Interim Spent Fuel Storage Facility was 4 950 fuel assemblies in 11 vaults. Future expansion of the facility could increase the capacity to 33 vaults.

All four nuclear power units are of the VVER-440/213 reactor type and are located at the Paks nuclear power plant (NPP). There are no current plans to increase the nuclear electricity-generating capacity in Hungary.

Breakdown of electricity sources (in %)



Source: Hungarian Power Companies Ltd., 2003

Sources, types and quantities of waste

Waste classification and sources

Most of the radioactive waste in Hungary is generated by operation of the Paks NPP, with much smaller quantities being generated by other users of radioactive isotopes.

The following is based on Appendix 2 to the Decree 47/2003 (VIII. 8.) ESZCSM on certain issues of interim storage and final disposal of radioactive wastes, and on certain radiohygiene issues of naturally occurring radioactive materials concentrated during industrial activity.

General classification of radioactive waste:

1. Radioactive waste is classified as being low and intermediate level where the waste's heat production during disposal and storage are negligeable.
   (a) Low- and intermediate-level radioactive waste (ILW) is short-lived where the half-life of the radionuclides is 30 years or less. ILW contains long-lived alpha emitter radionuclides only in limited concentration (this concentration is 4 000 Bq/g in the case of collecting packaging, and 400 Bq/g on average for the whole quantity of waste).
   (b) Low- and intermediate-level radioactive waste is long-lived where the half-life of the radionuclides and/or the concentration of the alpha emitter radionuclides exceeds the limits for short-lived radioactive waste.
2. High-level radioactive waste is waste where the heat production is so significant (above 2 kW/m^3) that it has to be considered during the design and operation of storage and disposal options.
3. Within the above classifications the authority can prescribe more detailed classifications for low, intermediate and high level radioactive wastes.

Classification for low- and intermediate-level radioactive waste:

1. The classification of the radioactive waste into low- and intermediate-level classes shall be performed based on the activity-concentration (AC) and exemption activity-concentration (EAC) of the radioisotope contained in it. For low-level wastes the activity concentration is between 1 EAC and 10^3 EAC.
2. If the radioactive waste contains more radioisotopes, then the classification shall take into account all radioisotopes. In that case for low level wastes the sum of the AC/EAC values for all the radioisotopes shall be under 10^3.

Quantities of radioactive waste and spent nuclear fuel

Inventory and rate of generation of HLW from NPP operation

HLW is generated primarily by the Paks NPP, and only in relatively small quantities. At present, there is no decision on the back-end of the fuel cycle so the final form of HLW, as between spent fuel and the highly active residue arising from its reprocessing, is not known. Spent fuel is stored for the time being in purpose-designed tubular storage modules in the reactor buildings. The rate of generation of HLW from routine operations is 2.5-5 m^3/year, which will result in a total of 130 m^3 by the end of NPP operation. The amount of HLW from decommissioning of the Paks NPP is currently estimated to be about 250 m^3, which is less than previous estimates.

Inventory and rate of generation of LLW/ILW from NPP operation

The amount of solid LLW/ILW produced at the Paks NPP is now estimated at 180 m^3/year, after compaction, and the total volume generated over the life-time of the plant is estimated to be about 3 400 m^3.

The rate of generation of liquid radioactive waste is about 270 m^3/year in total for the four reactor units and, after cementation, the volume of resulting solid LLW/ILW will be about 4 000 m^3.

The disposal capacity required for LLW/ILW from the decommissioning of the Paks NPP has recently been estimated to be about 17 100 m^3.

Rate of generation of LLW/ILW from small sources

About 20-30 m^3 of LLW/ILW, and 1 000-3 000 spent sealed radiation sources, arise annually from small sources outside the nuclear power industry. Most of these radioactive wastes, including the spent sealed sources, are generated in medical, industrial and research applications. The two most widely used radionuclides are ^{60}Co and ^{92}Ir. They are used in medical and industrial radiography and give rise to significant inventories of activity.

Interim Storage Facility for Spent Fuel (ISFS), Paks NPP.

Radioactive waste management policies and programmes

Waste management policies

Interim storage of spent fuel is carried out in storage modules in an Interim Spent Fuel Storage Facility at the Paks NPP. It is assured for 50 years and will be gradually extended in future.

The management of liquid and solid LLW and ILW is carried out by the operator of Paks NPP. This includes collection, processing, packaging, qualification and interim storage of these wastes on the NPP site. The Public Agency for Radioactive Waste Management (PURAM) is responsible for the future transportation and disposal of these wastes.

Commissioning of the disposal facility for LLW and ILW is scheduled for 2008 in the medium-long-term plans for work financed by the Central Nuclear Funds (KNPA).

PURAM is also responsible for preparing the Paks NPP for decommissioning and for performing all related activities after plant shutdown, including dismantling, waste disposal and site restoration. These activities will be financed by the Central Nuclear Financial Funds as prescribed by relevant regulations.

Programmes and projects

Disposal of HLW

Preparations for disposal of high-level and long-lived radioactive wastes started in 1995. The programme outlined long-term concepts but, during 1996-98, it focused mainly on in-situ site investigations of the Boda Claystone Formation, at 1 100 m depth. At that time the area under investigation was accessible from a former uranium mine. The final report of these investigations raised no question about the suitability of the Boda Claystone Formation for disposal of HLW and, consequently, a recommendation was made for construction of an underground research laboratory and for further research. Subsequently, however, as the result of an earlier decision, the uranium mine was closed for economic reasons, and access to the area of study was no longer available by that route.

In response to these developments, a new basis for further investigations was set out in 2001 by way of a document entitled "Determination and Evaluation of Handling Strategies for Spent Fuel and HLW: Establishing a Working Programme and Time Schedule". Work on strategy development and preparation of the programme, including site investigations, started in 2003. The aim of the investigations is to select a site for an underground research laboratory.

At present, there is no decision on the back-end of the fuel cycle. Although the Interim Storage Facility at Paks NPP provides for 50-year storage of the spent fuel from the NPP, a decision on the national strategy for closure of the fuel cycle is expected by 2008.

Disposal of LLW/ILW from the Paks NPP

Currently, the solid and liquid LLW/ILW wastes arising from operation of the nuclear power plant are processed and stored temporarily at the plant.

In 1996, a proposal was made for a further search for a new geological disposal site for the LLW/ILW from Paks NPP. This was based on geological investigations and on safety and economic studies, and it proposed exploration of mined cavities, 200-250 m below surface, in granite in the vicinity of Bátaapáti, Üveghuta. Professional and political debate about this programme led, in 1999, to the Hungarian Atomic Energy Authority (HAEA) requesting the International Atomic Energy Agency to organise an expert mission to review the activities carried out within the framework of the programme. This expert mission found that the process was reasonable and the site potentially suitable, but that further work on safety assessments would be necessary. A related finding was that the geological investigations should continue in order to support these safety assessments. Simultaneously, the exploration work was evaluated by the Hungarian Geological Survey who came to the same basic conclusions.

Following this, in 2001, a research project for site characterisation and confirmation was defined. On-site investigations using boreholes, trenches and wells have taken place on the basis of a geological exploration plan approved by the competent authority, and a start has been made on preparation of an environmental impact study and an integrated safety assessment. A programme of underground investigations from tunnels is now in elaboration. It is expected that in 2005 the licensing procedure will start, with a view to commissioning the repository in 2008.

Treatment and disposal facilities for radioactive waste from small sources

A Radioactive Waste Treatment and Disposal Facility (RWTDF) for dealing with low and intermediate level radioactive wastes from small sources outside the nuclear power industry was commissioned in 1976. It is situated at Püspökszilágy some 40 km northeast of Budapest. The repository is a typical near-surface facility with a capacity of 5 040 m^3, comprising concrete trenches, or vaults, and shallow wells for spent sealed sources. By the end of 2003 the remaining unfilled capacity of the repository was down to 37 m^3.

In the past two years, work concerned with the RWTDF has concentrated on demonstrating the safe operation of the facility and on determining the measures necessary for its future closure. In this regard some reconstruction and upgrading have been done and safety assessments have been carried out.

Since 2001, the main areas of upgrading have included improvements in the following areas:

- Physical protection: New fence system, new access control, new equipment for security guards.
- Radiation protection: Replacement of obsolete measurement devices, enhancement of environmental monitoring.
- Data acquisition: New data recording system, waste characterisation capability, new meteorological station.

Key recommendations for safety enhancement, based on the results of safety assessment, are as follows:

- Certain long-lived and high-activity spent sources should be removed from the facility.
- The repository caps should be designed with exceptional care, as this is a key safety-related element of the system.
- Any long-term settling within the vaults should be minimised, and the vaults should be completely backfilled at an appropriate time.
- Steps should be taken to minimise the probability of future human intrusion by recording information about the facility, and by an appropriate period of administrative control over the site.

In addition to using its own resources and expertise for these safety-enhancing and modernising activities, Hungary has external assistance and collaboration. In regard to technical co-operation in the safety enhancement programme, Hungary will be supported by the International Atomic Energy Agency and by the European Union PHARE project. The aim of the PHARE project is to select the most appropriate and acceptable method for the upgrading of safety.

Research and development

LLW/ILW treatment

Methods for boric acid recovery and caesium removal from the concentrated liquid waste at the nuclear power plant are being developed on a contractual basis with IVO International Ltd. The possibility of applying other volume reducing technologies, such as incineration and supercompaction, to solid LLW/ILW has also been studied.

LLW/ILW disposal

Most of the R&D being performed in Hungary on disposal of LLW/ILW is concentrated on identification of a suitable site for a mined cavity type of repository. The research includes site investigations, laboratory analysis of borehole samples, determination of soil characteristics (i.e. sorption, water permeability, isotope migration rates, etc.) and performance assessment.

Other important areas of R&D include waste characterisation, waste acceptance criteria, Quality Assurance and Quality Control arrangements and facility design.

HLW

As described under "Programmes and projects", the Permian Boda Claystone Formation in the Mecsek Mountain area is considered suitable for high-level waste disposal. The systematic investigations for evaluation of the suitability of this formation as a location for a waste repository were carried out till 1998 with the assistance of the Canadian company, Atomic Energy of Canada Limited. Now the investigations are carried on to select a site for an underground research laboratory.

Back end of the fuel cycle

Hungary plans to launch a long-term research project on the major aspects of the back end of the fuel cycle in order to support a decision on fuel cycle closure. The possible options are direct disposal of encapsulated spent fuel or reprocessing of the spent fuel for recovery of reusable materials, with disposal of the highly-active residues supported, perhaps, by partitioning and transmutation of its small amounts of highly radiotoxic, long-lived components.

Decommissioning and dismantling policies and projects

The safety codes governing operation of the Paks NPP, the Budapest research reactor, the training reactor of the Budapest University of Technology and Economics, and the Interim Spent Fuel Storage Facility require arrangements for decommissioning to be considered at the plant design stage. A preliminary decommissioning plan is an obligatory part of the licensing documentation submitted prior to commissioning. This plan must be updated regularly in accordance with the regulations in force and submitted to the HAEA. No decommissioning of any Hungarian nuclear facility is planned for the near future.

The design lifetime of the nuclear power units at Paks NPP is 30 years. Thus, if the currently intended lifetime extension were not implemented, the last unit of would be finally shut down in 2017. A study by the Slovak company DECOM investigated and compared various decommissioning strategies for the nuclear power plant. The most cost-effective option was to defer dismantling and site clearance for 70 years and to maintain the plant in a state of "supervised closure" in the interim. This option is the basis of the decommissioning cost calculations.

Transport

The Hungarian regulations for transport of radioactive material are based on relevant international conventions. The HAEA is the competent authority for licensing of transport packages and transport arrangements. The same general rules apply to the transport of radioactive waste as apply to radioactive materials, except that transport of radioactive waste across national borders is also regulated in accordance with the European Union Directive on transboundary shipment of radioactive waste.

The transport of radioactive waste for disposal or storage in the RWTDF is organised by the Public Agency for Radioactive Waste Management (PURAM) under its own authority, and using its own work force and equipment. Large gamma-emitting sources are usually sealed into a special disposal container by the Institute of Isotopes Co. Gamma-emitting sources with no surface contamination are transported in lead-shielded containers without special packaging. Other types of radioactive waste are shipped to the facility in drums.

Competent authorities

The Hungarian Atomic Energy Authority (HAEA) is responsible for regulation of nuclear facilities, including the Interim Spent Fuel Storage Facility. It is a central public administrative organisation and deals with the peaceful uses of nuclear energy, under Government supervision. Some specific aspects of its licensing procedures are handled by other special authorities as described below.

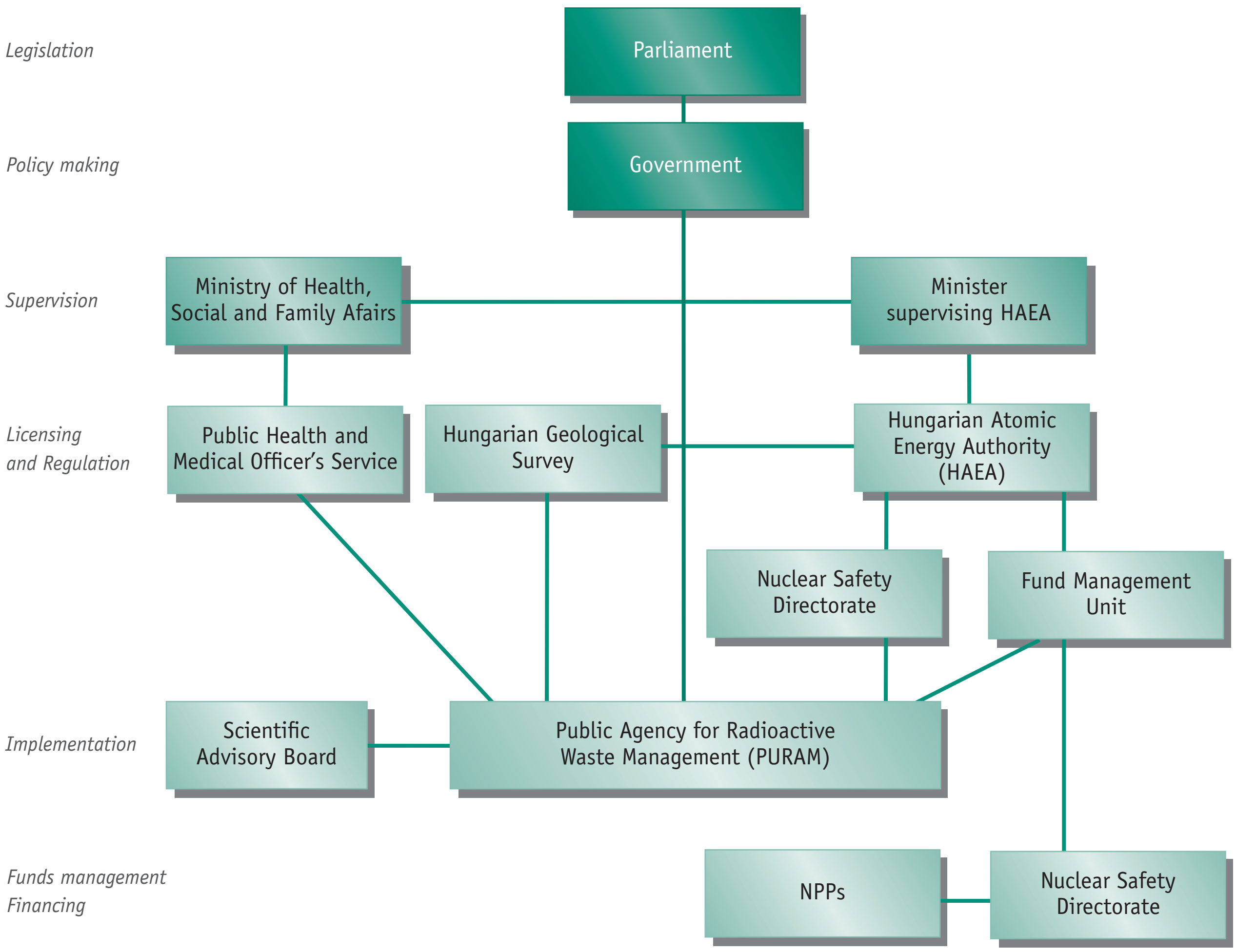
Under the *Atomic Energy Act* and Government Decree No. 240/1997 (XII.18.), a Central Nuclear Financial Fund was set up in January 1998 exclusively for financing radioactive waste disposal, interim storage and disposal of spent fuel, and decommissioning of nuclear facilities. The Minister supervising the HAEA has jurisdiction over the Fund, while HAEA is responsible for its administration.

Also under the *Atomic Energy Act*, the Government authorised the Director General of the HAEA to establish the Public Agency for the Radioactive Waste Management (PURAM), which has been in operation since June 1998. PURAM undertakes the work associated with disposal of radioactive waste, interim storage and disposal of spent fuel, and decommissioning of nuclear facilities.

The Minister of Health, Social and Family Affairs is responsible for licensing and supervision of the siting, construction, commissioning, operation, modification and closure of radioactive waste disposal facilities. This is carried out by way of the State Public Health and Medical Officer's Service, with expert advice and technical assistance provided by the National "Frédéric Joliot-Curie" Research Institute for Radiobiology and Radiohygiene.

The relationships between the authorities and bodies involved in licensing and supervision of nuclear facilities and radioactive waste management are depicted in the diagram below.

Main bodies involved in radioactive waste management in Hungary



Financing

Although the HAEA is responsible for its management, the Central Nuclear Financial Fund is a separate state fund pursuant to the Act XXXVIII of 1992 on Public Finance. Payments into the Fund are defined in accordance with the plans for radioactive waste disposal, interim storage and disposal of spent fuel, and decommissioning of nuclear facilities.

The levels of annual payment into the Fund by the Paks NPP are proposed by the Minister supervising the HAEA, in the process of preparing the Central Budget. Payments are based on advice from PURAM and approved by the HAEA and by the Hungarian Energy Office. The payments made by the Paks NPP are then taken into account in setting the price of electricity.

The institutes and businesses, other than the Paks NPP, that dispose of radioactive waste in the Radioactive Waste Treatment and Disposal Facility are also liable for contributions to the Fund in accordance with a price list set out in a ministerial decree. For those nuclear installations financed from the Central Budget, the Budapest research reactor and the training reactor of the Budapest University of Technology and Economics, payment into the Fund is provided from the Central Budget, as required.

At the end of 2003, the total sum accumulated in the Fund was equivalent to about € 189 million.

Public information

For more information, the websites of the relevant organisations are listed below.

Government

The Hungarian Atomic Energy Authority (HAEA)
Budapest
Website: http://www.haea.gov.hu/english/index.html
E-mail: czoch@haea.gov.hu

Public Agency for RW Management
H-2040, Budaörs, Puskás Tivadar u. 11
E-mail: peter.ormai@rhk.hu

Research

KFKI Atomic Energy Research Institute (AEKI)
Budapest
Website: http://www.kfki.hu/~aekihp/

Institute of Nuclear Research of the Hungarian Academy of Sciences
Debrecen
Website: http://www.atomki.hu/

National "Frédéric Joliot-Curie" Research Institute for Radiobiology and Radiohygiene
Budapest
Website: http://www.osski.hu/
E-mail: osski@hp.osski.hu

The Institute for Electric Power Research (VEIKI, Budapest)
Budapest
Website: http://www.veiki.hu/
Dr. Krómer István, general director
E-mail: i.kromer@veiki.hu

The Institute of Nuclear Techniques of the Technical University of Budapest (BME NTI)
Budapest
Website: www.reak.bme.hu

The Institute for Isotope and Surface Chemistry (MTA IKI) of the Hungarian Academy of Sciences
Budapest
Website: http://www.iki.kfki.hu/

Industry

The Power Engineering and Contractor Co. (ETV-ER_TERV Co., Budapest)
Budapest
Website: www.etv.hu
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This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

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Italy

National nuclear energy context

Commercial utilisation of nuclear power in Italy started in 1964 and by 1981 four nuclear power plants (NPPs) had been commissioned.

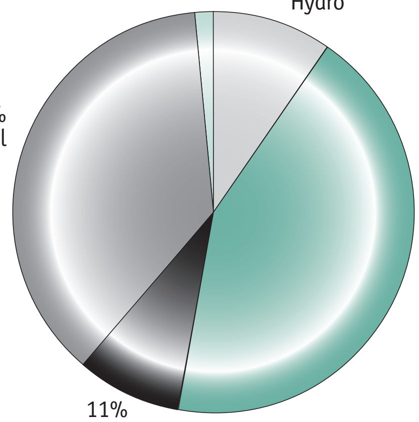
During that period, related nuclear fuel-cycle activities such as uranium and plutonium fuel fabrication and fuel reprocessing were developed at industrial or experimental pilot scale by the Nuclear Energy Research Agency (CNEN), now the National Agency for New Technology, Energy and the Environment (ENEA).

After the Chernobyl accident in 1986, however, there was a general public debate in Italy on the implications of using nuclear power and, following a referendum in November 1987, a new National Energy Plan called for the abandonment of nuclear power. Consequently, it was decided to shut down the Latina, Trino and Caorso NPPs in addition to the Garigliano NPP, which had already been shut down in 1978 and had been undergoing decommissioning since 1985.

At the same time, the interministerial Committee for Economic Planning (CIPE) required the National Electricity Company (ENEL) to make a start on the decommissioning of these NPPs.

Since 1999, the decommissioning of the four nuclear power plants has been taken in charge by SOGIN (*Società Gestione Impianti Nucleari*).

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

Waste sources and categories

In addition to the radioactive waste that have been generated by NPPs and the associated experimental nuclear fuel-cycle facilities, radioactive waste also arises from use of radioisotopes in medical, research and industrial applications.

In Italy, radioactive waste is classified into three categories according to the characteristics and concentrations of the radioisotopes that they contain, having regard to the possible options for their disposal. Guidance on this waste classification and on the technical requirements for waste forms and waste packages is given in the reference document Technical Guide no. 26 issued by ENEA-DISP (now APAT). The three categories of radioactive waste are as follows:

Category I: Waste whose activity decays in a few months to below a level at which there is any concern about safety. Such waste may be disposed of as ordinary waste under general waste regulations. It is generally described as very low-level waste (VLLW) and is mainly generated by hospitals and research establishments.

Category II: Waste whose activity decays to the level of a few hundred Bq/g within a few centuries. The activity of several specified radionuclides must not exceed prescribed values. Such waste is suitable for near surface disposal. It is usually described as short-lived, low- or intermediate-level waste (LLW/ILW).

Category III: Long-lived waste not included in categories I and II, high-level waste from reprocessing of spent fuel, and alpha-bearing waste from nuclear fuel cycle and R&D activities. Such waste will require deep geological disposal. This waste is described generally as long-lived and/or high-level waste (HLW).

For Category II waste, the ANPA reference document lists waste-conditioning requirements and other specific acceptance criteria for shallow land disposal. It defines two subcategories as follows:

1. Solid waste whose activity concentration is below the prescribed limits and which may be disposed of without further conditioning.
2. Waste whose activity concentration is above the prescribed limits and which needs to be conditioned and must fulfil further requirements to be accepted for final disposal.

A general criterion is in force in Italy for unrestricted release. Radioactive materials can be unconditionally released from regulatory control if the concerned radionuclides comply with both a concentration and a radioactive half-life threshold:

- activity concentration ≤ 1 Bq/g; and
- half-life < 75 days.

If both conditions above are not complied with, a specific authorisation is required for releases, reuse and recycle of the materials concerned. The authorisation is given on the basis of a case-by-case analysis which has to demonstrate compliance with the basic 'below regulatory concern' criterion below, both conditions of which must be met:

(a) effective dose ≤ 10 µSv/year; and

(b) either effective collective dose ≤ 1 man·Sv/year or the analysis demonstrates that exemption is the optimum option.

No specific criteria are provided for in Italian legislation for the release of radiologically regulated facilities and/or sites, although the general criteria stated above obviously applies; thus, a case-by-case analysis is employed.

Waste inventory

APAT produced an overall national inventory of the radioactive waste, spent sources and spent fuel currently stored in the 25 nuclear installations in Italy. Information on volumes and activity of radioactive waste in store is given in the tables below by category and by source.

The total amount of spent fuel from the nuclear power plants is over 265 tonnes heavy metal (HM). It is stored at the Avogadro, Caorso, Trino and Eurex nuclear facilities, and some will be shipped, in due course, from Avogadro to Sellafield (UK) for reprocessing. The amount of spent fuel from research reactors is less than 2 tHM and this is stored at various other sites.

As regards future amounts of waste, some 6 000 m^3, arising from reprocessing of spent fuel, will be returned from the reprocessing plant at Sellafield in the UK. This will comprise about 5 000 m^3 of Category II waste and about 1 000 m^3 of Category III waste, including 16 m^3 of HLW.

In addition, about 30 000 m^3 of Category II will arise from decommissioning of nuclear facilities.

Volumes and activity of radioactive waste in store in Italy, by category and by source

Category GT 26	International classification	Volume (activity)
Category I	VLLW	7 740 m^3 (0.3 TBq)
Category II	LLW short-lived	17 320 m^3 (741 TBq)
Category III	LLW-LL and HLW	1 000 m^3 (6 352 TBq)

Source (category)	Volume (activity)
Industry, hospitals, etc. (I and II)	7 740 m^3 (0.3 TBq)
Reactors (II)	17 320 m^3 (741 TBq)
Fuel cycle facilities (II and III)	1 000 m^3 (6 352 TBq)
Research (II and III)	1 000 m^3 (6 352 TBq)
Decommissioning (II)	1 000 m^3 (6 352 TBq)

Radioactive waste management policies and programmes

Waste management policies

There is currently no LLW disposal facility in Italy, and radioactive waste from NPPs and experimental fuel cycle facilities are stored at their sites of origin. Radioactive waste from medical, industry and research activities is collected by private operators for interim storage. Most of this waste is stored in untreated form, awaiting appropriate treatment and/or conditioning.

By the end of 1999, the Ministry of Industry, Commerce and Crafts, now named Ministry for Productive Activities (MAP), issued strategic guidelines for the management of liabilities resulting from past national nuclear activities.

According to this new policy a national site for radioactive waste disposal is envisaged by 2010 and all the nuclear installations should be completely decommissioned by 2020.

Programmes and projects

LLW repository project and site selection process

Since 1996 a special Task Force within the National Agency for New Technology, Energy and the Environment (ENEA) has been investigating strategies and technologies for construction of an engineered, near-surface LLW disposal facility.

Geographic screening began in 1998 using Geographic Information System (GIS) methodology to create a national map of suitable areas for location of an LLW repository. This is being developed in order to identify possible areas at a regional level.

In 2001 an Expert Group, set up by the relevant Ministries and Regional Authorities, issued a report presenting the results of a study aimed at identifying and proposing a procedure for site selection with the required level of consensus from the public and local authorities.

The growing international concern on terrorist activities has emphasized the risk for the unresolved solution of spent fuel and radioactive waste disposal management; consequently an Ordinance of the President of the Italian Government was adopted in February 2003.

The Ordinance gave to a Delegate Commissary the entire responsibility for spent fuel management, decommissioning policy and radioactive waste disposal. The Delegate Commissary is using the SOGIN competences and resources for the implementation of decommissioning and waste management activities.

On April 2003, a Commission has been charged by the Delegate Commissary to develop a proposal for a radioactive waste disposal solution.

The study included:

- safety criteria for waste disposal;
- proposal for a site selection procedure;
- feasibility studies for different disposal facility concepts (engineered near-surface, shallow and mined cavity);
- preliminary identification of candidate sites.

The Commission completed the assigned work on September 2003 and, on the basis of the results of this Commission, a Legislative Decree was approved in December 2003.The Legislative Decree n° 368 that establishes the decision procedure for the spent fuel HLW disposal site selection, entered into force by January 2004.

The main provisions of the L.D.368/03 are:

- A Commission of 19 experts, from different organisations including regional stakeholders, will identify a site for spent fuel and HLW disposal.
- The site will be validated by APAT, CNR and ENEA.
- The design will be approved by APAT.
- The facility should be ready to operate by December 2008.

Conditioning and decommissioning

Preliminary dismantling activities as well as the conditioning of the radioactive waste are on going at the shutdown SOGIN nuclear power plants and fuel cycle facilities.

The **Garigliano** 150 net MWe BWR was operated from 1963 to 1978. The plant has been totally defuelled and several activities have been performed such as a light decontamination and drainage of the vessel, primary circuit and spent fuel pit; dry low-level operational wastes compaction, cementation of liquid and semiliquid (sludge) radioactive waste.

The **Latina** 153 net MWe GCR was operated since 1962 up to 1987. The plant has been totally defuelled; the primary circuit has been filled with dry air, and blowers and portions of the primary circuit outside the reactor building have been dismantled.

The **Trino** 260 net MWe PWR was operated from 1965 to 1987 for the equivalent of about eleven full power years; a limited quantity of spent fuel is still present in the spent fuel pool; no major decommissioning activities have been performed. Decontamination of the primary circuit is in progress.

The **Caorso** 860 net MWe BWR was operated from 1981 to 1986. Decontamination of the circulation loops and clean-up have been completed in 2003. Dismantling activities on the turbine building, RHR tower and off-gas system are in progress.

As far as the fuel cycle facilities are concerned, all of them are at present shut down and managing their nuclear materials and/or radioactive waste, before starting decontamination and dismantling operations.

FN *(Fabbricazioni Nucleari)*, an industrial scale plant for LWR fuel fabrication located at Boscomarengo, was operated from 1973 to 1995.

EUREX pilot reprocessing facility, located at Saluggia, operated from 1970 to 1974 (MTR fuels) and from 1980 to 1983 (Candu fuels). Its main present task is to treat and condition the liquid reprocessing waste (some 120 m^3 ILW and some 100 m^3 LLW).

ITREC pilot reprocessing facility, located in the southern part of Italy (Trisaia), was operated in the seventies (uranium-thorium cycle fuels from the US Elk River reactor). After the solidification (by cementation) of its liquid reprocessing waste, its present task is to manage many other different solid and liquid waste streams.

IPU plutonium pilot MOX fuel fabrication facility, located at Casaccia Centre, was operated from 1968 to the early eighties (MOX fuel fabrication experimental campaigns). After treatment of many radioactive waste streams (mostly high plutonium-bearing liquids), the dismantling of glove boxes is going to start using a special remotely handled installation.

Research and development

Functions

ENEA and SOGIN both carried out R&D on the safety of radioactive waste management. The Agency for Environmental Protection and Technical Services (APAT) participates in presentation of the results in order to monitor and influence the development of this safety-related work.

Content of R&D plans

The main work areas are:

Radioactive waste and facility characterisation

Development of measurement techniques and procedures for the radiological characterisation of radioactive waste packages, and development of procedures for preliminary radiological characterisation of nuclear installations before dismantling.

Disposal of low-level waste

Research on development of a conceptual design for an engineered near-surface LLW disposal facility, with a particular focus on the development of the safety assessment methodologies.

Partitioning and transmutation

ENEA is involved in several international projects concerning partitioning of long-lived radionuclides from HLW and accelerator-driven transmutation systems. APAT has collaborated with ENEA staff in evaluating the effectiveness of transmutation.

In regard to the research activity on transmutation, ENEA recently applied to APAT for a preliminary authorisation to carry out experimental activities on a TRIGA research reactor.

Decommissioning and dismantling policies and projects

By the end of 1999, the Ministry of Industry, Commerce and Crafts, now named Ministry of Production (MAP), issued strategic guidelines for the management of liabilities resulting from past national nuclear activities. According this new policy all the nuclear installations should be completely decommissioned by 2020.

In this respect, in 1999 all the ENEL's liabilities connected to nuclear power were assigned to a newly established company, named SOGIN. The mission of SOGIN covers the implementation of a prompt decommissioning of the four national power stations until an unconditional release of the respective sites within twenty years, as well as the safe management of radioactive waste and spent fuel associated with the power stations.

The new policy was implemented by a Ministerial Decree of 26 January 2001 which established the plans and procedures for funding the activities associated with decommissioning of NPPs and nuclear fuel-cycle facilities. The strategy defined in this Decree was further detailed by another Ministerial Decree of 7 May 2001 which directed SOGIN to implement prompt decommissioning of the four national NPPs with a view to unconditional release of their respective sites within twenty years. The Decree also charged SOGIN with the safe management of radioactive waste and spent fuel from these NPPs using funds provided by the levy on electricity sales.

Comprehensive plans for prompt decommissioning of the Garigliano, Caorso, Trino and Latina NPPs have been presented by SOGIN to the Ministry of Production Activities, and they are currently under review by APAT.

Following the directives included in the Ministerial Decrees of 2001, in summer 2003, SOGIN also took under its responsibility the ENEA and FN fuel cycle facilities, with the main objective to manage the activities related to their decommissioning.

Issues that continue to hinder progress, however, are:

- Lack of a national site for the disposal of LLW and ILW.
- Lack of a centralised interim storage facility for spent fuel and HLW.

Also, the Italian Government issued a new decommissioning strategy at the end of 1999 based on prompt decommissioning, the so-called "DECON" option, thus requiring nuclear operators to change previous plans based on the "SAFSTOR" option, and getting plants to the stage of safe enclosure within the first decade after 2000.

Under the new strategy all shutdown Italian nuclear installations and facilities should be completely dismantled and their sites released without radiological constraint within 20 years from now. However, implementation of this strategy will depend on the following key points:

- The availability, within 10 years from now, of a centralised national site for the long-term interim storage of spent fuel and conditioned HLW and for disposal of conditioned LLW and ILW.
- The availability of sufficient funds.

Transport

Transport arrangements must comply with the provisions of specific Decrees issued by the Ministry of Infrastructure and Transport. These Decrees transpose the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Material into national legislation for the different modes of transport.

Only carriers authorized by the Ministry of Productive Activities may transport radioactive material. Authorisation is granted on the basis of technical advice from APAT and the Ministry of Interior.

Approval and validation of package design is carried out by APAT. For high-level sealed sources and fissile material transportation, however, further specific certification granted by APAT and Ministry of Infrastructure and Transport is required.

Competent authorities

The competent national bodies for radioactive waste management in Italy are as follows:

Ministry for Productive Activities

The Ministry for Productive Activities (formerly the Ministry of Industry) is the licensing authority for operation of all nuclear and radioactive installations. It receives technical advice from APAT. For installations concerned with radioactive waste storage and disposal, the concerted agreement of the Ministries of Environment, Internal Affairs, Welfare, and Health is also required.

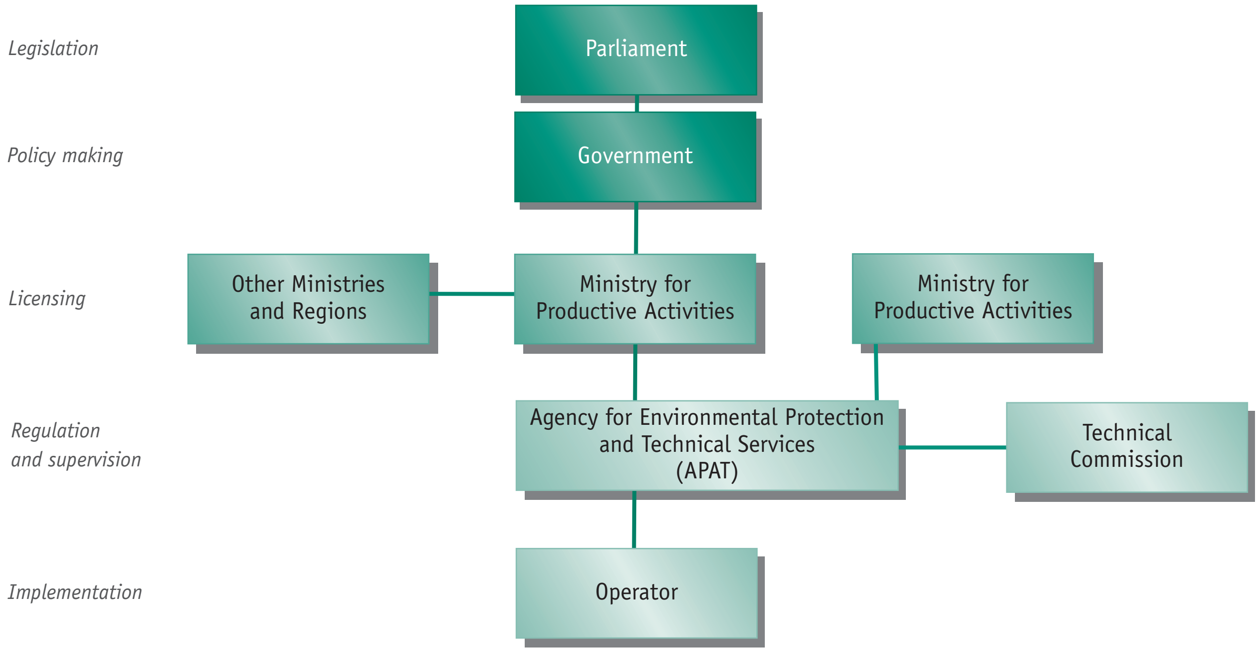
Agency for Environmental Protection and Technical Services (APAT)

The Agency for Environmental Protection and Technical Services (formerly the National Agency for Environmental Protection – ANPA) is responsible for the regulation and supervision of nuclear installations in matters of nuclear safety and radiation protection. Any licence granted by the Ministry for Productive Activities incorporates the legally binding advice of APAT. It is a body governed by public law, with administrative and financial autonomy under the supervision of the Ministry of the Environment.

Technical Commission for Nuclear Safety and Health Protection from Ionising Radiations

This Commission is composed of experts from ENEA, APAT, and from various Ministries. It gives technical advice in regard to the licensing of nuclear installations.

Main bodies involved in radioactive waste management in Italy



Financing

Waste management costs

The cost of waste disposal is generally considered to be the most significant component of the cost of waste management, which in turn is one of the most significant components of the cost of nuclear facility decommissioning. Thus, it is important to have an early estimate of waste disposal costs for the purpose of calculating the long-term funding liabilities. These costs will depend on the charges for disposal of waste in the national repository. As this has not yet been designed the likely charges are unknown. However, a current estimate is about € 7 000/m^3.

Financing long-term liabilities

Even before there was a legal requirement to do so, ENEL had created a fund to meet its long-term liabilities for decommissioning and spent fuel management. The accumulated fund was transferred to SOGIN at the time of its creation as an independent body, and amounted to about € 750 million at that time. This amount was judged sufficient to complete decommissioning activities by way of the deferred dismantling, "SAFSTOR" strategy.

Following the separation of SOGIN from ENEL, additional costs have arisen from changed economic conditions, additional company management costs, and a change of decommissioning strategy. These have been recognised, and arrangements have been made to finance them by way of a levy on electricity sales as described above.

Every year SOGIN is required to present its programme of future activities, with associated costs. On this basis, the national Authority for Electric Energy and Gas, the body that defines tariff policy, re-evaluates the levy on the price of electricity for the next three years.

For the year 2000 a provisional figure equivalent to about 0.03 euro cents per kwh was defined, corresponding to an annual income for SOGIN of about € 75 million.

Subject to the necessary agreements, the same procedure is envisaged for meeting the additional costs to SOGIN arising from dismantling the nuclear fuel cycle facilities currently owned by ENEA.

Public information

For more information, the websites of the relevant organisations are listed below.

Government

APAT (Agency for the Environmental Protection and Technical Services)
Website: www.apat.it
E-mail: webapat@apat.it (technical issues)
E-mail: urp@apat.it (public relations)

SOGIN
Website: www.sogin.it
E-mail: friello@sogin.it

Research

ENEA (Italian National Agency for New Technologies, Energy and the Environment)
Rome (headquarters)
Website: http://www.enea.it/

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

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Japan

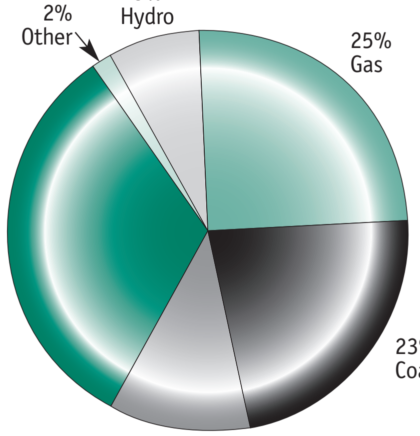
National nuclear energy context

Commercial utilisation of nuclear power in Japan started in 1966 and by 2002 there were 54 nuclear power units connected to the electricity grid. In 2002 a total of 277.8 TWh of electricity, 31.4% of the total production, was generated using nuclear power.

In 2002, the capacities for nuclear fuel fabrication were 1 674 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors and 5 tonnes HM/year of fast breeder reactor fuel. Spent fuel storage capacity was 19 565 tonnes HM, and the amount of spent fuel arising in 2002 was 935 tonnes HM.

A series of light water reactors (LWR), both pressurised water reactors (PWRs) and boiling water reactors (BWRs) have been constructed by ten electricity companies. The advanced thermal reactor (ATR), which is a heavy water moderated, light water-cooled reactor, and the fast breeder reactor (FBR) have been developed by the Japan Nuclear Cycle Development Institute (JNC). A gas-cooled nuclear power plant at Tokai power station, operated by the Japan Atomic Power Company (JAPC), was shut down in March 1998. At the end of 2002, 23 PWRs, 29 BWRs and the ATR were in operation, with a combined electricity generating capacity of about 46 GWe. The research and development of nuclear fuel cycle technology has been performed mainly by JNC, although some commercial facilities are operated or have been constructed by the private sector.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

Radioactive waste in Japan is classified into two main categories according to its level of activity, namely high-level waste (HLW) and low-level waste (LLW). Depending upon its origin, the LLW is further sub-classified into waste from power reactors, waste containing transuranic radionuclides, uranium waste and radioactive waste from medical, industrial and research facilities. An additional category of very low-level waste (VLLW) from reactor sites is also recognised.

The *Reactor Regulation Law* provides for the setting of upper limits on the concentrations of radionuclides in waste authorised for disposal from reactor facilities. These upper limits have been formulated on the basis of a report published by the Nuclear Safety Commission (NSC) and are used in the preparation of licence applications.

At the other end of the activity scale, the NSC is discussing “clearance levels” for radioactive waste. These are radionuclide concentrations below which waste may be released from radiological control, on the basis of a concept set out by the Atomic Energy Commission (AEC). Clearance levels have already been published for waste from light water reactors, gas-cooled reactors, heavy water reactors, fast breeder reactors and fuel-cycle facilities, together with details of methods for their certification.

High-level radioactive waste (HLW)

HLW includes the highly active liquids that arise from the reprocessing of spent nuclear fuels, and the solid glass waste form produced by the vitrification of these liquids. It contains substantial quantities of both fission products and actinides.

Low-level radioactive waste (LLW)

This is the general category of radioactive waste, other than HLW, which arises from various facilities and is sub-classified in some cases according to its origin.

Very low-level radioactive waste (VLLW)

VLLW is waste with a very low level of activity that is suitable for shallow ground disposal without the need for waste encapsulation or engineered structures.

Transuranic waste (TRU)

This is low-level radioactive waste arising from spent fuel reprocessing and mixed-oxide fuel fabrication that contains radionuclides of atomic number larger than uranium (e.g. neptunium plutonium, americium, etc.).

Waste from uranium fabrication facilities

This is the waste that arises from uranium fuel fabrication facilities, uranium enrichment facilities and other similar facilities. It contains the very long-lived uranium together with the products of its radioactive decay. Much of this waste comprises VLLW.

Waste from medical, industrial and research facilities

This waste is LLW that arises specifically from research institutes and other facilities that use radioisotopes such as hospitals and industrial facilities.

The amounts of radioactive wastes in storage in Japan in 2002 are shown in the table below, together with some information about disposals of LLW and VLLW and clearance of waste arising from decommissioning of nuclear facilities.

Category of waste		Cumulative amount of waste (as of March 2003)
High-level radioactive waste (vitrified waste)		746 canisters (vitrified waste) 431 canisters
Waste generated from nuclear reactors	Low-level radioactive waste containing comparatively high radioactivity (core internal structure, etc.)	control rod: 7 645 channel box, etc.: 56 629
	Low-level radioactive waste	528 845 drums (200 l) at nuclear power plants (150 515 drums (200 l) were disposed at Rokkasho disposal facility)
	Very low-level radioactive waste	(1 670 tonnes were disposed at JAERI's Tokai site)
TRU waste		80 067 drums (200 l) 3 068 m^3 at JNC
Waste originating from uranium fabrication facilities		36 532 drums (200 l)
Waste originating from medical, industrial and research facilities		419 000 drums (200 l)*

* This figure includes "TRU waste" and JNC "waste from uranium fabrication facilities".

Radioactive waste management policies and programmes

Waste management policies

In Japan, the disposal of LLW from nuclear reactors has taken place since 1992. In regard to disposal of the high-level vitrified radioactive waste from reprocessing of spent fuel, a *Specified Radioactive Waste Final Disposal Act* came into force in June 2000, defining the procedure for disposal-site selection, the nature of the implementing entity involved and the arrangements for accumulation of the necessary funds. As regards disposal of other radioactive wastes such as TRU, waste from uranium fabrication facilities, etc. basic regulatory principles have yet to be established.

The basic policy, however, is that responsibility for treatment and disposal of radioactive waste lies with the operators who have generated the waste.

Programmes and projects

LLW disposal programme

The Japan Nuclear Fuel Limited (JNFL) low-level radioactive waste disposal centre at Rokkasho-mura, in Aomori Prefecture, has been in operation since 1992. JNFL is permitted to dispose of 400 000 drums at the centre, and by the end of 2002 had buried some 147 000 drums of homogeneous and solidified LLW from nuclear power plants.

The AEC Advisory Committee on Nuclear Fuel-Cycle Backend Policy has discussed the policy for disposal of wastes containing comparatively high-level levels of beta- and gamma-emitting radionuclides, such as spent control rods, burnable poisons, and reactor internals, which arise from operation and decommissioning of nuclear power plants. The Advisory Committee published its findings on this subject in October 1998, and proposed the concept of underground disposal at a depth of 50-100 metres. Following this proposal, the Nuclear Safety Commission of Japan (NSC) issued a report on the basic policy for regulation and the setting of radionuclide concentration limits for disposal of these wastes. Since 2002, and following a one-year preliminary study, JNFL has been conducting a detailed survey of the geology and groundwater at Rokkasho-mura for the design of such a disposal facility.

The Advisory Committee also discussed the treatment and disposal of low-level wastes arising from nuclear research and the use of radioisotopes. In May 1998, it issued a report entitled "Guidelines on Treatment and Disposal of Radioactive Waste from Radioisotope Use, Nuclear Research and Other Related Facilities". Since then, the NSC has been discussing the basic policy for regulating disposal of these wastes. The Japan Atomic Energy Research Institute (JAERI), Japan Nuclear Cycle Development Institute (JNC) and the Japan Radioisotope Association are the main producers of these wastes and have been conducting studies with a view to implementing a disposal solution shortly.

TRU waste disposal programme

TRU waste is generated at the JNC Tokai reprocessing plant and at the mixed oxide (MOX) fuel fabrication facilities. TRU waste from the reprocessing of Japanese spent fuel sent overseas will soon be returned to Japan and the JNFL commercial reprocessing plant under construction at Rokkasho-mura will generate the same type of waste. The NSC is currently discussing the basic policy for regulating disposal of this waste.

Legal framework for HLW disposal

As described above, the *Specified Radioactive Waste Final Disposal Act* sets out the overall scheme for implementing disposal of vitrified HLW. It defines the roles and responsibilities of the government, the new implementing organisation, the Nuclear Waste Management Organisation of Japan (NUMO), the new fund management organisation, the Radioactive Waste Management Funding and Research Centre (RWMC) and the power reactor owners.

Under the act, the Ministry of Economy, Trade and Industry (METI), on behalf of the government, is responsible for defining the basic policy and disposal plan. METI is also responsible for supervising the activities of NUMO and RWMC.

In accordance with the act, NUMO is responsible for planning and conducting disposal site selection and site characterisation. It is also responsible for submitting the relevant licensing applications for repository construction, operation and closure. Site selection will be carried out in a stepwise manner. In the first step, preliminary investigation areas will be selected on a nationwide scale. This will be done mainly by a literature survey, and a survey of the long-term stability of the geological environment. In the second step, and on the basis of the preliminary investigations, areas will be selected for detailed surface-based investigations, including the drilling of boreholes, to evaluate the characteristics of the geological environment. In the final step, and on the basis of the surface investigations, potential disposal sites will be selected and investigated by way of underground facilities. NUMO's site selection activities are overseen by METI. At the every step NUMO must consult the relevant local population and METI consults the relevant local governors and mayors, all of whose opinions will be respected.

As the generators of HLW, the nuclear power reactor owners are responsible for sharing the costs of HLW disposal and for contributing to the national fund in proportion to the amounts of electricity they generate. METI authorises the budget of the NUMO programme and supervises the RWMC management of the national fund. The total cost of the programme is currently estimated by the Advisory Committee for National Resources and Energy to be approximately 3 trillion yen (corresponding to 0.13 yen/kWh) for a repository designed to accommodate 40 000 canisters of HLW.

HLW disposal development

In December 2002, in the first step of the siting process, NUMO invited municipalities to volunteer preliminary investigation areas (PIAs) as potential candidate sites. At the same time, it published four information documents entitled "Instructions for Application", "Siting Factors for the Selection of the Preliminary Investigation Areas", "Repository Concepts", and "Site Investigation Community Outreach Scheme". These documents are aimed at providing basic information for discussions amongst stakeholders and the general public of municipalities, and to support them in deciding whether they could accept the planned repository in their municipality. The selection procedure for PIAs will be finalised by the cabinet.

Following acceptance of an application from a volunteer municipality, NUMO will conduct an area-specific literature survey of earthquakes, volcanic activity, uplift and erosion. The evaluation of the area will then be conducted by way of a comparison with NUMO's siting criteria. The evaluation results will be documented in a report for each area, and will be submitted to the governors and mayors of the municipalities concerned. NUMO will make the evaluation report available for inspection in relevant prefectures and will invite comments on it. It will then compile the comments in another report, together with its own responses to the comments. This further report will then be sent to the governors and mayors of the relevant municipalities. With regard to the comments on the evaluation report, NUMO will select PIAs from the areas covered by the area-specific literature survey and will submit an application for approval of the selection of PIAs to METI. According to the act, METI must invite comments from the governors and mayors of the relevant municipalities and respect their comments in approving selection of the PIAs.

Returned vitrified HLW from overseas reprocessing

Japanese utilities have their spent nuclear fuel reprocessed by Cogema of France and BNFL of the United Kingdom. The contracts for these services entitle Cogema and BNFL to return the vitrified residues to their Japanese customers, and both Cogema and BNFL have decided to do so. The vitrified HLW to be returned is currently estimated to be about 2 200 canisters in total. The HLW waste canisters are placed securely inside specially-designed transport casks, and transport is by sea in a specially designed vessel. The casks and the vessel are designed and manufactured in accordance with all the relevant safety standards of the International Atomic Energy Agency (IAEA) and the International Maritime Organization (IMO). The first vitrified waste received from France was unloaded on 26 April 1995 at Mutsu-Ogawara, the port for Rokkasho-mura, in Aomori Prefecture. Each item of vitrified waste was checked for appearance, surface contamination, size, weight, containment, radioactivity calorific value, etc. and, after checking and confirming the inspection data, the Agency of Nuclear and Industrial Safety gave its approval for the wastes to be placed in the storage pits of the JNFL vitrified waste storage centre at Rokkasho-mura. All the received vitrified wastes will be stored there for 30 to 50 years.

The transport of vitrified waste from France and the United Kingdom to Japan is expected to continue for at least 10 years, at a frequency of one or two shipments per year according to Japanese utilities. Up to March 2004 there have been nine such shipments, with a total of 892 canisters received safely from France.

Research and development

R&D on HLW disposal

In regard to implementation of R&D on HLW disposal, AEC has specified the overall framework in the Long-Term Programme issued in November 2000.

NUMO is responsible for conducting R&D focused on the safe implementation of disposal with the best available technology, taking economic and practical aspects into consideration. The Government and other relevant organisations carry out R&D in support of the safety regulation framework and on other fundamental issues related to safety assessment. These include geoscientific studies and repository technology development aimed at increasing confidence in the concept. In this context, JNC is required to ensure further the reliability of repository technology and to establish safety assessment methodology based upon previous experience and technical achievements. This work will be carried out by the research projects on crystalline and sedimentary rocks at the Underground Research Laboratories (URL) in Mizunami and Horonobe respectively, and on the work at the ENTRY and QUALITY facilities in Tokai.

Surface-based investigation of a site at the Mizunami URL has been in progress since 1996. Mizunami City has proposed transferring the work to a municipally-owned area, and an agreement for use of this area between the city and JNC was signed in January 2002. Shaft sinking was to start in 2003, with the main excavation of the research drift to be completed by 2009. The Horonobe URL project was approved by the agreement between the local Governments and JNC in November 2000. A JNC office was opened in Horonobe in April 2001 and a surface-based investigation started. JNC selected the site for constructing an underground facility in the region of Horonobe town in July 2002. Shaft sinking will begin in 2005, aiming for a completion of the major part of the drift by 2010.

Decommissioning and dismantling policies and projects

Several research nuclear facilities have already been decommissioned, or are in the stage of planning for final shutdown and decommissioning. So far, the nuclear-powered ship "Mutsu" and the Japan Power Demonstration Reactor (JPDR) have been decommissioned by Japan Atomic Energy Research Institute (JAERI). The JAERI Reprocessing Test Facility (JRTF) and the Japan Research Reactor No. 2 (JRR-2) decommissioning programmes are the current major decommissioning projects in JAERI.

The Tokai power station, which is the oldest commercial gas-cooled nuclear power plant of the Japan Atomic Power Company (JAPC), was finally shut down in March 1998. This will be the first example of commercial nuclear power plant decommissioning in Japan. The regulatory procedure was started in 2001. In addition, the Fugen nuclear power plant, a prototype of the advanced thermal reactor operated by JNC, was shut down in March 2003. The preparatory study for decommissioning the Fugen plant is in progress.

Transport

Regulations for the transport of nuclear materials on land are based on the *Law for the Regulation of Nuclear Source Material, Nuclear Fuel Material and Nuclear Reactors*. They are administered by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Economy, Trade and Industry (METI), the Ministry of Land, Infrastructure and Transport (MLIT) and the Prefectural Public Safety Commission (PPSC). The MLIT and the Japan Coast Guard govern transport by sea under the *Ship Safety Law*, and the MLIT governs transport by air under the *Civil Aviation Act*.

The technical standards for nuclear fuel transport are stipulated in ministerial ordinances and notifications based on the Regulations for the Safe Transport of Radioactive Substances recommended by the International Atomic Energy Agency (Safety Standards Series No. ST-1, 1996 edition).

Under these regulations, confirmation of safety is required before shipping of packages containing 0.1 kg or more of uranium hexaflouride, fissile material packages or so-called type B packages. This confirmation is divided into three phases:

- design approval for nuclear fuel packages;
- approval and registration of packaging;
- shipment confirmation for packages and for the method of transport.

Competent authorities

The main government organisations responsible for nuclear safety regulation, including radioactive waste management, are the Ministry of Economy, Trade and Industry (METI), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Ministry of Land, Infrastructure and Transport (MLIT). They answer to the cabinet, which is advised by the Nuclear Safety Commission (NSC). These ministries and the NSC are supported by various specialist divisions and committees.

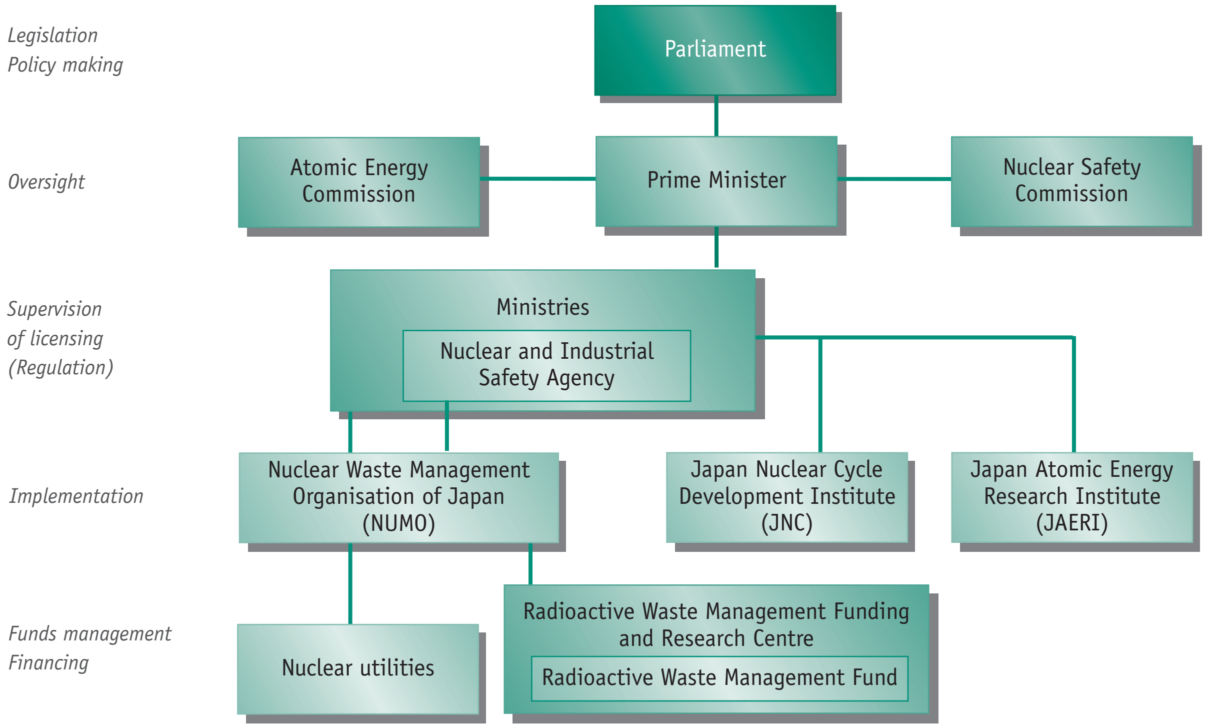
In accordance with the *Specified Radioactive Waste Final Disposal Act*, the Nuclear Waste Management Organisation of Japan (NUMO) was established in 2000 as the organisation responsible for implementing HLW disposal. It was set up by the private sector and was approved by the Minister of Economy, Trade and Industry.

NUMO is responsible for implementation of final geological disposal of HLW and for collection of the fees necessary to fund its disposal activities.

The act further specifies that METI shall evaluate the NUMO work plan in order to ensure that it has sufficient technical, financial and human resources to carry out its responsibilities.

METI, together with a HLW disposal technical consultants group organised under the Advisory Committee for Energy, will also investigate whether the process for disposal facility siting is scientifically appropriate.

Main bodies involved in radioactive waste management in Japan



Financing

Financing system for HLW disposal

The *Specified Radioactive Waste Final Disposal Act* established the Radioactive Waste Management Fund ("the Fund") into which financial resources for disposal of HLW are to be deposited. The Fund is managed by the non-profit-making Radioactive Waste Management Funding and Research Centre. It is maintained independently from the nuclear utilities in order to avoid being left unsecured by reason of excessive debt or bankruptcy of the utilities during the long period over which the HLW must be managed.

The act requires that an annual fee shall be collected from the nuclear utilities. This fee is calculated on the basis of the nuclear power reactors operated by each utility, by way of the following formula: Annual fee = A x B, where A is the final disposal cost per HLW canister, and B is the number of HLW canisters equivalent to the amount of spent nuclear fuel generated during the year by operation of the utility's reactor(s).

In addition, the nuclear utilities are required to pay fees, by instalment, for disposal of spent fuel generated before establishment of the Fund. The fees are collected by NUMO and transferred to the Fund. Then, in accordance with the requirements of the act, the fees are deposited and/or invested.

Waste management fee

The size of the annual waste management fee charged to a nuclear utility depends on the thermal efficiency of the nuclear power plant(s) concerned. In 2001 it was approximately 0.13 yen/kWh, on average, for electricity generated by nuclear power plants. An additional 0.07 yen/kWh is charged as a fee for the waste management operations prior to the establishment of the Fund. These annual fees are determined by METI.

Funding for decommissioning

A METI ordinance stipulates that the licensee of a nuclear facility must reserve a certain amount of money every financial year for funding its decommissioning. The total cost of decommissioning of a 1 100 MWe capacity LWR plant was estimated in 1984 to be about 30 billion yen. The regulatory authorities made this estimate on the basis of a standard decommissioning process. They ensure the adequacy of the reserved amount by financial audit and review of accounting report submitted by the licensee.

Public information

For more information, the websites of the relevant authorities and organisations are listed below.

Government

Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Tokyo
Website: http://www.mext.go.jp/

Ministry of Economy, Trade and Industry (METI)
Tokyo
Website: http://www.meti.go.jp/
E-mail: webmaster@meti.go.jp

Atomic Energy Commission (AEC)
Tokyo
Website: http://aec.jst.go.jp/

Nuclear Safety Commission of Japan (NSC)
Tokyo
Website: http://www.nsc.go.jp

Research

Japan Atomic Energy Research Institute (JAERI)
Kashiwa-shi, Chiba-ken
Website: http://www.jaeri.go.jp/
E-mail: www-admin@www.jaeri.go.jp

Japan Nuclear Cycle Development Institute (JNC)
Tokai-mura, Naka-gun, Ibaraki-ken
Website: http://www.jnc.go.jp/
E-mail: www-admin@jnc.go.jp

Central Research Institute of the Electric Power Industry (CRIEPI)
Tokyo
Website: http://criepi.denken.or.jp/index-j.html
E-mail: www-pc-ml@criepi.denken.or.jp

Industry

Nuclear Waste Management Organisation of Japan (NUMO)
Tokyo
Website: http://www.numo.or.jp/
E-mail: webmaster@numo.or.jp

Japan Nuclear Fuel Limited (JNFL)
Aomori-ken, Aomori-shi
Website: http://www.jnfl.co.jp/
E-mail: pr@jnfl.co.jp

For further information, please contact:

OECD Nuclear Energy Agency
12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
Tel.: +33 (01) 45 24 10 15,
Fax: +33 (01) 45 24 11 10, Internet: www.nea.fr

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Korea

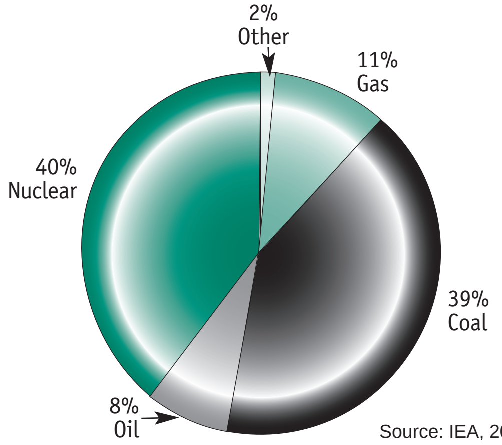
National nuclear energy context

Commercial utilisation of nuclear power in Korea started in 1978 and by 2002 there were 18 nuclear power units connected to the electricity grid. In 2002 they generated 107.4 TWh of electricity, 38.7% of the total electricity generated in that year.

Also in 2002, the capacities for nuclear fuel fabrication were 400 tonnes heavy metal per year (HM/year) of uranium fuel for heavy water reactors and 400 tonnes HM/year of uranium fuel for pressurised water reactors. Spent fuel storage capacity was 9 803 tonnes HM, and the amount of spent fuel arising in 2002 was 579 tonnes HM.

Two more nuclear power units have been completed since that time. According to the 5th Long-term Electricity Expansion Plan, as revised in January 2000, a further eight units will be added.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

Radioactive waste in Korea is classified by way of two categories. One is the high-level radioactive waste (HLW) arising from nuclear power generation and the other is the low- and intermediate-level radioactive waste (LILW) arising from nuclear power generation and also from the use of radioisotopes in medical research and industrial applications.

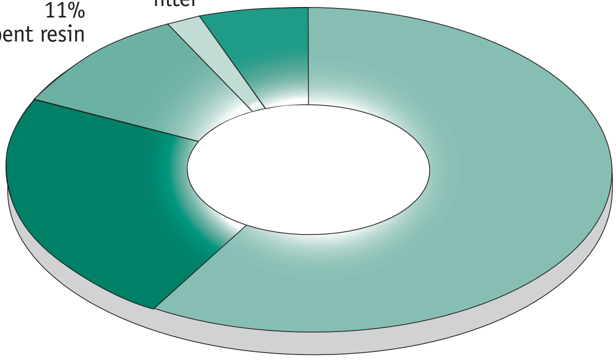
HLW is defined as radioactive waste with a specific activity greater than 4 000 Bq/g of alpha-emitting radionuclides with a half-life of more than 20 years, and a heat-generating capacity of more than 2 kW/m^3. In Korea, HLW consists only of spent nuclear fuel. From 2005, the annual rate of arising of spent nuclear fuel will be about 381 tonnes HM from 4 CANDU reactors and 215 tonnes HM from 16 PWR reactors, including those currently under construction. A total of 5 985 tonnes HM of spent nuclear fuel is currently stored at the four nuclear power plants sites, either in spent fuel pools or in dry storage facilities. This amount is expected to increase to about 9 800 tonnes HM by 2010, more than half of which will be spent fuel from the CANDU reactors.

LILW from reactor operations consists of dry, active waste, solidified liquid waste, spent resin and spent filters. A total of 3 492 drums of this waste was generated in 2002 by the current 18 operating nuclear power plants. At the end of 2002, a total of 79 849 drums of LILW was in store at the four nuclear power plant sites. The total on-site storage capacity for about 99 900 drums is sufficient to meet requirements until 2010.

A considerable amount of LILW is also generated from radioisotope use in hospitals, industry and other institutions, and from nuclear fuel manufacturing and R&D activity. This waste is collected and stored in a facility at the Nuclear Environment Technology Institute (NETEC) of Korea Hydro & Nuclear Power Co., Ltd. (KHNP). In 2002, a total of 235 drums was collected and transported to the NETEC facility. At the end of 2002, a cumulative total of 4 712 drums of LILW was in store at the NETEC facility. Although the volume of waste arising from radioisotope use is still relatively small compared to the power reactor waste volume, the annual generation rate is expected to rise rapidly as the industrial use of radioisotopes increases.

The percentage breakdown of LILW, by type and volume, is shown in the figure below.

Types and percentage share of LILW (by volume)



Radioactive waste management policies and programmes

Waste management policies

The safe management of radioactive waste is recognised as an essential element of the sustainable generation of nuclear power and energy self-sufficiency in Korea. In this context, a candidate site for a radioactive waste disposal repository has been sought for the past two decades. Because of the lack of success, the Korean Atomic Energy Committee (AEC) decided, in June 1996, to create an organisation dedicated to this purpose. This organisation is the Nuclear Environment Technology Institute (NETEC), originally created as a special body within the Korea Electric Power Corporation (KEPCO), which was responsible for radioactive waste management under the control of the Ministry of Commerce, Industry and Energy (MOCIE). Since April 2001, however, responsibility for nuclear power business has been transferred from KEPCO to a new company, Korea Hydro & Nuclear Power Co., Ltd. (KHNP) and NETEC is now part of KHNP.

In 1997, NETEC carried out a study of Korean radioactive waste management policy and submitted its results to government. In September 1998, a new national program for radioactive waste management policy, based on these results, was approved by AEC, which is responsible for determining policy on atomic energy matters in Korea. The fundamental principles of this new national policy are as follows:

- Direct control by government.
- Top priority to be given to safety.
- Minimisation of waste generation.
- Application of the "polluter pays" principle.
- Transparency of the disposal repository siting process.

The implementation plans are as follows:

Management of LILW and spent fuel

- LILW generation should be minimized and it should be managed at nuclear reactor sites until the opening of a waste disposal repository.
- Spent fuel should be stored at reactor sites until 2016, with expansion of on-site storage capacity.

Construction plan for a national radioactive waste management complex

- An LILW repository will operate from 2008. The repository capacity will be 100 000 drums at the first stage and will be increased gradually to 800 000 drums. The type of disposal facility, e.g. rock cavern or near-surface vault, will depend upon the nature of the site.
- A centralised, interim storage facility for spent fuel will be built by 2016. Storage capacity will be 2 000 tonnes HM at the first stage, and increased eventually to 20 000 tonnes HM. The type of store, e.g. dry or wet, will be decided in due course.

The Korea Atomic Energy Research Institute (KAERI) and KHNP carry out R&D on radioactive waste management. The treatment and disposal of HLW / spent fuel is studied by KAERI. KHNP studies the treatment and disposal of LILW and interim storage of spent fuel. Work is currently focused on the following topics:

- Waste treatment and volume reduction technology.
- Low-level waste vitrification technology.
- LILW disposal and safety assessment technology.
- Improvement of existing technology for spent fuel storage and transportation, and development of advanced spent fuel storage technology.

Programmes and projects

LILW management

In addition to current use of conventional treatment methods such as evaporation, compaction, drying, cementation, etc., advanced technology for LILW treatment is being developed. The process of vitrification has been identified as the most promising innovative technology from the point of view of being environmentally sound and of being able to reduce substantially the volume of LILW, to improve the waste stability and to enhanced the public acceptance of its disposal. Vitrification immobilises the radionuclides in a very stable glass form and the associated volume reduction should result in efficient and prolonged use of a repository, which is most important for a small, highly populated country.

A feasibility study of the vitrification process was initiated in 1994 and a pilot-scale vitrification facility was installed in July 1999. This facility consists of an induction-heated, cold-crucible melter (CCM) for combustible waste, a plasma torch melter (PTM) for non-combustible waste, and an off-gas treatment system. NETEC has been developing the technology with a target for commercialisation of the process from 2005.

Site selection for LILW repository and AFR storage of spent fuel

Since 1986, a great deal of effort has been exerted to secure a site for an LILW repository and an Away From Reactor (AFR) storage facility for spent nuclear fuel. In 2000 the government first instigated with local communities an open solicitation system to find a repository site. In February 2004 a modified system was launched, which included preliminary site characterisation and addressed possible environmental impacts. These studies incorporated dialogue with all interested parties, thereby earning community trust. A Site Review Committee composed of members from government, research institutes, nongovernmental social groups, and universities will make the final selection.

The site eventually selected will then be supported financially in accordance with the financial support programme, as amended in December 2000. About 300 billion won (€ 240 million) are to be provided for the duration of disposal facility construction and for an operational period of about 30 years. This sum is equivalent to the financial support given to a community with 4 nuclear power units, and the Head of the local government will be given authority for allocation of most of the fund. The financial support programme consists of a special support programme and a basic support programme. The special support programme will apply to the local county in which the site is located, and the basic support programme will cover the surrounding local counties within a 5 km radius of the facility, in order to ensure an administratively reasonable distribution of the fund.

Bird's eye view of the radioactive waste management facility to be operated by KHNP.

View of glass being drained from the bottom of a cold-crucible melter installed in NETEC for the development of low-level waste vitrification technology.

View of KN-12 transportation cask developed by NETEC.

Research and development

R&D programme for HLW disposal

The current 10-year plan for medium- and long-term nuclear R&D was accepted by the AEC in 1997. This plan includes a programme for development of a Korean repository concept for HLW disposal, and for the associated system performance assessment. The programme consists of three stages:

Stage 1: from 1997 to 2000, was to set up methodologies for developing the disposal concept and for assessing the performance of the proposed repository concept.

Stage 2: from 2000 to 2003, focused on further development of the reference disposal concept. A tool for radiological safety assessment of the proposed system (MASCOT-K) was developed and verified at this stage.

Stage 3: from 2003 to 2006, involves finalising the Korean repository concept for HLW disposal. The System Performance Assessment (TSPA) will then be carried out on the finalised concept. It is also planned, during this stage, to validate the reference disposal concept by way of small-scale, in-situ excavation studies carried out underground.

When complete, the combined research output of this 10-year study will be submitted to the Korean government in order to guide its development of a national policy for HLW disposal. It is expected that this policy will define the direction and prioritisation of further R&D activities.

Decommissioning and dismantling policies and projects

D&D of the TRIGA Mark-II and III research reactors

Decommissioning and dismantling (D&D) of the TRIGA Mark-II and III research reactors was started in January 1997 and will be completed in December 2008, when the LILW disposal repository will be operational. The decommissioning plan, environmental impact assessment and decommissioning design were carried out 1998. In July 1998, all of the spent fuel from the TRIGA Mark-II and III reactors was safely transported to the United States.

At the end of 1998, the decommissioning plan was submitted to the Ministry of Science and Technology (MOST) for licensing, and the Korea Institute of Nuclear Safety (KINS) reviewed it in 1999. The report of their review was considered in January 2000 by the Expert Group for environmental radiation, one of four sub-groups of the Nuclear Safety Commission, and the recommendation made by that Expert Group will be submitted to the Commission for its final approval. Dismantling will begin when the license is issued and will continue to 2006 or 2007.

Simultaneously, R&D in this field will be carried out for the future D&D of other nuclear facilities, including nuclear power plants.

Transport

Transport of radioactive materials is regulated by way of the *Atomic Energy Act* and its associated Enforcement Decree and Enforcement Regulations. The requirements are specified in the MOST Notice entitled “Regulations on the Packaging and Transport of Radioactive Materials” and in “Technical Standards of Radiation Safety Management”. These domestic regulations are based on “Regulations for the Safe Transport of Radioactive Materials”, published by the International Atomic Energy Agency and given effect by the *Atomic Energy Act*. The MOST Notices also include regulations for inspection of transport containers during manufacture and in service.

Those waste generators outside the nuclear power industry, who are mainly users of radioisotopes, are required to meet the costs of transporting their own waste. Radioisotope users may send spent sealed sources directly to the Nuclear Environment Technology Institute (NETEC), or get NETEC to undertake the transportation for them. For unsealed sources, however, the Korea Radioisotope Association (KRIA) collects the wastes for transport to NETEC. In general, radioisotope wastes are transported by road.

LILW from nuclear power plants is currently stored at the sites where they arise. When the disposal facility is available, however, it is expected that transport of this waste to the repository will be by sea.

Some shipments of spent fuel from reactor sites have been carried out for R&D and inspection purposes. These shipments used a cask (KSC-1) developed by KAERI. A large amount of spent fuel is moved between reactors on the same nuclear site because of lack of storage capacity in some older reactors, and the frequency of this is expected to increase in future. Up to 2001, KHNP used another cask (KSC-4) developed by KAERI for the movement of spent fuel on the Kori site. In order to improve the transport efficiency, however, KHNP has developed a new cask (KN-12) and related transportation system. The performance of this system has been demonstrated successfully by way of a series of transport operations since 2002.

Competent authorities

The Atomic Energy Committee (AEC) is the highest policy-making body on nuclear matters in Korea. The Deputy Prime Minister is the chairman of the AEC. Members include ministers, and distinguished scholars and experts.

The Ministry of Science and Technology (MOST) is responsible for issue of permits for construction and operation of nuclear facilities and for implementation of the safety regulations covering spent fuel and radioactive waste management facilities, and nuclear R&D.

The Nuclear Safety Commission (NSC) is established under the jurisdiction of the MOST in order to deliberate and decide important matters on nuclear safety, pursuant to the *Atomic Energy Act*.

The Korea Institute of Nuclear Safety (KINS) is a group of experts who perform regulatory inspections, review licenses and make recommendations to MOST on the nuclear safety matters.

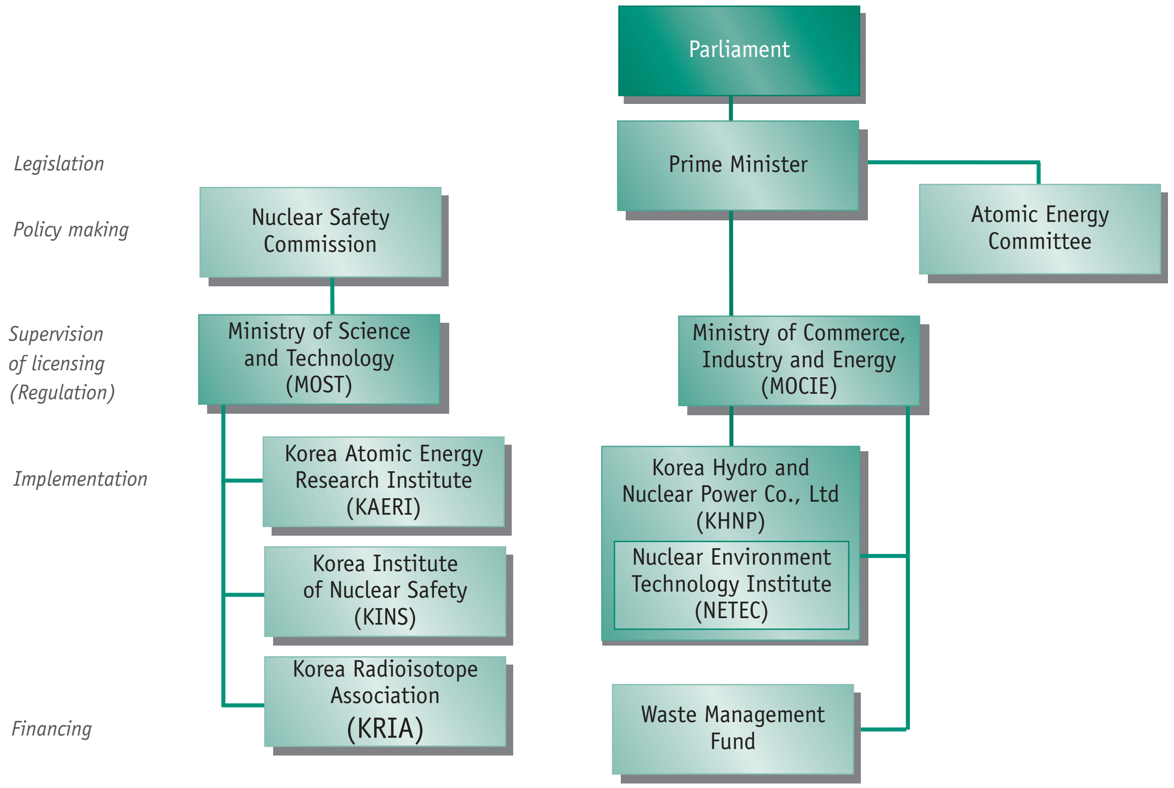
The Ministry of Commerce, Industry and Energy (MOCIE) establishes and implements the electric power development plan, and supervises the general aspects of nuclear power plants. The MOCIE is responsible for formulating policy, and implementing associated measures, for spent fuel and radioactive waste management, excluding spent fuel treatment and disposal. It is also responsible for designating a radioactive waste management disposal undertaker.

The Korea Hydro and Nuclear Power Co., Ltd (KHNP), the electricity utility, is responsible for safe and economic construction and operation of nuclear power plants, and as radioactive waste disposal undertaker, for the conduct of radioactive waste management business and related R&D. The Nuclear Environment Technology Institute (NETEC) is a special body within KHNP.

The Korea Atomic Energy Research Institute (KAERI), a national institute for nuclear research, carries out projects for the treatment and disposal of high-level radioactive waste.

The Korea Radioisotope Association (KRIA) is in charge of import and export of radioisotopes and radiation generating devices, educating and training radiation workers, collecting and transporting of radioisotope waste to NETEC, and maintaining the national registry of occupational radiation exposures.

Main bodies involved in radioactive waste management in Korea



Financing

In 1985, the *Atomic Energy Act* was amended to establish a Radioactive Waste Management Fund. This was designed to secure financial resources for radioactive waste management projects based on the "polluter pays" principle. As a result, radioactive waste producers then became financially responsible for radioactive waste management.

After a series of organisational changes since then, the *Electric Business Act* was amended to secure the financial resources for radioactive waste management in light of these changes. The MOCIE entrusted the radioactive waste management business to NETEC, a special body that is part of KHNP. Any radioactive waste producers, except KHNP, must send their waste to NETEC, which then imposes a charge on the waste generator for classification, packaging, and disposal of the waste, based on its type and condition. The *Electric Business Act* requires KHNP to collect funds from the nuclear power plants for the management of their radioactive waste.

The Enforcement Regulations of that Act prescribe the details of charges to be made for financing the decommissioning of nuclear power plants and the disposal of LILW and spent fuel. The appropriate charge for each year is determined by applying an annual escalator to the costs for nuclear power plant decommissioning and for LILW and spent fuel disposal, as estimated in 1992. These costs have recently been re-estimated, and consequent amendment of the Enforcement Regulations is expected in near future.

Public information

For more information, the websites of the relevant authorities and organisations are listed below.

Government

Ministry of Commerce, Industry & Energy (MOCIE)
Website: www.mocie.go.kr
Ministry of Science and Technology (MOST)
Website: www.most.go.kr

Research

Korea Institute of Nuclear Safety (KINS)
Website: www.kins.re.kr
Korea Atomic Energy Research Institute (KAERI)
Website: www.kaeri.re.kr
Korea Electric Power Research Institute (KEPRI)
Website: http://www.kepri.re.kr/

Industry

Korea Hydro & Nuclear Power Co., LTD. (KHNP)
Website: www.khnp.co.kr
Nuclear Environment Technology Institute (NETEC)
Website: www.knetec.com
Korean Power Engineering Company (KOPEC)
Website: www.kopec.co.kr

Others

Korea Atomic Industry Forum
Website: www.kaif.or.kr
Korea Nuclear Energy Foundation
Website: www.knef.or.kr
Korea Radioisotope Association
Website: www.ri.or.kr
Korean Nuclear Society
Website: www.nucler.or.kr
The Korean Association for Radiation Protection
Website: www.karp.or.kr

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For further information, please contact:

OECD Nuclear Energy Agency
12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
Tel.: +33 (01) 45 24 10 15,
Fax: +33 (01) 45 24 11 10, Internet: www.nea.fr

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Radioactive waste management programmes
in OECD/NEA member countries

Mexico

National nuclear energy context

Commercial utilisation of nuclear power in Mexico started in 1990 and by 2002 there were two nuclear power units connected to the electricity grid. In 2002 they generated 9.7 TWh of electricity, 5.5% of the total electricity generated in that year.

Also in 2002, the spent fuel storage capacity was 984 tonnes heavy metal (HM), and the amount of spent fuel arising in that year was 20 tonnes HM.

The Energy Programme for 2001-2006, issued by the Federal Government in 2001, emphasises the use of nuclear power with high standards of safety and reliability consistent with the international standards of the industry. Also, it includes the analysis of the implications of introducing new, fourth generation reactor designs in the long term and, in particular, of reprocessing the spent nuclear fuel from the reactors in operation.

Under the Mexican Constitution, and associated *Nuclear Law*, nuclear energy can be used only for peaceful purposes. These purposes include the following activities:

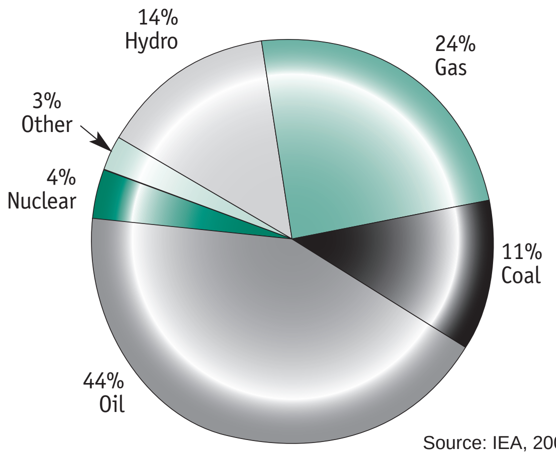
- Energy production and associated activities.
- Mining and milling of radioactive minerals.
- Nuclear fuel production and associated activities.
- Reprocessing nuclear fuel.
- Transport, storage and disposal of spent nuclear fuel and waste reprocessing.

The only body entitled to generate electricity from nuclear sources is the *Comisión Federal de Electricidad* (CFE) a government-owned electric utility. Public sector bodies, universities, institutes and research centres are entitled to use nuclear reactors only for non-energy purposes.

The National Energy Plan of 1990 called for an electricity production capacity from nuclear power on the order of 3.0 GWe and 6.9 GWe by 2010. However, due to changes in the national economic situation and public opinion, the future expansion of nuclear power in Mexico is now uncertain. The current production capacity from nuclear power is around 1.4 GWe and no new nuclear power facility is under construction or planned in the near future.

All exploration and mining activities associated with the nuclear fuel-cycle have been halted since the mid-1970s and there are no plans to restart them. A fuel-fabrication pilot plant at the National Institute for Nuclear Research (ININ) was in operation in the 1990's and produced four fuel assemblies for the Laguna Verde nuclear power plant (NPP), unit two. This facility is likely to be decommissioned due to economic reasons.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

Radioactive waste classification

Radioactive waste in Mexico is classified depending upon activity levels and the half-lives of the radionuclides present in the following categories:

- Low-level radioactive waste (LLW) (which is subdivided into classes A, B and C).
- Intermediate-level radioactive waste (ILW).
- High-level radioactive waste (HLW).
- Mixed waste.
- Uranium and thorium tailings.

The above classification takes into account the characteristics that can influence the waste disposal arrangements, as follows:

(i) Concentrations of long-lived radionuclides, and any short-lived precursors, that constitute a potential hazard for long times after institutional control, the waste form and storage methods are able to ensure safety.

(ii) Concentrations of short-lived radionuclides where requirements such as institutional control, waste form, and storage methods are effective for ensuring safety.

(iii) Mixtures of chemical, biological and radiological components that represent both toxic and radiological hazards to the population and the environment.

Description of classification

Subclasses A, B and C, are based on the activity concentrations and half-lives of the radionuclides present in the radioactive waste, in accordance with the Mexican Official Standard NOM-004-NUCL-1994 "Radioactive Waste Classification".

Low-level radioactive waste – class A

Radioactive waste that within a period of 100 years constitutes a level of risk that is acceptable for the population and environment. Engineered barriers are required to warrant its integrity for at least 100 years.

Low-level radioactive waste – class B

Radioactive waste that within a period of 300 years constitutes a level of risk that is acceptable for the population and environment. Engineered barriers and the waste matrix of the package are required to provide stability of the waste and warrant its integrity for at least 300 years.

Low-level radioactive waste – class C

Radioactive waste that within a period of 500 years constitutes a level of risk that is acceptable for the population and environment. Engineered barriers are required to warrant their integrity for at least 500 and the waste matrix or the package that provide stability are required to warrant their integrity for at least 300 years.

Intermediate-level radioactive waste

Radioactive waste whose risk remains above acceptable levels for more than 500 years, so that a geological repository constitutes the disposal option.

High-level radioactive waste

This waste is classified according to its origin, and includes those radioactive wastes arising from reprocessing of spent nuclear fuel, and the spent nuclear fuel itself once it is declared as waste. A geological repository constitutes the disposal option.

Mixed radioactive waste

Radioactive waste that contains radioactive material and other hazardous materials.

Uranium and thorium tailings

Radioactive waste arising from ore-processing in a mill to extract the metal content.

Quantities of waste

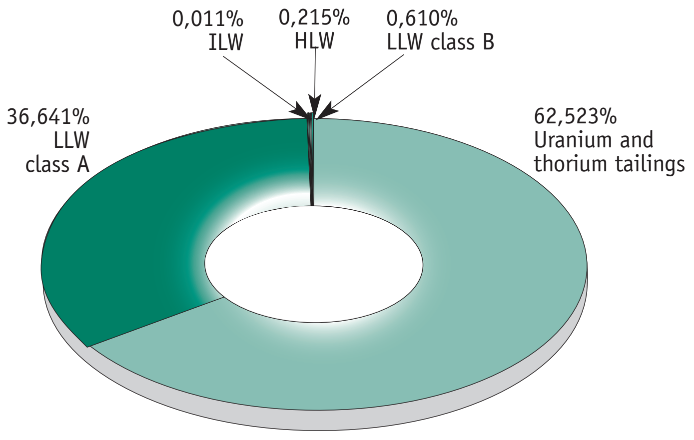
The radioactive waste produced up to April 2003, and the breakdown by waste category, are shown respectively in the following table and the figure below.

Mexico's accumulated radioactive waste

Waste type		Total quantities as of April 2003 (in m^3)
LLW	– class A	23 808 *
	– class B	396
	– class C	0
ILW		7
HLW		140
Mixed waste		0
Uranium and thorium tailings		40 625 **

* Includes radioactive waste disposed in La Piedrera disposal facility (20 858 m^3) and radioactive waste stored in LV NPP (2 913.07 m^3) site and the radioactive waste storage centre (CADER) (37.4 m^3).
** Radioactive waste disposal in Peña Blanca disposal facility.

Distribution of accumulated radioactive waste inventory



Nuclear power plants

The total amount of waste arising from the operation of the Laguna Verde NPP as of April 2003 comprised 2 913 m^3 of LLW, 7 m^3 of ILW and 140 m^3 of HLW (spent fuel). The annual average production is approximately 369 drums (200 litre) and 15 high-integrity containers of LLW, and an average of 100 spent fuel assemblies from each refuelling.

Fuel cycle

A uranium-milling experimental plant, located in Villa Aldama, Chihuahua and already decommissioned, was in operation at the end of the 1960s. Approximately 65 000 tonnes (40 625 m^3) of uranium tailings were generated, and were disposed in Peña Blanca, Chihuahua. This disposal facility is currently closed.

The fuel-fabrication pilot plant at ININ generated during its period of operation approximately 4 m^3 of LLW.

Hospitals, industry and research

90% of solid radioactive waste generated from sources other than nuclear power production comes from research activities and 10% from medical applications. The same percentages apply to the generation of liquid radioactive wastes. Moreover, 95% of discarded or spent radioactive sources arise from industrial applications, and 5% from medicine and research.

Radioactive waste management policies and programmes

Waste management policies

Small amounts of radioactive waste are generated from nuclear activities other than nuclear power. These wastes constitute approximately 5% of the total national waste generation and there are no plans to expand these nuclear activities in the short term.

Currently, radioactive waste is temporarily stored in authorised facilities. There are neither arrangements for its disposal nor any decommissioning plan of nuclear facilities. Studies are underway to assess the techniques for waste volume reduction. Also, different designs for disposal facilities are being evaluated together with preliminary studies of disposal sites and investigation of associated social, political and economic factors.

An interim solution for the spent nuclear fuel, considering the current situation of Mexico's nuclear programme, was to modify the current spent fuel pool design in order to provide sufficient storage capacity for the operating lifetime of the reactors, until a decision on the future of the nuclear programme was reached.

The spent fuel arising from the operation of the Triga Mark III research reactor is being stored in the reactor pool.

Programmes and projects

Overview of the conditioning, storage and final disposal programme

Radioactive wastes arising from medical, industrial and research activities are treated and conditioned at the ININ radioactive waste treatment facility using compaction and spent source immobilisation techniques, and stored temporarily at the radioactive waste storage centre (CADER) also operated by the ININ.

The Laguna Verde NPP classifies its radioactive wastes as dry wastes (paper, clothes, gloves, etc.) and solidified wastes (sludges, spent resins, etc.). Dry wastes are treated, compacted and placed in drums (200 litres). The other wastes are solidified in a cement or bitumen matrix, except the resins which are stored without any treatment in high integrity containers. These wastes are temporarily stored at the plant, under CFE control, in specially prepared areas in two storage facilities, one for dry wastes and the other for solidified radioactive wastes and high integrity containers. As mentioned spent fuel is temporarily stored in the pools inside each of the two reactor buildings.

Existing plants and storage and disposal sites

The ININ radioactive waste treatment facility is designed to process annually 200 m^3 of solid wastes and 200 m^3 of liquid wastes, by a precipitation process. It can also deal with 240 m^3 per year of waste by way of dilution and decay, and with immobilisation of 300 spent radioactive sources.

The CADER is composed of three buildings for interim waste storage. The first with a capacity of 3 664 drums (200 litres) is 75.4% full and the second is used only for storage of spent radioactive sources. The third with capacity for 1 046 drums (200 litres) is 91.6% full. There are also 1 418 m^3 of radioactive wastes in trenches at this facility, which come from past activities, including the decommissioning of some pilot fuel-cycle plants. These wastes will be recovered for disposal when a disposal site is eventually selected.

The Laguna Verde NPP has two interim storage facilities, one for dry wastes with a capacity of 9 424 drums (200 litres) DDRSS, and another, ATS, for solidified and wet wastes with a capacity of 4 452 drums and 300 high integrity containers. By

April 2003, the DDRSS and the ATS were at 71.4% and 55.7% of their respective capacities. The annual average rate of radioactive waste generation is 370 drums of dry wastes and 15 high integrity containers for wet wastes (the solidification process was suspended in 2001). The remaining capacity of the DDRSS is about 2 300 drums. At the current rate of waste generation it is estimated that the ATS will be full in five years, the construction of a new ATS storage module and the introduction of supercompaction for dry wastes are being considered as future options.

The LLW from activities other than power production may be disposed in the same facility as that intended for radioactive waste produced by the Laguna Verde NPP.


Laguna Verde NPP, units 1 and 2. PCFE, Mexico.

Research and development

Future development of technological concepts

The ININ is studying the migration, dispersion and leaching techniques, the treatment of radioactive wastes by incineration, as well as the treatment of organic radioactive wastes. To date there are no research or studies underway in Mexico for the development of new technology for the treatment of wastes.

Decommissioning and dismantling policies and projects

The National Commission for Nuclear Safety and Safeguards (CNSNS), as the regulatory body, requires the licensee of the Laguna Verde NPP (CFE) to establish and follow a strategy for the decommissioning of both units of the plant at the end of their operating life. This should provide enough financial resources for decommissioning, therefore CFE has established a policy of funding. The licensee has selected the option of deferred dismantling with interim safe storage of the shutdown plant, the so-called SAFSTOR option, as the most suitable for decommissioning the plant. The CFE policy requires a review of the funds at least once every five years, in order to assure that they will be sufficient for their purpose.

As part of the licence renewal process for the TRIGA Mark III research reactor, the CNSNS requires enough financial resources for decommissioning the facility to be available five years before the end of its operating life.

Transport

Mexico has adopted the International Atomic Energy Agency recommendations on "Regulations for the Safe Transport of Radioactive Material", as amended in 1990.

The transport of radioactive waste in Mexico is mainly carried to convey the waste from industry, medicine and research to the ININ radioactive waste treatment facility, where it is processed and conditioned before being stored in the CADER. Up to date, no radioactive waste from the Laguna Verde NPP has been moved off-site.

The ININ is responsible for this transport. It is carried out by road, in special vehicles, in compliance with the above-mentioned regulations. 97 m^3 of radioactive wastes are transported annually along with 95 conditioned spent radioactive sources.

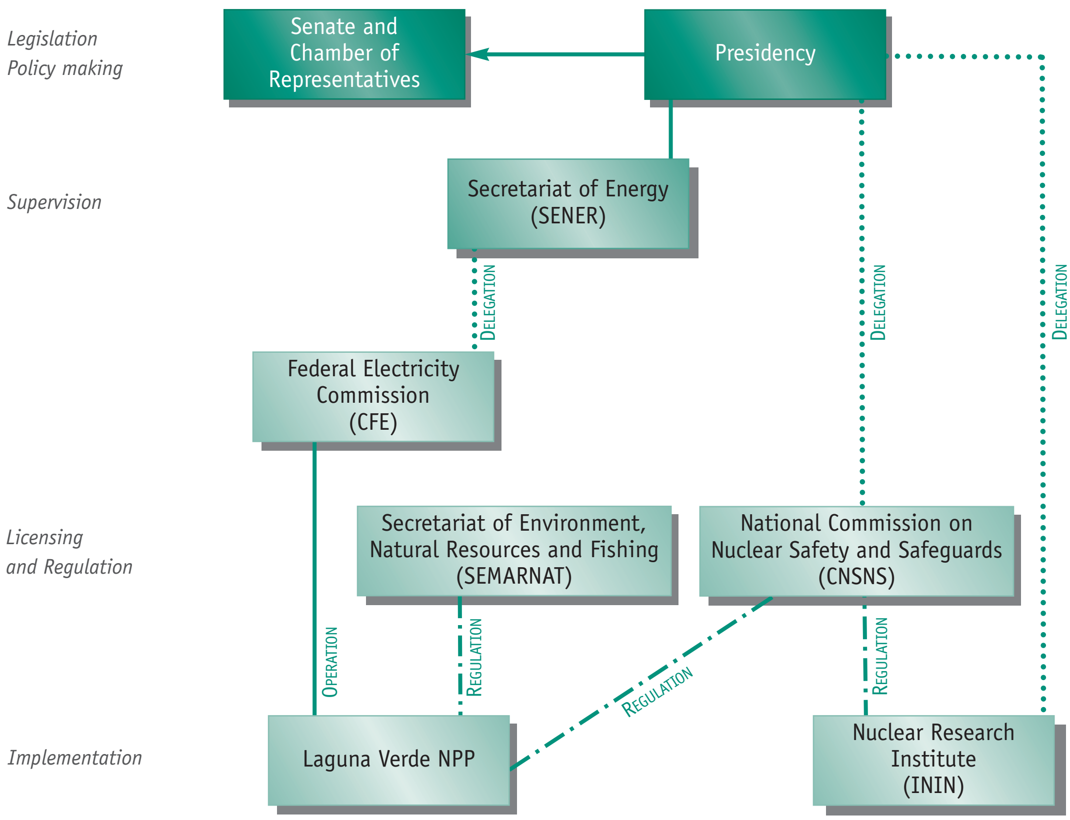
Competent authorities

The Secretariat of Energy (SENER) is responsible for the storage, transport and disposal of nuclear fuels and radioactive wastes, regardless of their origin. These responsibilities have been delegated to the CFE, in the case of the radioactive wastes from the NPP operation, and to the ININ, in the case of the radioactive waste from other sources. Depending upon future policy developments, these responsibilities could be transferred to other private or public bodies.

In any case, the National Commission for Nuclear Safety and Safeguards (CNSNS) will keep its current responsibility for licensing current and future installations, and for carrying out inspections and audits. CNSNS is also empowered to take any measures necessary to verify compliance with the regulations in force.

The Secretariat of the Environment and Natural Resources (SEMARNAT) is responsible for regulating the non-radiological environmental aspects of waste management.

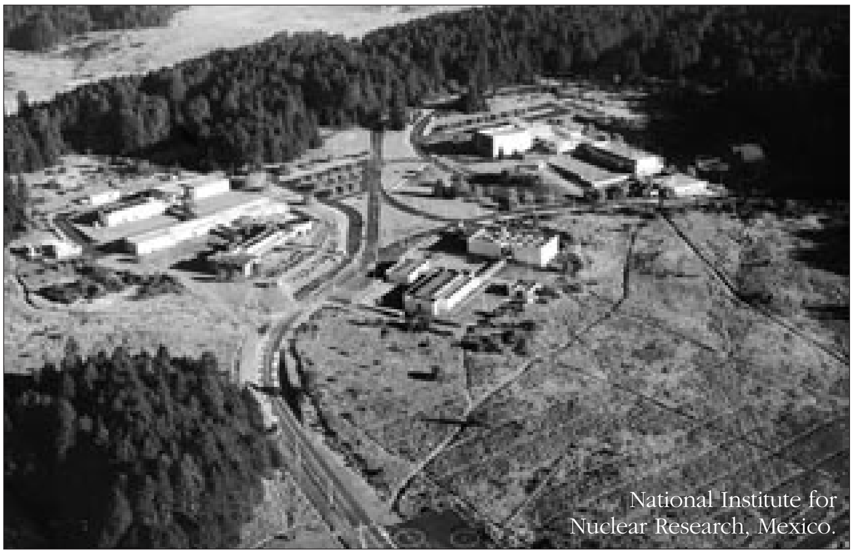
Main bodies involved in radioactive waste management in Mexico



Financing

The CFE is responsible for financing the management of radioactive waste from NPP operations. The industry, medicine and research, for treatment, conditioning, and provisional storage of the radioactive waste generated should pay a fee, established by the ININ. However, the adequate fee has not been established yet within the framework of the radioactive waste management programme to be defined so, for the time being, the government provides funding.

Several spent fuel disposal options are being studied, and funds are kept in order to provide the necessary resources. Financing of this fund is assured by means of a levy on electricity sales.


National Institute for Nuclear Research, Mexico.

Public information

For more information and contact, the relevant authorities and organisations are listed below.

Government

National Commission for Nuclear Safety and Safeguards
Dr. Barragán 779
Col Narvarte
03020 México D. F.
Website: www.cnsns.gob.mx

The competent body authorised to inform the public about activities related to radioactive waste is:
Social Communication Unit
Secretariat of Energy
Av. Insurgentes Sur No. 552 1er piso
Col. Roma Sur
O6769, México D.F.
Responsible: Lic. Cybele Díaz
E-mail: Cybele.Diaz.Energia@rtm.net.mex
Visitor centre

Research

National Institute for Nuclear Research
Km. 36.5 Carretera México-Toluca
Ocoyoacac
52045 Estado de México
Website: www.inin.mx

Industry

Laguna Verde nuclear power plant has an information centre for visitors. Through this centre the utility provides information to the public regarding nuclear energy and LVNPP.
Laguna Verde Nuclear Power Plant
Km. 44.5 Carretera Cardel-Nautla
Laguna Verde, Veracruz
C.P. 91476, México
Website: www.cfe.gob.mx

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

For further information, please contact:

OECD Nuclear Energy Agency
12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
Tel.: +33 (01) 45 24 10 15,
Fax: +33 (01) 45 24 11 10, Internet: www.nea.fr

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Netherlands

National nuclear energy context

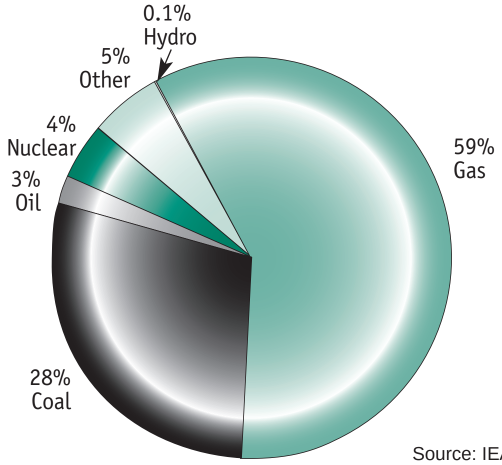
Commercial utilisation of nuclear power in the Netherlands started in 1969 and by 2002 there was one nuclear power unit connected to the electricity grid. In 2002 it generated 3.7 TWh of electricity, 4.2% of the total electricity generated in that year.

Also in 2002, the spent fuel storage capacity was 73 tonnes heavy metal (HM), and the amount of spent fuel arising in that year was 12 tonnes HM.

The Dodewaard NPP was shut down in 1997 and is now in the decommissioning phase. All spent fuel has been removed from the plant and transferred to Sellafield, in the United Kingdom, for reprocessing. The last shipment of spent fuel from Dodewaard was made in April 2003. The Dodewaard NPP will be brought into a state of safe enclosure in the next two years. Actual dismantling of the NPP will occur only after a period of 40 years. The envisaged end-point for this site is a green field condition.

The Borssele NPP was originally planned to shut down at the end of 2003 but, following an agreement between the parties forming the new government, it will now remain in operation until 2013, the end of its 40-year design-life.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

In the Netherlands, radioactive wastes are generated by way of nuclear power production and by the use of radioactive materials in medical, research and industrial applications. Those wastes containing low or medium levels of activity consisting mainly of short-lived radionuclides are categorised as low- and intermediate-level radioactive waste (LILW). Other wastes containing higher levels of activity and those containing long-lived radionuclides are categorised as high-level waste (HLW).

Nuclear power plants

The LILW from nuclear power plants consists of disposable protective clothing, plastics, paper, metals, filters and resins. Resins are conditioned with cement at the power plant to create a stable product, while all other waste is treated and conditioned at the central treatment and storage facility of the Central Organisation for Radioactive Waste (COVRA), located in Borssele. Some 100 m^3 of conditioned LILW is generated annually, mainly at the Borssele NPP. Removal of activated components from the Dodewaard NPP currently contributes a small amount to the annual arisings of LILW, but this will stop in near future. Over a period of 100 years, the cumulative amount of LILW, including institutional waste, will be about 188 000 m^3.

High-level waste (HLW) arises mainly from reprocessing of spent fuel, and about 10 m^3 is produced annually. Over the same period of 100 years, the cumulative amount of HLW, including decommissioning waste, will be about 3 040 m^3. A breakdown of the cumulative amounts of HLW by origin is represented in the table below.

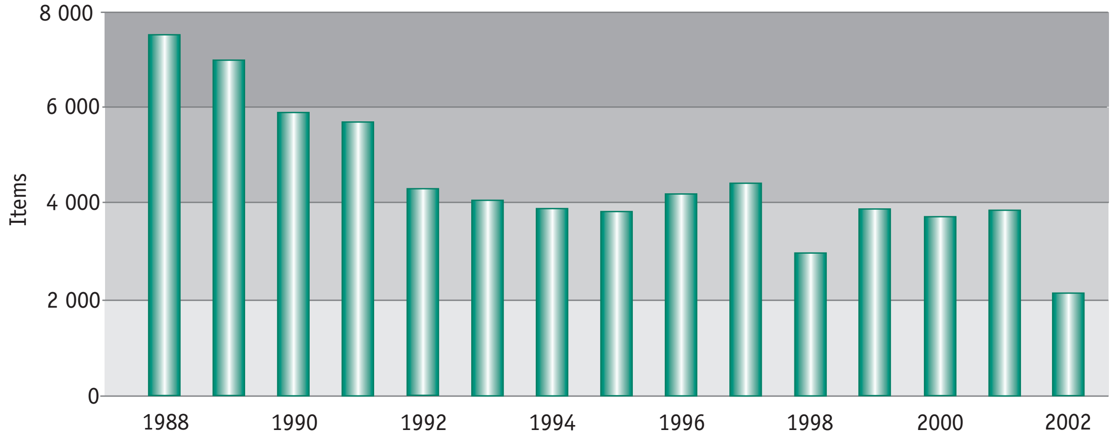
Netherlands' radioactive waste

Type of HLW by origin		Volume (in m^3)
Heat-generating waste	Fuel elements and fissile residues	40
	Vitrified HLW	70
Non heat-generating waste	Decommissioning waste	2 000
	Reprocessing waste	810
	Other high activity waste	120

Hospitals, research and industry

The LILW arising from the use of radioactive materials in hospitals, research institutions and industry is highly varied. It includes liquids and solid materials such as paper, plastics, metals and glass, but also consists of animal carcasses, laboratory tools or equipment and sealed radioactive sources. All these forms of waste are treated and conditioned at the COVRA central treatment and storage facility. About 100 m^3 of such conditioned waste is produced annually.

Annual arisings of LILW from hospitals, etc.



TENORM

In addition to the waste described above, relatively large volumes of very low-level radioactive waste is produced during the processing of some metal ores. This waste contains naturally occurring radionuclides whose concentrations have been enhanced by the technical operations involved. Hence it is described as Technically Enhanced Naturally Occurring Radioactive Material (TENORM) waste. This waste is usually generated in the form of a relatively stable product, such as a slag or calcine, for which no further conditioning is needed. The annual production of such waste is about 1 000 m^3.

Radioactive waste management policies and programmes

Waste management policies

The Dutch policy on radioactive waste management is based a report that was presented to parliament by the government in 1984. This report covered two areas. The first concerned the long-term interim storage of all radioactive wastes generated in the Netherlands, and the second concerned the government research strategy for eventual disposal of these wastes.

Consideration of this report led, in regard to the first area, to establishment of the Central Organisation for Radioactive Waste (COVRA) in Borssele, and in regard to the second, to establishment of a research programme on disposal of radioactive waste. Pending the outcome of research into disposal, and assurance of political and public acceptance, it was decided to construct an engineered surface-storage facility with sufficient capacity for all the radioactive wastes generated in a period of at least 100 years.

The radioactive waste disposal research programme was completed in 1993, and concluded that there are no safety-related factors that would prevent the deep underground disposal of radioactive waste in salt. However, the level of public acceptance of underground waste disposal remained low. Progress of the disposal programme was stalled by lack of approval for site investigations in salt formations considered suitable for this purpose and, hence, the prospect of a waste disposal facility being available within a few decades is remote.

Programmes and projects

Current radioactive waste management policy

In 1993 the government adopted, and presented to parliament, a position paper on the long-term underground disposal of radioactive and other highly toxic wastes. This forms the basis for further development of a national radioactive waste management policy, which now requires that any underground disposal facility be designed in such a way that each step of the process is reversible. This means that retrieval of waste, if deemed necessary for whatever reason, would always be possible.

The reasons for introducing this concept of retrievability came from considerations of sustainable development. Waste is considered a non-sustainable commodity whose generation should be prevented. If prevention is not possible, the preferred option is to reuse and/or recycle it. If this in turn is not practical at present, disposal of the waste in a retrievable way will enable future generations to make their own decisions about its eventual management. This could include the application of more sustainable management options if such technologies become available. The retrievable emplacement of the waste deep underground would ensure a fail-safe situation in case of neglect or social disruption.

Although waste retrievability allows future generations to make their own choices, it is dependent upon the technical ability and preparedness of society to keep the facility accessible for inspection and monitoring over a long period. It also entails a greater risk of exposure to radiation and requires long-term arrangements for maintenance, data-management, monitoring and supervision. Furthermore, provision of retrievability in disposal deep underground is likely to make the construction and operation more complex and costly.

Thus there may be some conflict between the requirement for retrievability and the technical requirements for safe closure of a disposal facility. In practice the feasibility of keeping a geological repository accessible for retrieval purposes is restricted to a maximum of about two hundred years, depending on the type of host rock. Borehole convergence due to plastic deformation of the host rock is negligible in granite, but repositories in salt and clay without any supportive measures in the galleries, tend to close around the emplaced waste. In safety studies, this plastic behaviour and consequent convergence of salt and clay have been considered a positive asset because of enhanced containment and heat dissipation in the repository. In the Netherlands, only salt and clay are available as possible host rocks for an underground disposal facility so practical considerations indicate that the retrieval period should be limited to a realistic length of time. A progressive, step-wise procedure for repository closure is considered the most likely approach to reconciling the two objectives of retrievability and safety.

Spent fuel

The Dodewaard and Borssele NPPs have entered into contracts with BNFL, in the United Kingdom, and Cogema, in France, respectively, for reprocessing the spent fuel from their reactor operations. The HLW arising from reprocessing will be returned to the Netherlands. Since the Netherlands will be unable to dispose of this HLW for the next few decades, an engineered HLW storage facility, HABOG, is being built at the COVRA site. It is planned also to store spent fuel from the research reactors in Petten and Delft in the HABOG facility.

Details of the COVRA treatment and storage facility

COVRA operates a centralised facility for management of LILW at Borssele. This facility was built between 1990 and 1992 and includes the following:

- an office building, including an exhibition centre;
- a building for the treatment of LILW;
- storage buildings for conditioned LILW;
- a building for storage of wastes from ore-processing industries, i.e. TENORM waste;
- a storage building for depleted uranium oxide, (to be completed).

The building for treatment of LILW has buffer-storage areas for the different kinds of waste, and various treatment installations. The treatment installations became operational in 1993, and currently comprise the following:

- super-compactor;
- separator for organic/inorganic liquids;
- dedicated incinerator for biological wastes;
- dedicated incinerator for organic liquids;
- shearing and cutting installation;
- cementation station;
- wastewater treatment system.

The HABOG storage facility mentioned above was commissioned at the end of 2003. It is a vault-type facility with two separate compartments. One compartment is for storage of drums and other packages containing cemented or bituminised fuel element cladding and other HLW. The other compartment is for storage of the heat-generating, vitrified HLW from reprocessing of spent fuel from the NPPs, and of unreprocessed spent fuel from the research reactors. Waste in the first compartment does not require additional cooling, but that in the second compartment does. The vitrified HLW and spent fuel are stacked on five levels in vertical, air-cooled storage wells. The storage wells are filled with an inert gas to prevent corrosion of the canisters and are equipped with a double jacket. Cooling air flows under natural convection between the walls of the double jacket, thus avoiding direct contact of the cooling air with spent fuel or vitrified HLW canisters.

The HABOG interim storage facility. COVRA, Netherlands.

Research and development

CORA research programme

A national research programme on retrievable disposal of radioactive waste, carried out under the scientific supervision of the Committee on Radioactive Waste Disposal (CORA), was concluded in 2001. The primary objective of the CORA research programme was study of the feasibility of retrievable disposal in salt and clay formations, and long-term storage.

The main conclusions of the CORA report were:

- Retrieval of radioactive waste from repositories in salt and clay is technically feasible. The disposal concept envisages the construction of short, horizontal disposal cells each containing one HLW canister.
- Safety criteria can be met. Even in a situation of neglect, the maximum radiation dose that an individual can incur remains far below 10 µSv/year.
- Structural adjustments to the repository design are required to maintain accessibility. This applies particularly to a repository in clay, which needs additional support to prevent borehole convergence and eventual collapse of the disposal drifts.
- Costs are higher than those for a non-retrievable repository, mainly due to maintenance of accessibility of the disposal drifts.

Although it was not included in the terms of reference, the CORA programme also addressed social aspects in a scoping study of local environmental organisations' views. In particular, it considered the ethical aspects of long-term storage of radioactive waste versus retrievable disposal. Although the results may not be representative of the views of a broader public, including other institutions with social or ideological objectives, some preliminary conclusions may be drawn as follows:

- Radioactive waste management is strongly associated with the negative image of nuclear power. As such, underground disposal is rejected on ethical grounds since nuclear power is considered unethical and a solution for radioactive waste could revitalise the use of nuclear power.
- Permanent control by the government is considered as the least harmful management option, although the possibility of social instability is recognised as a liability for which no solution can be provided.
- Although the study did not provide an opening to a consensus on the long-term management of radioactive waste, it can nevertheless be regarded as a start of stakeholder involvement.

The next steps

Because the Netherlands has adopted the strategy of storage in dedicated surface facilities for least 100 years, there is no immediate urgency to select a specific disposal site. However, further research is required to resolve outstanding issues and to be prepared for site selection in case of any change to the current timetable, arising by way of future European directives for example. The CORA committee recommended validation of some of the results of safety studies under field conditions, and co-operation with other countries, particularly on joint projects in underground laboratories, is foreseen in this context. As regards other technical aspects, it recommended that attention be given to the requirements for monitoring of retrievable repositories. Non-technical aspects will also be addressed.

The parliament has recently agreed the proposed research programme and endorsed the budget required for it.

Decommissioning and dismantling policies and projects

It is generally accepted internationally that there are three basic strategies for decommissioning nuclear power plants:

(i) Early dismantling, within a period of ten years.
(ii) Deferral of dismantling for 50 years, with safe enclosure of the facility in the interim.
(iii) In-situ decommissioning.

These three strategies were considered in the Environmental Impact Assessment for decommissioning of the Dodewaard NPP. The environmental impact was judged to be very small for all three strategies, and so the operator selected the least expensive strategy, namely deferred dismantling. Although the government had a slight preference for early dismantling, for various reasons, no objection was raised against the decision of the operator.

The intended end-point of the decommissioning process is return of the site to a "green field" situation. This means that, after dismantling of all the NPP structures, the site will be decontaminated to such low levels of residual radioactivity that it can be released from regulatory control for unrestricted use.

It is expected that, in due course and for the same reasons, the deferred dismantling strategy will also be selected for decommissioning of the Borssele NPP.

Transport

Purposes of transport

In the Netherlands there are hundreds of sites on which radioactive materials are used. The activities on these sites generate wastes that must be transported to the central storage facility. COVRA collects all LILW from these sites with its own vehicles, and responsibility for the waste transfers to COVRA when loaded into its vehicle. About 1 000 m^3 of such waste is moved annually, and only by road. This is a very small quantity when compared to the total amount of radioactive material transported in the Netherlands by road, rail and air for conventional industrial and medical use.

The transport of spent fuel from the nuclear power plants to the reprocessing plants abroad is also carried by road, by specialised foreign companies.

Safety aspects

Transport of radioactive waste is carried out strictly under the transport laws of the Netherlands. These laws implement the provisions of the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Materials and of associated international conventions and agreements. The safety record of waste transport in the Netherlands is outstanding.

Competent authorities

Regulatory authorities

All activities involving radioactive materials, including importation, transport, use, treatment, storage, and disposal, are regulated under the *Nuclear Energy Act*, and in most cases require a licence. Licensing is a joint responsibility of the following ministries:

- the Ministry of Housing, Spatial Planning and Environment, which is the leading authority;
- the Ministry of Economic Affairs;
- the Ministry of Social Affairs and Employment;
- the Ministry of Health, Welfare and Sport.

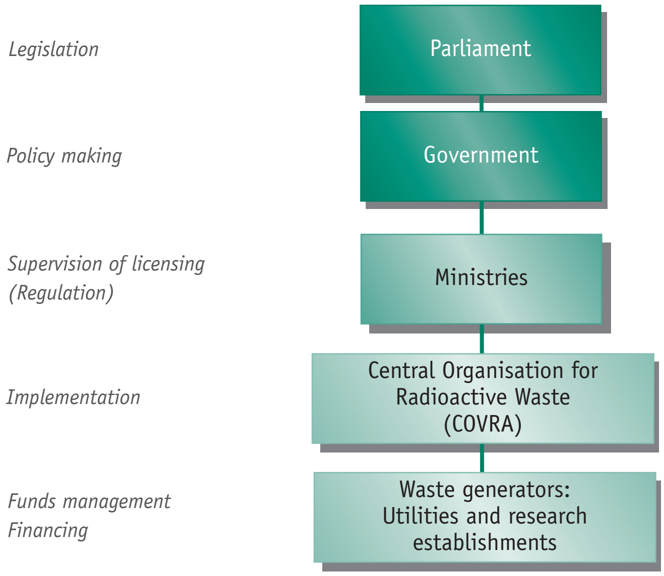
The Nuclear Safety Department and the South West Regional Inspectorate of the VROM, both of which are parts of the Ministry of Housing, Spatial Planning and Environment, are responsible for inspection and enforcement in regard to nuclear activities and applications of radioactive sources and materials respectively.

Waste Management Agency

The Central Organisation for Radioactive Waste (COVRA) was established in 1982, and designated by a governmental decree in 1987 as the organisation responsible for implementing radioactive waste management in the Netherlands. It was set up originally as a private company, owned by two nuclear utilities, Dodewaard (30%) and Borssele (30%), the Energy Research Foundation (30%) and the Government (10%).

Following liberalisation of the electricity market, however, and recognising the discouraging outlook for nuclear energy in the Netherlands, the entire ownership of COVRA was transferred to the Government with effect from 15 April 2002.

Main bodies involved in radioactive waste management in the Netherlands



Financing

It is accepted in the Netherlands that financing of radioactive waste management should adopt the "polluter pays" principle. Hence, the fees charged by COVRA upon collection of LILW include all direct costs for transport, conditioning and storage as well as financial provisions for the costs of future storage and eventual disposal. COVRA assumes full ownership of the waste, and fees will not be adjusted retrospectively. The part of the fee attributable to costs of future disposal is placed in a capital growth fund. This fund is expected to grow to the necessary level during the 100-year period of interim storage, and its adequacy is analysed periodically.

Appropriate arrangements were made for transfer of the fund at the time of transfer of COVRA ownership to Government, and its previous owners are now discharged from any further liabilities for radioactive waste management. COVRA, and ultimately the State, now has full financial responsibility for the management of radioactive waste in the Netherlands.

The Central Organisation of Radioactive Waste – COVRA, Netherlands.

Public information

Further information may be obtained from several institutes and organisations. Addresses are given below. Visitors' centres are located at COVRA and at the nuclear power plant at Borssele.

Government

Ministry of Housing, Spatial Planning and Environment
Den Haag
Website: http://www.vrom.nl/international/

Ministry of Economic Affairs
Den Haag
Website: http://www.minez.nl/home.asp?page=/homepages/english_home.htm
E-mail: ezinfo@postbus51.nl

Research

NRG (Nuclear Research and Consultancy Group)
Petten and Arnhem
Website: http://www.nrg-nl.com/
E-mail: info@nrg-nl.com

Industry

COVRA
P.O. Box 202 4380 EA Vlissingen

EPZ (nuclear power plant at Borssele)
P.O. Box 130
4380 AC Vlissingen

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

For further information, please contact:

OECD Nuclear Energy Agency
12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
Tel.: +33 (01) 45 24 10 15,
Fax: +33 (01) 45 24 11 10, Internet: www.nea.fr

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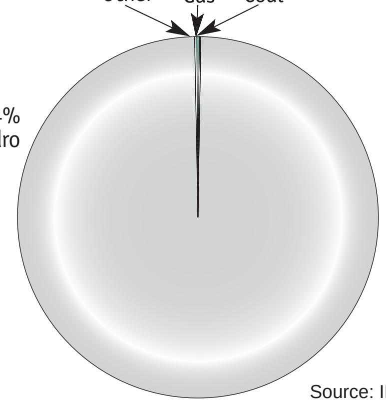
Norway

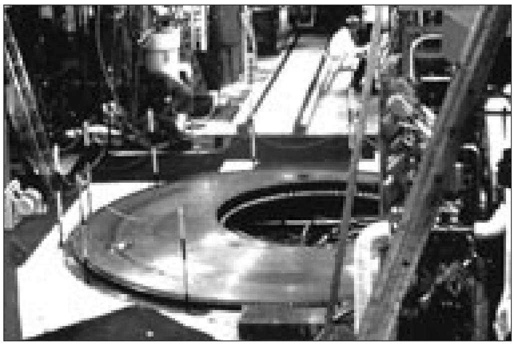
National nuclear energy context

The Norwegian nuclear programme started in 1948 with the creation of the Institute for Atomic Energy, known since 1980 as the Institute for Energy Technology (IFE). The original goal had been to initiate a nuclear power programme but, in 1980, the Norwegian Government decided that the use of nuclear energy was not relevant for the foreseeable future. This decision was made in light of domestic technological developments and an assessment of foreign nuclear technologies. The core of nuclear activity in Norway therefore remains the research reactor programme, currently comprising the 2 MW JEEP II reactor at Kjeller, which started up in 1967, and the 25 MW Halden boiling water reactor (HBWR) in Halden, which was built in 1959 and is used by the OECD Halden Reactor Project.

Breakdown of electricity sources (in %)



Source: IEA, 2003



The Halden Reactor Project.

Sources, types and quantities of waste

In Norway, radioactive wastes are generated by way of research reactor operations and by the use of radioactive materials in medical, research and industrial applications. Norwegian legislation does not currently prescribe criteria for classification of radioactive waste, but the International Atomic Energy Agency system, as described in "Classification of Radioactive Waste" (SS. No 111-G.1.1), is applied as far as reasonably practicable.

In general, most of these wastes contain only low or medium levels of activity consisting mainly of short-lived radionuclides and are categorised as low- and intermediate-level radioactive waste (LILW). Other types of waste are long-lived LILW.

In addition to this is the spent nuclear fuel from the research reactors.

Low- and intermediate-level waste

The annual rate of arising of LILW is about 120 drums (210 litres).

The cumulative quantity of LILW, by the end of 2003, consists of 3 600 drums (210 litres) with a total activity of 183 TBq (including 158 TBq of tritium), held in the National Combined Disposal and Storage Facility for LILW (KLDRA) in Himdalen, and a further 100 drums (210 litres) in IFE storage facilities in Kjeller.

Spent nuclear fuel

The cumulative quantity of spent nuclear fuel by the end of 2003 was about 16.28 tonnes held in IFE's storage facilities.

Radioactive waste management policies and programmes

Waste management policies

Norwegian policy on management of spent nuclear fuel has undergone various developments. In the 1960s, reprocessing of spent fuel for recovery of useable material was an emerging technology. Against this background, part of the spent fuel from the first Norwegian research reactor, JEEP I, which operated from 1951 until 1967, was used as feed material for an experimental reprocessing plant at the Kjeller site. This plant operated from 1961 until 1968 and is now fully decommissioned. The rest of the spent fuel from the JEEP I reactor is stored at Kjeller, together with spent fuel from the NORA reactor, which operated from 1961 until1968, and from the JEEP II reactor, which is still in operation.

The first HBWR core loading was stored on-site and the second was reprocessed in Belgium in 1969. Since then all the subsequent HBWR spent fuel is being stored on-site.

All Norwegian LILW has been conditioned and stored at Kjeller since the IFE facilities were commissioned in 1948, including LILW from the HBWR, which has been routinely transported to Kjeller. In 1970, about 1 000 drums of LILW were disposed of by burial in a 4 metre-deep trench, covered with clay, on the IFE site at Kjeller. Discussion of final disposal options for LILW resulted in establishment in 1999 of the Combined Disposal and Storage Facility for LILW (KLDRA) in Himdalen, approximately 26 km southeast of the Kjeller site.

The conditioned LILW stored at IFE in Kjeller has now been moved to Himdalen, and the waste buried originally at Kjeller, as described above, has been excavated, reconditioned and has been disposed of or stored in this new facility. The present policy is to use the Himdalen facility for disposal of LILW, excluding those wastes that are radioactive because they contain technically enhanced levels of naturally occurring radioactive materials (TENORM). Some LILW waste, mainly historic waste, will be stored in a section of the Himdalen facility waiting for a final decision on whether to relocate it or to encapsulate it in concrete for disposal. The disposal facility is designed to have sufficient capacity to meet disposal requirements until 2030. Before that time a decision will be made on whether or not to convert the associated storage section into a disposal facility.

Programmes and projects

The Himdalen facility for LILW

The Combined Disposal and Storage Facility in Himdalen is about 40 km east of Oslo. It is owned by the Directorate of Public Construction and Property *(Statsbygg)*, and operated by the Institute for Energy Technology (IFE). The facility consists of four large halls excavated in a mountain, three of them for disposal and one for storage. The total capacity is equivalent to 10 000 drums (210 litres). A total of 3 600 waste containers had been placed in the facility by the end of 2003 and filling of the first and nearly half of the second of the three repository halls is complete. Since operation started, there have been no accidents or public protests.

Cavern for waste disposal
at the Himdalen facility.
IFE, Norway.

Spent fuel storage facilities at IFE's Kjeller site. IFE, Norway.

The combined disposal and storage facility in Himdalen. IFE, Norway.

Spent nuclear fuel from the IFE research reactors

In December 1999, the Government granted a new 9-year licence for continued operation of the research reactors in Halden and Kjeller. The spent fuel from these reactors is now safely stored at their respective sites but no decision has been made for its long-term storage and disposal, and the public and political focus was on this point. Consequently, the Government appointed an independent expert group to discuss these questions and report on the strategies and options for the future storage and disposal of the spent nuclear fuel. The group delivered its report to the Ministry of Trade and Industry in December 2001.

The group concluded that there is a need for interim storage for at least 50 years. The group did not discuss the specific siting of the facility, but stressed that the siting procedure must be transparent and must involve all stakeholders. The group also noted that wastes other than spent fuel will require storage in such a facility and that the quantities of such waste should be investigated.

The expert group report was sent for a public hearing, and comments were to be received by the Ministry of Trade and Industry by May 2002. Some of the recommendations are followed up by the establishment of working group(s) to plan the way forward.

Radioactive waste facility at Kjeller for treatment and short-time storage of LILW in Norway. IFE, Norway.

Research and development

Research

At present, there is no substantial research on radioactive waste management in Norway. At a later stage, however, research may have to be carried out on development of a national repository for spent fuel and long-lived waste. Decommissioning activities may require enhanced research activities.

Development

Contaminated sediments in the Nitelva River, near the IFE site at Kjeller, were removed in 2000 and 2001. The most contaminated portions of the sediments, with locally elevated plutonium concentrations of the order of 100-1 000 Bq/g, have been conditioned in waste packages and disposed of in the Himdalen facility.

Decommissioning and dismantling policies and projects

Radioactive waste management

It is anticipated that all the LILW generated from decontamination and dismantling of IFE nuclear facilities will be conditioned at the Radioactive Waste Treatment Plant at Kjeller and then transported to the disposal facility in Himdalen.

Spent fuel from the research reactors will be stored in the existing, specially designed IFE storage facilities until long-term arrangements for its management have been implemented, as described under "Programmes and projects". IFE will deliver a report with their plans for decommissioning and estimations of waste generation to NRPA by December 2004.

Funding

Decommissioning of the research reactors and other nuclear facilities will be financed mainly by way of Government funds.

Transport

Transport of radioactive waste is carried out by road. The transport shipments consist primarily of:

- Radioactive waste to the IFE at Kjeller from hospitals, industrial and research facilities and the IFE Halden research reactor.
- Conditioned waste packages to the disposal facility in Himdalen from the IFE waste treatment plant at Kjeller.
- Irradiated nuclear fuel and experimental fuel is transported between the IFE's Halden and Kjeller sites.

The Directorate for Civil Protection and Emergency Planning (DSB) is the responsible body for land transport of all dangerous goods. The safety standards laid down in national regulations are based on the International Atomic Energy Agency "Regulations for the Safe Transport of Radioactive Material". In regard to implementation of the regulations for radioactive waste transport, the Norwegian Radiation Protection Authority (NRPA) is the competent authority.

Competent authorities

The **Ministry of Health** is responsible for licensing applications. Based on NRPA's recommendations to the Ministry, licenses are granted by the King in Council. Legislations are issued by the ministry.

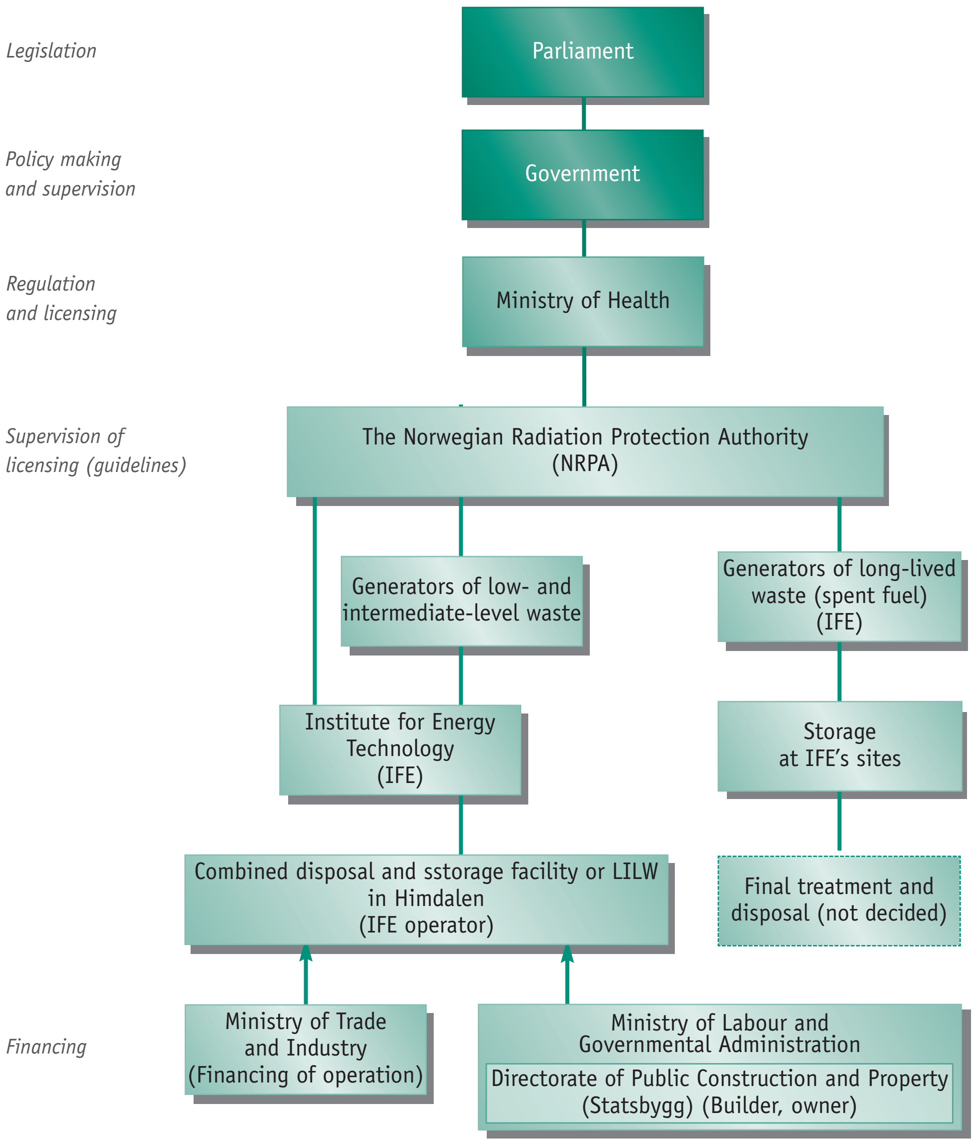
The **Ministry of Trade and Industry** provides financial resources for the research reactors operation, radiation protection, environmental monitoring and radioactive waste treatment at IFE, and for operation of the facility in Himdalen.

The **Institute for Energy Technology (IFE)**, with facilities in Halden and at Kjeller, is the second largest technical research institute in Norway, and the only nuclear research institute. It operates the national Radioactive Waste Treatment Plant at its Kjeller site, the Combined Disposal and Storage Facility in Himdalen, and the storage facilities for spent fuel from its research reactors.

The **Norwegian Radiation Protection Authority (NRPA)** is a directorate under the Ministry of Health. It is the regulatory body for radiation protection, nuclear safety and security, and nuclear emergency preparedness. It also performs supervision, handling of license applications, granting permits and issuing of guidelines.

The **Directorate of Public Construction and Property (Statsbygg)** is a Directorate under the **Ministry of Labour and Governmental Administration** and is owner and builder of the Himdalen facility.

Main bodies involved in radioactive waste management in Norway



Financing

As explained above, the Ministry of Trade and Industry is responsible for financing the national aspects of radioactive waste management in Norway, and legal provision for this is made by way of Acts of Parliament concerned with *Nuclear Energy Activities* and *Radiation Protection and the Use of Radiation*. As regards costs, the annual turnover (2003) for normal operation of the Radioactive Waste Treatment Plant at Kjeller was about 3.5 million NOK (€ 410 000) and for the facility in Himdalen about 5.0 million NOK (€ 590 000).

Public information

Norwegian laws require openness and possibility for active public involvement in the whole process of radioactive waste management. The operator must supply information to the public about procedures, safety and environmental aspects. The NRPA will supply information about legal aspects and about the findings of evaluations and inspections. Further information may be obtained from the addresses given below.

Government

NRPA (The Norwegian Radiation Protection Authority)
P.O. Box 55, NO-1332 Østerås
Website: http://www.nrpa.no
E-mail: nrpa@nrpa.no

Research

IFE (Institute for Energy Technology)
P.P. Box 40, NO-2007 Kjeller and NO-1751 Halden
Website: http://www.ife.no
E-mail: firmapost@ife.no

For further information, please contact:

AEN NEA

OECD Nuclear Energy Agency
12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
Tel.: +33 (01) 45 24 10 15,
Fax: +33 (01) 45 24 11 10, Internet: www.nea.fr

OECD

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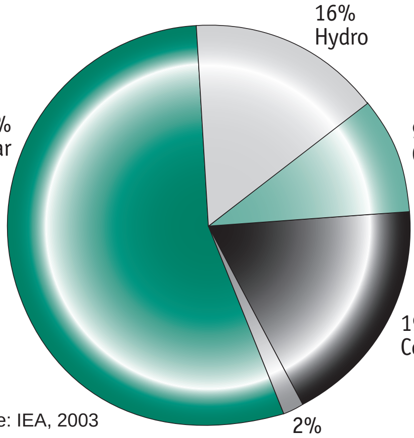
Slovak Republic

National nuclear energy context

Commercial utilisation of nuclear power in the Slovak Republic started in 1972 and by 2002 there were 6 nuclear power units connected to the electricity grid. In 2002 they generated 16.5 TWh of electricity, 53.9% of the total electricity generated in that year.

Also in 2002, the spent fuel storage capacity was 1 690 tonnes heavy metal (HM) which was utilised up to 60%.The three operational nuclear power plants in the Slovak Republic are Bohunice V-1, Bohunice V-2 and Mochovce. Bohunice V-1 NPP comprises two first-generation, Russian-designed pressurised water reactors (PWR), units 1 and 2. Bohunice V-2 NPP comprises two second-generation Russian-designed PWRs, units 3 and 4. Mochovce NPP also comprises two second-generation Russian-designed PWRs, units 1 and 2. Construction of another two PWR units at Mochovce was started but was subsequently ceased, after about 50% completion. The first nuclear power plant built in what is now the Slovak Republic was a gas-cooled, heavy water moderated reactor (GCHWR) of 150 MWe capacity, and it was located at Bohunice. It is known as A-1 and was shutdown in 1977 following an operational incident.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

In the Slovak Republic, radioactive wastes are generated by way of nuclear power production and by the use of radioactive materials in medical, research and industrial institutions. These wastes are described, by reference to their source, as “radioactive waste from NPPs” and “institutional radioactive waste”. All producers of radioactive waste are required to keep the amounts of waste that they create as low as reasonably achievable, by both technical and administrative means and, at each NPP, the programmes for radioactive waste minimisation are evaluated annually.

Liquid radioactive waste

Liquid radioactive waste includes concentrates, sludges, sorbents and oils, of which the most significant are the concentrates. The commissioning of Mochovce NPP in 1999, and the higher generation of concentrates during start-up, has increased the generation of such waste since then.

Solid radioactive waste

Apart from spent nuclear fuel, which is a specific form of waste, solid radioactive waste consists of filters, metal waste, concrete, and combustible and compressible materials. At Bohunice V-1 and V-2 NPPs and at Mochovce NPP such waste is first sorted, where it arises, according to activity level and to plans for its further treatment.

Precise information is not available for the quantities of solid waste generated and stored because some combustible wastes are incinerated continuously and are not included in records. Also, the operators record some types of radioactive waste by individual item or by weight, depending upon the method of storage. However, a significant increase in solid waste generation took place between 1998 and 2000 as a result of Bohunice V-1 NPP reconstruction.

Total quantities of radioactive waste

As regards NPP operational wastes, approx. 7 630 m^3 of liquid concentrates were in store at the Bohunice site at the end of 2002. This represents 64% of its storage capacity for this type of waste.

The total amount of solid waste stored at the NPPs was approx. 3 280 m^3 at the end of 2001. The table below summarises the quantities of stored wastes, including the institutional waste and the waste arising from decommissioning of the A-1 NPP.

Source	Radioactive waste type	Quantity
Bohunice and Mochovce NPP operation	Spent fuel	10 867 elements
	Solid	3 280 m^3
	Liquid	7 630 m^3
Decommissioning of the A-1 NPP	Solid	7 110 m^3
	Liquid	860 m^3
Institutions	Solid	10.7 tonnes

Radioactive waste management policies and programmes

Waste management policies

The strategy for radioactive waste management in the Slovak Republic was established by a Government decision in 1994, and is in accordance with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, which it ratified in 1998. This strategy includes the following steps:

- Conditioning of radioactive waste into a form suitable for disposal or long-term storage.
- Disposal of radioactive waste in a near-surface repository.
- Storage of radioactive waste that is not suitable for disposal in the near-surface repository.
- Research and development of a deep geological repository.

In 1996, an independent NPP Decommissioning and Radioactive Waste Management Company, SE-VYZ, was set up within Slovak Electric Plc, the Slovak electricity company. SE-VYZ is responsible for both predisposal and disposal phases of radioactive waste management and for decommissioning of nuclear facilities. It now operates all waste management facilities, excluding those facilities owned and operated by the Nuclear Power Plant Research Institute, VÚJE.

It has been decided by Government to shut down units 1 and 2 of the Bohunice V-1 NPP in 2006 and 2008 respectively. Spent nuclear fuel arising from these reactors at Bohunice will amount to between 4 028 and 4 768 assemblies by the end of their lifetime, depending on the level of uranium enrichment of the fuel. In addition, approx. 1 860 m^3 of wastes that will not meet the criteria for near-surface disposal are expected to arise from decommissioning of these reactors.

The two power units at Mochovce, which have been in operation since 1999 and 2000 respectively, are expected to generate 2 959 spent fuel assemblies during their lifetime. Approximately 760 m^3 of wastes that will not meet the criteria for near-surface disposal are also expected to result from decommissioning of these reactors.

In total, 2 500 tonnes HM of spent nuclear fuel is expected to be generated from operation of these NPPs over their lifetime.

As regards the A-1 NPP at Bohunice, its spent nuclear fuel has been transported to the Russian Federation. However, approximately 1 500 m^3 of the A-1 NPP decommissioning waste will not meet the criteria for near-surface disposal.

Programmes and projects

Pre-treatment of radioactive waste

The first step after radioactive waste is generated is termed “pre-treatment”, and generally consists of collection, segregation and a period of interim storage. This initial step is important because it provides an opportunity to separate waste streams according to the requirements for their effective treatment, conditioning and disposal as set out in the Government decision of 1994. This represents a substantial change from the earlier policy of interim on-site storage of all wastes until eventual decommissioning of the nuclear plant.

The typical annual production of waste from the four reactor units at the Bohunice site is 400-500 m^3 of concentrates, 100-200 m^3 of solid waste and about 25 m^3 of spent sorbents.

Treatment and conditioning of radioactive waste

Treatment is intended to improve the safety or economy of radioactive waste management by subjecting the waste to operations such as volume reduction, radionuclide removal and change of chemical composition. This may be carried out by processes such as incineration, compaction, evaporation, ion exchange, precipitation, etc.

Conditioning of radioactive waste involves those operations that transform radioactive waste into a form suitable for transportation, storage and disposal. The operations may include immobilising the waste, placing it into containers and providing additional packaging. Common immobilisation methods include solidification in cement or bitumen and vitrification in a glass matrix.

The main effort is currently concentrated on providing the NPPs with these treatment and conditioning technologies.

The low-level waste incinerator at the Bohunice site is owned by VÚJE and has operated since 1992. An associated plant for cementation of incinerator ash has operated since 1995. Only Bohunice V-1 NPP and Bohunice V-2 NPP radioactive waste is treated in this facility.

Two bituminisation facilities have been commissioned. The first is owned by VÚJE and has been used since 1984, first for experimental purposes and later for bituminisation of concentrates and organic spent fuel coolant, but it was out of operation during 2002. The second is owned by SE-VYZ and was commissioned in 1994 for bituminisation of PWR concentrates. Another SE-VYZ facility for bituminisation of concentrates (PS-100) is undergoing active tests after issue of an operating licence in 2002. The capacity of each facility is 120 litre/hour of concentrate, and the total amount treated by bituminisation by the end of 2002 was approximately 1 290 m^3.

A pilot vitrification facility, with a capacity of 50 litre/day, has been used since 1996 for conditioning inorganic spent fuel coolant from the A-1 NPP. Because of corrosion damage to the fuel cladding during operation and spent fuel storage at the A-1 NPP, the total activity in this spent fuel coolant represents nearly 10% of the radioactive inventory of the damaged spent fuel, and hence the vitrified product is not acceptable for near-surface disposal. Modification of this facility for conditioning of spent fuel coolant with higher levels of ^{137}Cs is currently under development.

Containers of spent nuclear fuel in interim spent fuel storage facility, Bohunice nuclear power plant.

The Bohunice Radioactive Waste Conditioning Centre (BSC) was designed by NUKEM of Germany, and is now the main facility for radioactive waste treatment and conditioning. The processes available include cementation, incineration, high-pressure compaction and evaporation. Because of its complexity, commissioning of the BSC was carried out in two phases during 2000, and a licence for it operation was granted in 2001 by the Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR).

Operation of the BSC during 2002 has achieved the incineration of 74.8 tonnes of solid waste and 5 m^3 of liquid waste, the compaction of 107.5 tonnes of solid waste, the cementation of 322.5 m^3 of concentrates and the filling of 203 fibre-reinforced concrete (FRC) containers.

Construction of a facility for treatment and conditioning of liquid radioactive waste from Mochovce NPP is expected to start in 2004.

Near surface disposal

For those wastes that contain only low or medium levels of activity consisting mainly of short-lived radionuclides, commonly described as low- and intermediate-level radioactive wastes (LILW), the final step of the national radioactive waste management system is disposal in a near-surface disposal facility in Mochovce.

Its safety is ensured by a combination of engineered and natural barriers that keep the disposal vaults dry and prevent radioactive releases into the environment. The repository was built in a geological formation with low permeability and high sorption capacity, and the disposal vaults were surrounded by an additional, artificially constructed clay layer. The temporary and final covers are designed to avoid water penetration into the disposal vaults. The repository is designed for disposal of solid and solidified LILW in special fibre-reinforced concrete containers that represent an additional engineering barrier. (The licence for these containers belongs to a French company, *Sogefibre*, and they are approved by ANDRA in France.)

Selection of the repository site was carried out between 1975 and 1978. Out of 34 sites selected on a preliminary basis, 12 were chosen for further investigation and, based on agreed selection criteria, the site of Mochovce was chosen as the most suitable for repository construction. Permission for the Mochovce repository commissioning was granted by the ÚJD SR in October 1999 and, after assessment of the repository commissioning report, permission for full operation was granted in September 2001. By the end of March 2003 a total of 392 containers were disposed of. The capacity of this near-surface disposal facility for LILW is sufficient for all operational waste, but not for all decommissioning waste, and it is expected that the capacity of the Mochovce repository will be increased in due course to accept also decommissioning waste.

For the time being, conditioned radioactive waste that is not acceptable for disposal in the near-surface repository will be stored at the NPP site where it arises. Further arrangements for its storage are under discussion, as are arrangements for buffer storage of short-lived waste whose activity will eventually decay to levels that are acceptable for near-surface disposal, or for release from radiological control.

Deep geological disposal

It is estimated that, during their design lifetime, the nuclear power plants will produce 2 500 tonnes HM of spent nuclear fuel and 3 700 tonnes of radioactive waste that is unacceptable for the near-surface repository at Mochovce and will require deep geological disposal. Research and development for deep geological disposal of high level waste and spent fuel in the Slovak Republic started in 1996. Current work involves preliminary geological investigations, source term studies, safety analyses and public involvement designed to provide a basis for pre-selection of repository sites. As regards selection of a host-rock environment, both crystalline and sedimentary rocks are under consideration. International experience has been used in defining the first set of criteria for site selection.

This work, and a critical review of existing geological data, led to identification of 15 prospective sites that are potentially suitable for a deep geological repository. Further investigation, taking account of geological, structural, tectonic, hydrological, rock-engineering and geochemical properties, together with consideration of natural resources and possible conflicts of interest, has led to selection of four areas proposed for further exploration in more detail.

Research and development

Management of the radioactive waste from the early development work at the A-1 NPP at Bohunice presents a special problem because of insufficient segregation and record-keeping during its operation. A large part of the liquid operational waste was treated and conditioned for disposal or was treated in order to reduce its level of activity. At the end of 2002 the inventory of liquid radwaste was 860 m^3. About 10 m^3 of fresh liquid concentrates are produced annually from decommissioning of the NPP and these are bituminised.

Decommissioning and dismantling policies and projects

Decommissioning started in the 1980s on a step-by-step basis and, after 1994, continued according to an overall decommissioning plan. The first phase of this plan, up to 2007, is focused on completion of the waste management infrastructure and on treatment, conditioning and disposal of all operational wastes. Significant dismantling will start only during the second phase, after discussions of options that include early dismantling, and deferred dismantling of the reactor and primary cooling circuit with safe enclosure.

Decommissioning options for the Bohunice V-1 NPP are currently under expert evaluation and discussion.

Transport

The licensing procedure for transport of radioactive waste in the Slovak Republic firstly requires approval for the transport containers and equipment, and then permission for the actual shipment of waste using the approved containers and equipment. A new type of container for transport of liquid radioactive waste was approved in 2002. The validity of previous permits has been extended for seven types of transport containers that have already been approved.

During 2002 about 582.6 tonnes of solid radioactive waste and 682.6 m^3 of liquid radioactive waste were shipped to the waste treatment plant, and 214 filled FRC containers, equivalent to 663.4 m^3 of solid and solidified waste, were shipped to the disposal repository.

Competent authorities

The **Nuclear Regulatory Authority of Slovakia (UJD SR)** is responsible for supervision of nuclear safety, including all aspects of radioactive waste management (except preconditioning management of institutional waste).

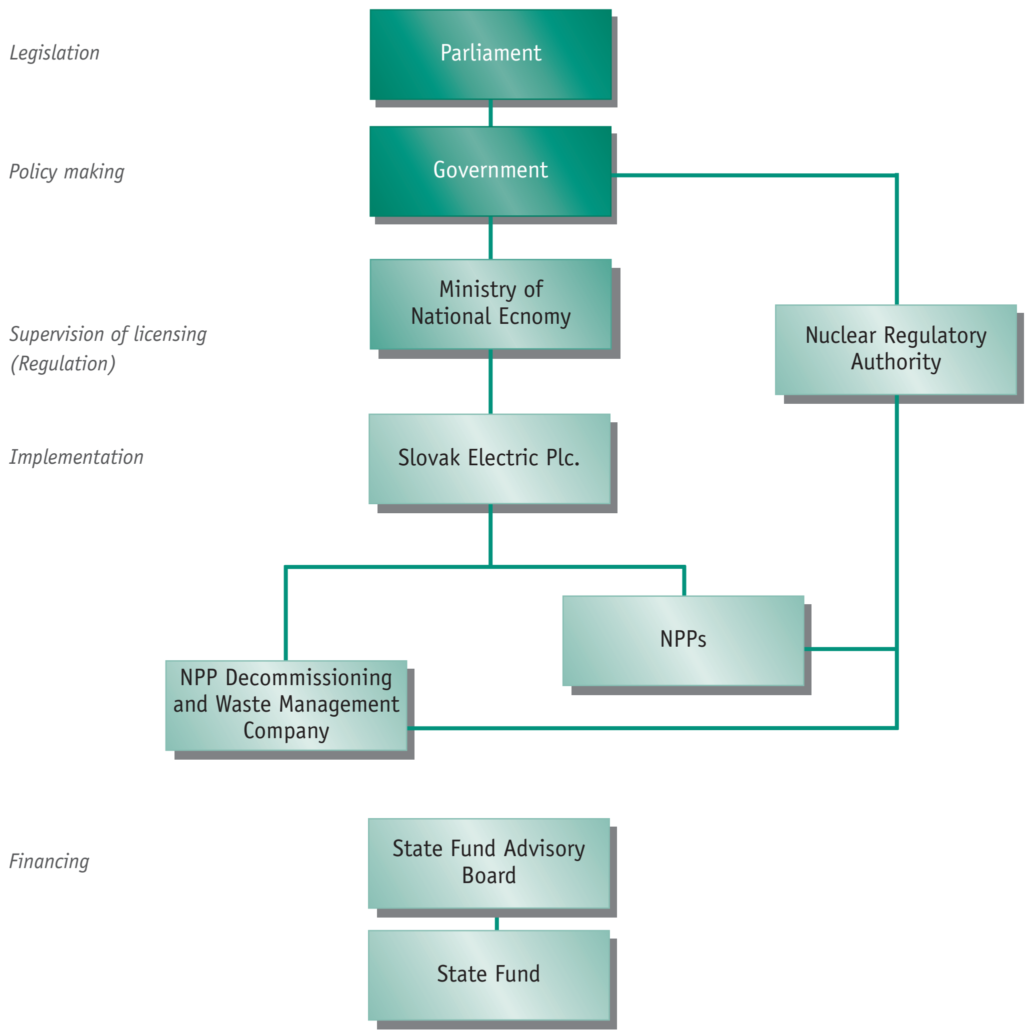
The **Ministry of Health** is responsible for radiation protection regulations.

The **State Fund Board** is responsible for providing advice to the Minister of National Economy regarding expenditures by the implementing body.

Currently, the UJD SR and the Ministry of Health are each responsible for inspection of the relevant nuclear facilities.

In accordance with the *State Decommissioning Fund Act*, only the owner/operator of nuclear facilities may use the resources of the State Fund. Since the only owner/operator of nuclear facilities is Slovak Electric Plc., a 100% state-owned joint stock company, it is currently the only implementing body for radioactive waste management, including disposal. Within Slovak Electric Plc., the three subsidiary companies are involved in these activities are: Jaslovske Bohunice NPP, Mochovce NPP, and SE-VYZ, the NPP Decommissioning and Radioactive Waste Management Company.

Main bodies involved in radioactive waste management in the Slovak Republic



Financing

The State Fund is designed to cover the costs of the back-end of the nuclear fuel cycle and of decommissioning nuclear facilities, including conditioning and disposal of waste arising from decommissioning. It was established by the *Act on the State Fund for Decommissioning of Nuclear Facilities and Spent Fuel and Radioactive Waste Management* (Act No. 254/1994), amended by Acts No. 78/2000 and No. 560/2001.

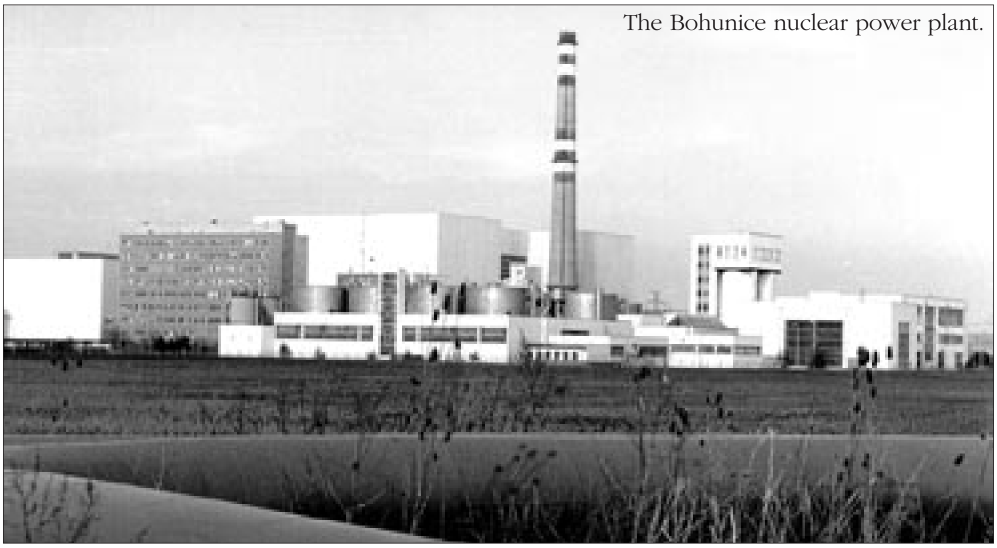
The following assumptions were made to calculate the associate fees:

- the minimum difference between discount/interest and inflation rates shall be 2.92%;
- the electricity rates shall increase to 1.9 Sk/kWh, minimum, in 2009.

According to the Act (as amended), the owner of the nuclear power plants (now Slovak Electric Plc.) shall pay to the Fund annually 6.8% of the sale price of the electricity sold by the plants and 350 000 Sk for each MW of installed electrical power. Based on the actual (year 2000) electricity rate, the fee has been calculated to be somewhat less than 0.13 Sk/Wh. Details of the calculation of fund contributions are to be established by a binding legal regulation to be issued by the Minister of National Economy.

The Ministry of National Economy is responsible for the management of the Fund. The financial resources are deposited in the State Fund account. These funds generate interest, the rates of which are established by the Slovakian National Bank.

There is no separate fee for radioactive waste management in Slovakia. Instead, the financial resources required for these purposes are a part of the annual budget for expenditures from the State Fund, in accordance with the applicable legal requirements and decisions made by the Minister of National Economy.


The Bohunice nuclear power plant.

Public information

More information may be found by way of the websites listed below.

Government

Nuclear Regulatory Authority of the Slovak Republic (UJD)
Bratislava
Website: http://www.ujd.gov.sk/main.html
E-mail: info@ujd.gov.sk

Industry

Company Slovenské elektrárne, a.s.
Bratislava
Website: http://www.seas.sk

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

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Spain

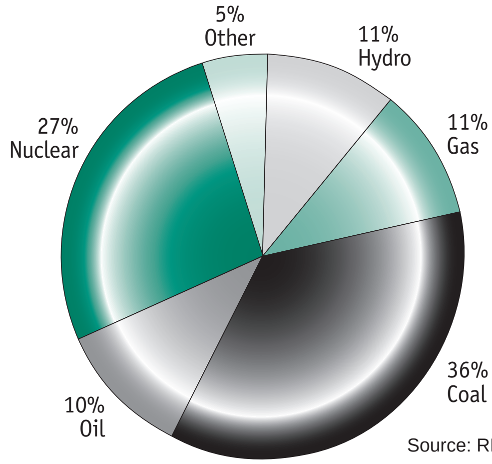
National nuclear energy context

Commercial utilisation of nuclear power in Spain started in 1968 and by 2002 there were 9 nuclear power units connected to the electricity grid. In 2002 they generated 63 TWh of electricity, 27.2% of the total electricity generated in that year.

Also in 2002, the capacity for nuclear fuel fabrication was 300 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors. Spent fuel storage capacity was 4 911 tonnes HM, and the amount of spent fuel arising in 2002 was 145 tonnes HM.

The most significant recent event in the context of nuclear energy was the granting, in October 2002, of a new operating licence for the José Cabrera nuclear power plant (NPP). It is authorised to operate until April 2006, when it will be finally shut down.

Breakdown of electricity sources (in %)



Source: REE, 2002

Sources, types and quantities of waste

Radioactive waste generation began in Spain during the 1950s with the first use of radioactive isotopes in industrial, medical and research institutions. There are currently more than one thousand such institutions authorised to use radioactive isotopes, and described as "small producers" of radioactive waste. However, most radioactive waste is generated from operation and dismantling of nuclear power plants and, in smaller quantities, from the fabrication of nuclear fuel.

Those wastes containing low or medium levels of activity consisting mainly of short-lived radionuclides are generally described as low- and intermediate-level radioactive waste (LILW). Other wastes containing higher levels of activity and those containing long-lived radionuclides are described as high-level waste (HLW). In addition, spent nuclear fuel from the nuclear power plants is recognised as a specific type of HLW waste in its own right.

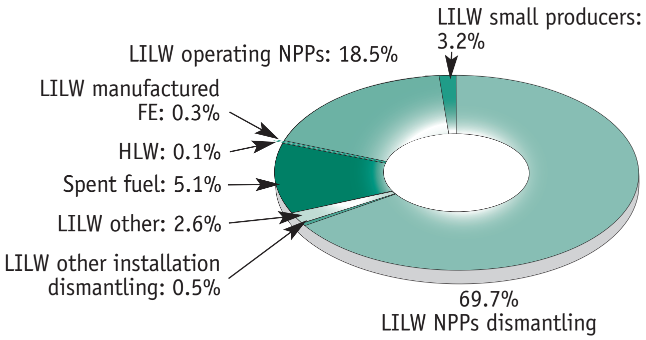
In 2002, about 1 694 m^3 of conditioned LILW was produced, and at the end of that year a cumulative total of some 31 000 m^3 of conditioned LILW was in storage in Spain.

The quantity of spent nuclear fuel in storage at the end of 2002 was about 2 885 tonnes HM. In due course, a quantity of HLW will be returned to Spain from abroad. This will comprise vitrified highly active residues from the reprocessing of spent fuel from the Vandellós I NPP together with minor quantities of fissionable materials recovered during reprocessing of spent fuel from the Santa María de Garoña NPP before 1983.

Based on the current installed nuclear power capacity, and on a nuclear power plant lifetime of 40 years, the total, eventual amount of LILW to be managed will be approximately 200 000 m^3. The total amount of HLW will be some 10 000 m^3, the volume equivalent to 6 750 tonnes HM of spent fuel, together with some vitrified HLW.

The table below summarises the amount of radioactive wastes to be managed as estimated to December 2002.

Sources, types and quantities of radioactive waste



Waste type	Source	Quantity (in m^3)
LILW	Fuel fabrication	520
	NPP operation	36 620
	Small producers	6 280
	NPP dismantling	137 640
	Other installation dismantling	1 060
	Other sources	5 230
Spent fuel	NPP	10 000
HLW	NPP	80

Radioactive waste management policies and programmes

Spain has an almost complete nuclear fuel cycle comprising uranium mining, production of uranium concentrates, fabrication of nuclear fuel, generation of nuclear power and radioactive waste management. Uranium enrichment is carried out abroad. There are no reprocessing facilities. The only SF reprocessed to date has been that generated by Vandellós I NPP, sent to France, and certain amounts sent to Great Britain by the José Cabrera and Santa María de Garoña plants prior to 1983. Spent fuel is now stored at the nuclear power stations where it arises. Low- and intermediate-level waste (LILW) generated in nuclear and other facilities, including waste arising from decommissioning, is disposed of in a near-surface repository. There is no military nuclear programme in Spain.

Waste management policies

Radioactive waste management and planning strategies, and the scheduling of major related activities, must be approved by government. Accordingly, the Royal Decree that led to creation of the Empresa Nacional de Residuos Radioactivos, S.A. (ENRESA), the body responsible for radioactive waste management activities in Spain, requires the company to draw up an annual report describing the actions taken during the previous financial year, together with a revised version of its current General Radioactive Waste Plan. This Plan makes proposals for the strategies and main activities to be carried out by ENRESA in regard to its remit. It is submitted by the Ministry of Economy to the Government for approval, and where appropriate, with subsequent notification to Parliament.

Programmes and projects

Low- and intermediate-level waste (LILW)

The strategy for management of LILW is based on the inter-related requirements for the waste to match the requirements of the disposal facility and for the disposal facility to be designed so as to accommodate the wastes. Two major areas of action flow from this. The first concerns the conditioning, transport, characterisation and criteria for acceptance of radioactive wastes, and the inspection arrangements required to guarantee compliance with acceptance criteria. The second concerns the design, construction and operation of the disposal facilities.

Except in the case of small producers, the initial treatment and conditioning of LILW is the responsibility of the producer, who is obliged to produce waste packages that satisfy acceptance criteria defined by ENRESA. These criteria are approved by the safety authorities for subsequent conditioning and disposal at the El Cabril disposal centre. In the case of small producers, all necessary waste treatment and conditioning is carried out at the El Cabril facility.

The contracts between ENRESA and the waste producers set out the acceptance criteria for disposal of wastes at El Cabril and the technical specifications for characterisation and acceptance of wastes. A key element of the latter process is the waste quality verification laboratory.

El Cabril disposal centre

ENRESA has operated the El Cabril disposal centre since 1992, with the objective of securing safe disposal of the LILW produced in Spain. This centre is located in the northwest of Córdoba province, in the municipal district of Hornachuelos. Preparatory work for the facility started in 1986, construction started in January 1990 and authorisation for start-up was received in October 1992.

The centre has two main areas, one for waste disposal and the other for waste conditioning and auxiliary buildings, including the waste quality verification laboratory.

The disposal system comprises a set of multiple barriers. The waste packages are immobilised by cementation within concrete containers measuring 2.25 x 2.25 x 2.20 metres, the whole constituting a block weighing some 24 tonnes. These containers are emplaced in disposal vaults, each of which has a capacity for 320 containers. The containers are placed in contact with each other, a central cross or strip being left to allow for the manufacturing and positioning tolerances of the container. The base slab of the platforms on which the disposal vaults rest constitutes the main element of the overall assembly. Its functions are to provide mechanical support and to collect any water that might infiltrate the system and channel it to a network of pipes installed in accessible galleries below the platforms, thus providing a control network.

The capacity of the El Cabril centre is envisaged as being sufficient for LILW disposal in Spain until about 2020.

The centre is also equipped to treat the so-called "institutional" wastes from small producers, to reduce the volume of compactable wastes, to condition wastes generated in the facility itself and to recondition the waste packages using concrete containers. The waste conditioning systems and the disposal systems are both remotely controlled from the control room, the only exceptions being the handling of certain wastes with very low contact dose-rates, from small producers, and operation of the incinerator.

Spent fuel (SF) and high-level waste (HLW)

The approach adopted in 1999 by the current, 5th General Radioactive Waste Plan as regards policy for management of spent fuel (SF) and high-level waste (HLW) reflects both the domestic situation in Spain and the general, international position on these matters. A distinction is made between interim and final technological solutions, recognising the need for further analysis of long-term options.

The strategy for the interim storage of SF and HLW involves the following steps:

- An increase in the SF storage capacity of reactor pools, as far as possible by means of re-racking. Completed by 1999.
- Provision of additional SF storage capacity using casks, which included the construction of a temporary storage facility. In operation for Trillo NPP since 2002.
- Construction of a centralised interim storage facility by 2010, in order to accommodate returned HLW, in the form of vitrified wastes and fissionable materials, arising from reprocessing abroad. This facility will also be required to store other wastes that cannot be disposed of at the El Cabril disposal centre, as well as SF that cannot be accommodated at the NPPs for lack of capacity in reactor pools or because of their future dismantling.

These steps will allow sufficient time for defining the complete programme for management of SF and HLW. The 5th General Radioactive Waste Plan aims to bring together the investigations for a Deep Geological Disposal (DGD) facility and for separation and transmutation of long-lived radionuclides. This will allow analysis of options, involving combination of these techniques, so as to provide Government with the necessary information for making its decision.

The Plan states that no decision on the eventual fate of SF and HLW will be taken before 2010. In the meantime, the main activities will be as follows:

- No further geological studies will be performed until this decision is taken and, instead, existing geological data will be used for performance assessment of a DGD facility.
- Non site-specific conceptual repository designs for DGD repositories in granite, clay and salt will be modified to introduce the capability for retrieving emplaced waste.
- Safety performance assessment of DGD repositories will combine geological information, repository design and the results of R&D. These assessments will provide quantitative information about evolution of the repository for guiding R&D activities and optimising facility designs. These studies will also consider the possible effects of the new fuel cycle technologies associated with separation and transmutation of the long-lived radionuclides.

The ENRESA work programme is being modified in accordance with this Plan, and currently involves the following items:

- A report on management options for SF and HLW
- Integrated studies on non site-specific deep geological repositories, one in each of the granite, clay and salt formations.
- A compilation of the R&D results and geological information from the former Site Selection Plan.

A non-site-specific performance assessment of disposal in granite (ENRESA-2000 granite) was completed at the end of 2001. A similar exercise for disposal in clay was finished in 2004. A first revision of an integrated study for a deep geological repository in granite (AGP Básico Granito 2003) was finished at the end of the year 2003.

Research and development

The Spanish Government recognises the importance of research and development in providing sound support for radioactive waste management projects, and entrusted ENRESA with responsibility for structuring and developing R&D plans according to strategic, project-related needs. ENRESA does not itself carry out R&D activities. Within the framework of the multi-annual R&D plans, it promotes, co-ordinates, controls and finances research activities through contracts with research institutes, universities and/or industrial companies.

An important feature of ENRESA's R&D activities is collaboration on international projects with international bodies and with other countries. Participation is by way of bilateral agreements, involvement in the working groups of the International Atomic Energy Agency (IAEA) and the OECD Nuclear Energy Agency (NEA), and by way of the European Union research programmes, either directly or through third parties. Projects are funded directly by ENRESA, by other participants in co-operation projects, and by the European Commission (EC) in the case of EC Shared-Cost Programmes.

The current plan covers the following areas of activity:

- basic technologies of waste characterisation and behaviour, applicable to various fields of management undertaken by ENRESA;
- separation and transmutation;
- disposal;
- performance and safety assessment;
- support of facilities: LILW, dismantling and radiological protection.

Decommissioning and dismantling policies and projects

From the point of view of technological development and radioactive waste production, decommissioning of nuclear power plants is the most important issue in this area. Decommissioning of the Vandellós I NPP is of particular current importance, with the decommissioning of other NPPs already in view for the medium term. The decommissioning and dismantling plan for Vandellós I NPP was approved by the government in January 1998. The technical option selected was deferral of final dismantling and site clearance for about 25 years with safe enclosure of the reactor core in the interim. Dismantling of peripheral equipment and facilities was completed by ENRESA in summer 2003 and the period of safe enclosure started.

For planning purposes, it is estimated for other nuclear power plants that complete dismantling will take place within three years of final shutdown of the reactors.

Vandellós nuclear power plant.

Transport

Spanish transport regulations are based on the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Materials. In addition, however, ENRESA must give advance notice of its shipments to the Nuclear Safety Council, the Civil Protection Board, the Police and to other administrative authorities. Prior to any shipment, ENRESA inspects and checks all technical and administrative aspects of the waste and of the vehicles involved. The Spanish Nuclear Safety Council inspects some 100 shipments per year. A special contingency plan has been developed in accordance with the requirements of the Civil Protection Board for the event of any incident during transport.

At the present time, only LILW is transported, as there are no disposal or central storage sites for SF and HLW. LILW is delivered to the El Cabril site regardless of origin, be it nuclear facilities or small users. Transport is by road in ENRESA-designed vans or semi-trailers and currently involves about 275 shipments per year, and 250 000 km of road travel.

Competent authorities

By law, the **Ministry of Economy (MINECO)** is responsible for enforcing nuclear legislation and for granting licenses, subject to a mandatory and binding report from the **Nuclear Safety Council (CSN)**. The CSN was set up in 1980 as the only competent body in matters of nuclear safety and radiological protection, and is generally responsible for the regulation and supervision of nuclear installations. This body, governed by public law, is independent of the state administration and reports directly to Parliament.

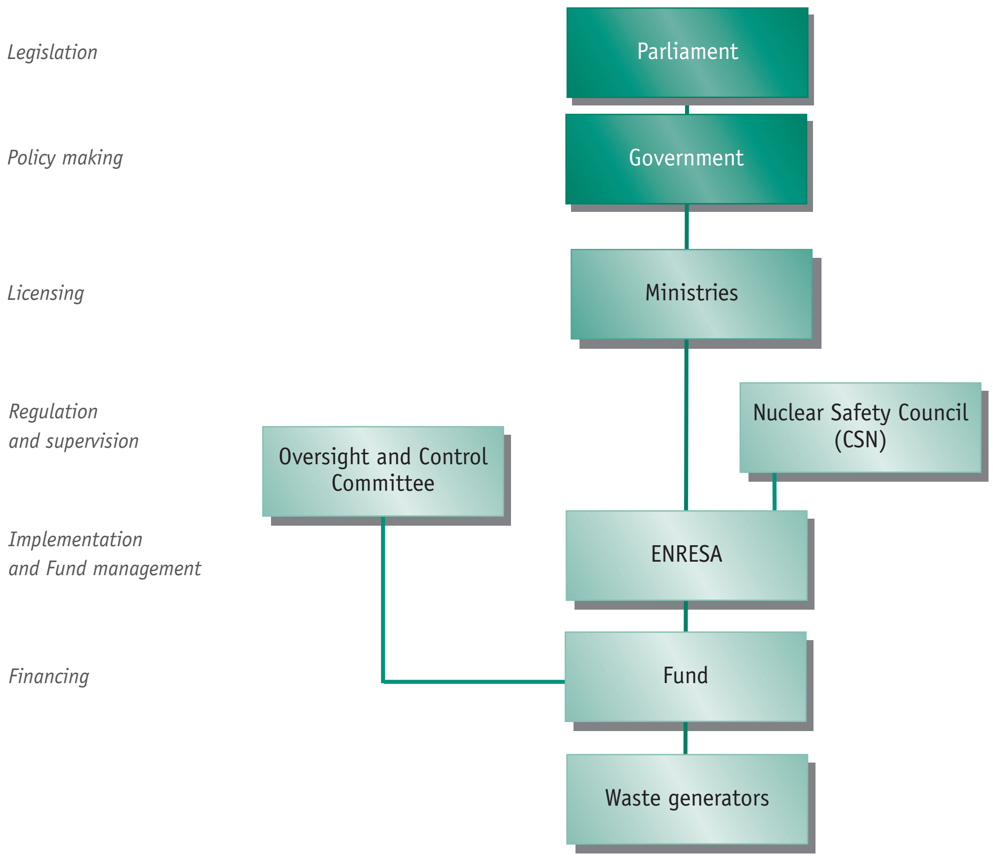
The **Ministry of Environment** participates in the licensing process, in collaboration with the CSN, by providing an environmental impact assessment, as do regional and local governments in the areas under their competence.

The **Empresa Nacional de Residuos Radioactivos, S.A. (ENRESA)** was set up in 1984 to be responsible for radioactive waste management and decommissioning of nuclear facilities in Spain. It is a state-owned company whose shareholders are the **Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT)** and the **Spanish State Industrial Holding (SEPI)**, both governmental institutions. ENRESA operates as a management company whose role is to develop radioactive waste management programmes according to policy and strategy approved by the Spanish Government, by way of a General Radioactive Waste Plan proposed by ENRESA.

The activities for which ENRESA is responsible are as follows:

- handling, treatment and conditioning of radioactive waste in some specific cases (for instance small producers);
- site design, construction and operation of centralised storage and disposal facilities;
- setting up of the necessary systems for collection, transfer and transport of radioactive wastes;
- decommissioning and dismantling of nuclear installations;
- conditioning of uranium mining and milling tailings when required;
- support to civil protection services in cases of nuclear emergency.

Main bodies involved in radioactive waste management in Spain



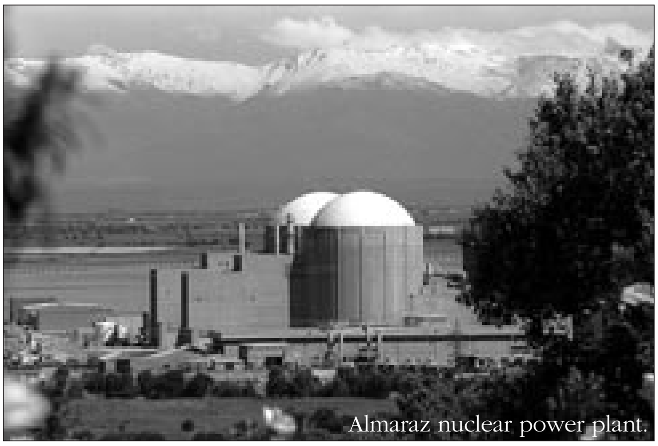
Financing

In accordance with the 1984 Royal Decree that established ENRESA, a system for funding radioactive waste management has been set up and is based on payment on account into an interest-earning fund. This takes account of the delay between the time of waste production and the time when the main costs of its management are incurred.

The funds for meeting the costs of the back-end of the nuclear fuel-cycle and of reactor decommissioning are collected by way of a levy on all the electricity sales. This levy is calculated on a yearly basis taking account of a revised appraisal of costs and the level of available funds. Thus the revenues to cover the difference between costs and available funds should be collected during the operational lifetime of the NPPs, currently foreseen as being 40 years.

In the case of the small producers, a system of tariffs has been defined by the Government for payment to ENRESA for the services rendered.

Every year, ENRESA updates its forecast of the income required. This forecast is included in the General Radioactive Waste Plan, which is sent for approval to the Ministry of Economy, which then takes the document as its main reference for fixing the applicable levy by way of the Royal Decree on Electricity Tariffs.



Almaraz nuclear power plant.

Public information

For more information, the websites of the relevant authorities and organisations are listed below.

Industry

Information on radioactive waste management issues is mainly provided by ENRESA, either in the visitor centres or through periodical publications, brochures, videos, etc. Five visitors centres are presently open, at ENRESA Headquarters in Madrid, ENRESA offices in Córdoba and three corresponding to the locations where ENRESA is carrying out its activities at the El Cabril site, Vandellós I plant and the former uranium mining and milling facility at Andújar.

ENRESA
Madrid
Website: www.enresa.es
E-mail: sopcom@enresa.es

Government

The Nuclear Safety Council is also responsible for keeping the public informed, either by way of its visitors centre or through periodical publications.

Consejo de Seguridad Nuclear
Madrid
Web site: www.csn.es
E-mail: comunicaciones@csn.es

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

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12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
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Sweden

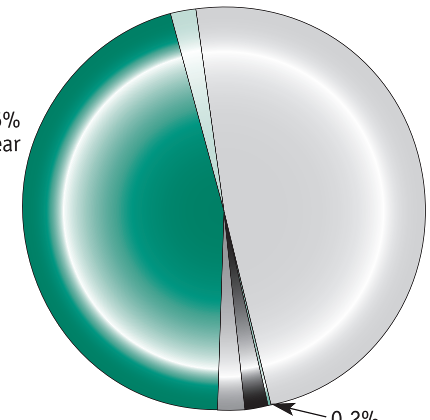
National nuclear energy context

Commercial utilisation of nuclear power in Sweden started in 1972 and by 2002 there were 11 nuclear power units connected to the electricity grid. In 2002 they generated 65.6 TWh of electricity, 45.9% of the total electricity generated in that year.

Also in 2002, the capacity for nuclear fuel fabrication was 600 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors. Spent fuel storage capacity was 5 000 tonnes HM, and the amount of spent fuel arising in 2002 was 228 tonnes HM.

Modernisation of unit 1 of the Oskarshamn nuclear power plant (NPP) was completed in November 2002, after almost one year. The unit was restarted in December 2002 and re-connected to the electricity grid in January 2003. In addition to the improved levels of safety, the new turbine will increase the electricity generating capacity by 5%.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

In Sweden, radioactive wastes are generated by way of nuclear power production and by the use of radioactive materials in medical, research and industrial applications. Most of it, however, comes from operation of nuclear power plants and is divided into three main categories. The wastes are grouped into these categories according to the half-lives and activity levels of the radionuclides they contain, and having regard to the requirements for management and disposal.

The first category is short-lived, low- and intermediate-level waste (LILW). This includes spent components, filters etc. from operation, maintenance and decommissioning of nuclear power plants. The second category consists of high-level waste in the form of spent nuclear fuel. It comprises a minor part of the volume but contains most of the short- and long-lived radionuclides. The third category is long-lived LILW and includes spent components from the reactor core, for example. A distinction is made between the wastes that arise from operation of a facility and those that arise from its decommissioning, but this is primarily concerned with licensing of a repository. The waste is basically the same regardless of whether it comes from power plant operation or decommissioning. These categories are summarised in the table below.

Radioactive waste was also created during the research and development that preceded commercial nuclear power in Sweden. This was carried out mainly at Studsvik, outside Nyköping, and radioactive waste is still generated there, mainly from the R2 research reactor. In addition, small quantities of radioactive waste arise from the fabrication of fresh nuclear fuel at the factory in Västerås, owned by Westinghouse Atom AB.

The radioactive waste from nuclear facilities is designated as “nuclear waste” in the *Nuclear Activities Act* but spent nuclear fuel does not become nuclear waste, legally, until it has been deposited in a disposal repository. Prior to that it is classified as “nuclear material” on account of the fissionable substances that it contains.

Although these radioactive wastes are categorised so that, in principle, they may be managed and disposed of separately, in practice they can be merged into groups that are disposed of in the same final repository.

Waste volumes

About 85% of the waste from nuclear power plants is short-lived LILW and the remainder is long-lived LILW and spent nuclear fuel. Including both operational and decommissioning wastes, the total estimated volume of these waste types arising from the Swedish nuclear power programme after 40 years of reactor operation will be around 260 000 m^3. The volumes of each category are shown in the table below, which excludes some operational waste already disposed of directly in the near-surface repositories at the nuclear power plants and at Studsvik.

Sweden's categorisation of radioactive waste

Half-life		Activity level		
Short-lived	**Long-lived**	**Low-level**	**Intermediate-level**	**High-level**
Low content of radionuclides with a half-life < 30 years, such as Co-60, Cs-137	Significant content of radionuclides with a half-life < 30 years, e.g. Am-241, Ni-59, Pu-239	Requires neither cooling nor radiation shielding	Requires radiation shielding but not cooling	Requires radiation shielding and cooling

Total volumes of waste from Swedish nuclear power programme

Short-lived LILW	Long-lived LILW	Spent nuclear fuel
225 000 m^3	19 000 m^3	18 000 m^3

Radioactive waste management policies and programmes

Waste management policies

In the early years – from 1970 onwards – policies in Sweden focused around R&D, to find a suitable and cost effective method for waste disposal and to establish general acceptance of the reference method. When the KBS-3 method was accepted in the 90s, focus shifted to selection of candidate sites for a deep geological repository, and to further technical development of the disposal concept. The Swedish Nuclear Fuel and Waste Management Company (SKB), which is jointly owned by the nuclear power plant operators, must fulfil certain legal requirements in regard to research and development on final disposal of spent fuel and is responsible for this work.

Feasibility studies for siting of the repository were carried out in eight municipalities. At the end of 2000, SKB presented a report as a basis for Government decision on the siting process. This report gave the background for selection of three candidate sites. It also presented the programme for geological surveys of the candidate sites and the background for the choice of method for disposal of spent nuclear fuel and HLW.

At the end of 2001, the Swedish government endorsed the plan for the site selection phase and stated that the KBS-3 repository design shall be used for planning the work. This design involves the disposal of the spent nuclear fuel in copper/steel canisters, surrounded by a layer of protective bentonite clay, at a depth of about 500 m in stable Swedish crystalline bedrock. An important safety principle is that several barriers should protect the spent nuclear fuel.

The municipalities of Forsmark and Oskarshamn, where two of the candidate sites are located, granted permissions for the fieldwork. Site investigations on these two sites started during 2002. The municipality of Tierp, the location of the third site, decided to refrain from further participation.

The objective for the site-selection phase is to assemble site-specific information and evaluate the construction and long-term safety of a site-specific repository. The site investigations and the necessary consultations with the communities are estimated to take 5-7 years. The technical development and demonstration of the KBS-3 method is being carried out at the Äspö Hard Rock Laboratory (HRL) and at the Canister Laboratory.

The goals for the next five years are to select the site for the repository, and to apply for licences to construct and operate the facilities for encapsulation and disposal of spent fuel. The encapsulation plant and the repository are planned to be in operation in about 2015.

Programmes and projects

Waste management

The Swedish arrangements for management of radioactive waste comprise a system for waste transport by sea, a disposal repository for LILW, called SFR, at the Forsmark NPP, and a central, interim storage facility for spent nuclear fuel, called CLAB, at the Oskarshamn NPP. SFR and CLAB are both owned by SKB. SFR is operated by Forsmark Kraftgrupp, and CLAB is operated by OKG, both on behalf of SKB.

During 2003, a total of about 190 tonnes HM of spent fuel and 4 casks with core components have been transported from the nuclear power plants to CLAB. At the end of 2003, a total of about 4 100 tonnes HM of spent fuel was already in store at CLAB. To meet future needs SKB is expanding the capacity of CLAB from the present 5 000 tonnes to 8 000 tonnes. The new capacity will be available in 2005. Also during 2003, 700 m^3 of LILW was transported to SFR and, at the end of 2003, a total of about 30 000 m^3 had been disposed of in the facility.

The SFR and CLAB are regarded as early cornerstones of the Swedish nuclear waste management strategy and they provide a good foundation for further development of the nuclear waste management system. The Swedish plans for waste repositories are presently as follows. A deep disposal facility for spent fuel, the SFL-2, is planned to be built in crystalline bedrock, at a depth of 500 metres by the KBS-3 method. Other long-lived waste will be stored until another planned repository, the SFL 3-5, has been built in the bedrock at about 300 m depth. A repository for short-lived decommissioning waste, the SFR-3, is planned to be constructed as an expansion to the existing repository for LILW from reactor operation, the SFR-1. The possibility of licensing landfills for wastes with very low-level activity also exists according to the *Ordinance on Nuclear Activities*.

Site investigations

In regard to the site investigations in Forsmark and Oskarshamn, and according to earlier government decisions, SKB is required to consult with Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Institute (SSI) about their planning and execution. A structured series of consultation meetings has thus started. In order to provide insight and to promote transparency the concerned municipalities are invited to participate as observers.

Both SKI and SSI have established advisory expert groups to assist in the monitoring and review of the site investigation. The SKI group (INSITE) was established in the autumn of 2001 and the corresponding SSI group (OVERSITE) shortly afterwards.

The Äspö Hard Rock Laboratory (HRL)

It is planned that the activities at the Äspö HRL will continue until the initial operating stage of the deep repository is finished, around 2020-2025. An integrated evaluation of experience from this initial operation and the results from the Äspö HRL will thus provide material to support the licence application for regular operation of the deep repository. An important role for the Äspö HRL in this perspective is to conduct long-term experiments where different aspects of importance for the performance of the deep repository are tested over a long time, in some cases up to 15-20 years.

The experiments in the “Prototype Repository” focus on monitoring of the function of the repository system and the interaction of the various parts of the repository. Certain activities aimed at development and testing of practical solutions for waste emplacement have also been included. Altogether, six deposition holes have been made in a bored tunnel, two in an inner section and four in an outer. The tunnel is backfilled with a mixture of bentonite and crushed rock, and a plug will separate the two sections. The Prototype Repository differs from a real repository in that heaters generate the heat instead of spent nuclear fuel. The experiments in the Prototype Repository will continue for about 20 years.

The present activities at Äspö HRL focus on:

- Testing of models describing the barrier function of the host rock.
- Demonstration of disposal technology and the performance of engineered barriers.


Äspö Hard Rock Laboratory.

Research and development

SKB R&D

As regards the SKB R&D programme, the Government is advised by SKI and other experts including SSI and the Swedish National Council for Nuclear Waste (KASAM). On the basis of their evaluation and advice, the Government has accepted that the main line of SKB research and development work for the final disposal of spent nuclear fuel should be the KBS-3 method.

On the present state of knowledge, and from a Swedish perspective, the view of SKI and SSI is that the KBS-3 method provides an adequate balance between requirements for long-term safety, protection from intrusion and reasonably good possibilities for retrieval if, for any reason, this should be necessary or desirable in the future. However, there is as yet no final approval of the KBS-3 system. In a safety analysis report published in 1999, SKB claims that the prospects of building a safe deep repository for spent nuclear fuel in the Swedish bedrock are “very good”.

The systems analysis must also describe what will happen if the development of a disposal facility is postponed and if it is decided, instead, to prolong interim storage of spent nuclear fuel in CLAB, or in another underground storage facility. The situation could arise if attempts were made to justify this alternative by claiming that better methods for disposing of nuclear waste might emerge in the future. It is already recognised, however, that prolonged interim storage means passing on responsibility to future generations for storage, which will require constant monitoring to ensure that safety is not jeopardised. A long-term, stable society with technical and financial resources to maintain and monitor the storage facility would be required for this.

In September 2001 SKB submitted their R&D Programme 2001. SKI and SSI reviewed this on behalf of Government and found that SKB had presented a comprehensive programme of good quality that complied with the requirements in the *Act on Nuclear Activities*. However, concerns were expressed on several issues, the most important being:

- SKB should improve presentation and documentation of the strategy for implementing the disposal programme, with due regard to interdependencies.
- SKB timetables for the implementation leave very little scope for delays and contingencies.
- SKB assumptions regarding the time needed for regulatory review of licence applications for the encapsulation plant and the repository for spent nuclear fuel are likely to be underestimates.
- SKB should develop more detailed plans and a research programme for the storage and disposal of long-lived LILW.
- SKB should improve description of the feedback between safety assessments and site investigation for the repository for spent nuclear fuel.

Based on the SKI and SSI regulatory review and recommendations, the Government approved SKB's R&D programme in December 2002.

Regulatory R&D

The regulatory authorities, SKI and SSI, must supervise and provide impetus for the SKB work. In order to do this, the authorities need to be competent counterparts to SKB. Consequently, they are conducting extensive research programmes of their own.

SKI has a comprehensive R&D programme with a budget of about € 9 million. It provides the basis for planning the SKI regulatory role in nuclear waste management, in review and supervision of safety in nuclear facilities and in review and supervision of the SKB R&D programme. It also supports the review and supervision of the funding system for future costs of the management and disposal of spent fuel and radioactive waste and the decommissioning of nuclear facilities. The SKI strategy is to develop and maintain an independent performance assessment capability for the expected reviews of licence applications for the deep repository and the encapsulation facility. The SSI research is more focused on effects of ionising radiation and biosphere transport of radionuclides. Risk communication is an area of common interest to both authorities, with focus on building appropriate procedures for transparent decisions.

Essentially all areas of importance for the evaluation of safety and radiation protection of nuclear waste installations are covered in the research programmes of SKI and SSI. Continued activities by the authorities involve research in the general area of criteria, indicators and compliance. Technical issues such as copper corrosion, bentonite back-filling, and performance assessment methodology are also included in the SKI R&D programme.

The Canister Laboratory

In order to test the methods for sealing and testing canisters, SKB has built a Canister Laboratory in Oskarshamn. Electron beam welding (EBW) is the main method used for sealing of the copper lids on the canisters. Ultrasonic and x-ray equipment is used for non-destructive testing. The Canister Laboratory is also used for testing of other parts of the encapsulation process.

One alternative welding method that has produced good results in practical trials for several years is Friction Stir Welding (FSW). Equipment for FSW has now been installed in the laboratory and full-scale tests were to start in the spring of 2003. The fundamental difference from EBW is that, with FSW, the material does not melt when joined. In FSW, a specially designed rotating tool is used. It is equipped with a central probe that is pressed down between the joint surfaces. Because the metal doesn't melt and the temperature can be kept to a relatively low level by controlling the process parameters, a fine-grained, homogeneous structure is obtained in the weld.

Decommissioning and dismantling policies and projects

Current status

Up to the present time, Sweden has only decommissioned and dismantled a number of small research reactors and laboratories in Studsvik and in Stockholm. The research reactors were zero power reactors, except for one with a power of less than 1 MWth. The spent fuel from these reactors is in interim storage pending a decision on its eventual fate. The radioactive waste from dismantling has been either disposed of in a repository or is kept in interim storage. As regards power reactors, the 65 MWth/12 MWe Ågesta pressurised heavy water reactor was shut down in 1974 and is partially decommissioned, and the 650 MWe Barsebäck 1 boiling water reactor was shut down in November 1999 and has been defuelled.

Transport

Operation of the Swedish spent nuclear fuel and radioactive waste transport system is regulated by three acts with associated regulations, the *Act on Nuclear Activities* (1984:3), the *Radiation Protection Act* (1988:220) and the *Act on Transport of Dangerous Goods* (1982:821). These incorporate international requirements on the transport of dangerous goods. SKI, SSI and the Swedish Maritime Administration (SMA) supervise compliance with these acts.

All Swedish spent fuel and operational radioactive waste is transported by SKB. All transport is by sea with an INF 3 ship, "Sigyn", which is capable of world-wide transportation. The transport containers used meet all international criteria and standards. The ship, trucks and transport containers are owned by SKB and all the ports that the ship visits during such transports are owned by the NPPs.

Spent nuclear fuel is first transported from the NPPs to the central interim storage facility for spent nuclear fuel (CLAB). According to current plans, it will then be transported to the spent nuclear fuel disposal repository, after a storage period of 30-40 years. Operational waste is transported to the repository for radioactive operational waste, SFR. The transport system is designed to meet current needs and will be modified as necessary to meet future requirements.

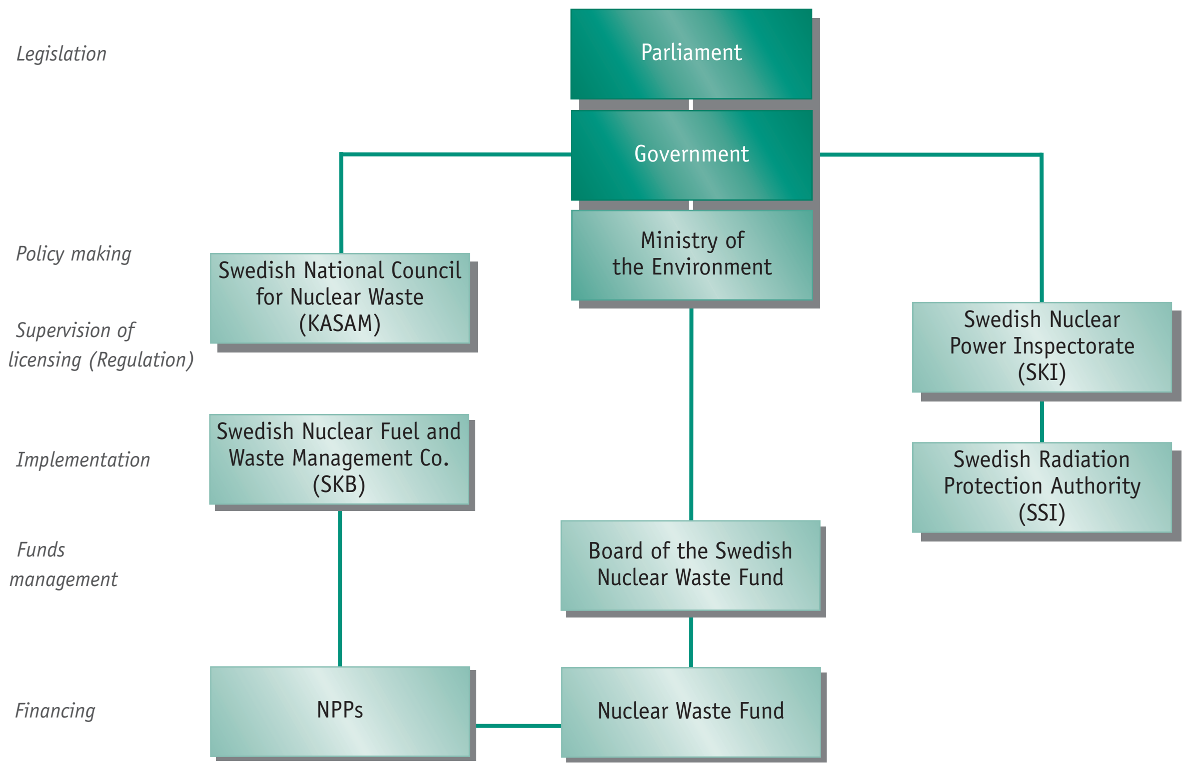
Competent authorities

Two governmental authorities, the **Swedish Nuclear Power Inspectorate (SKI)** and the **Swedish Radiation Protection Authority (SSI)** regulate radioactive waste management.
Both authorities work under the **Ministry of the Environment**.

SKI is the regulatory body for the safety of nuclear installations, and is also responsible for review of the R&D programme of SKB. SSI is responsible for regulations in the area of ionising radiation. The **Swedish National Council for Nuclear Waste (KASAM)**, an advisory committee to the Government, carries out independent review of the SKB R&D programme. KASAM also presents Government with a three-yearly assessment of current knowledge on nuclear waste management.

The **Swedish Nuclear Fuel and Waste Management Company (SKB)** was set up jointly by the nuclear power utilities to assume their legal obligation to develop and implement final disposal measures. Consequently, SKB must pursue the associated research and development as a condition of continued operation of the Swedish nuclear power reactors.

Main bodies involved in radioactive waste management in Sweden



Financing

Overview of the financial system

In 1981, the Nuclear Waste Fund was established by legislation to cover future expenses of the safe management of spent nuclear fuel, the decommissioning and dismantling of nuclear power reactors, and the research and development carried out by SKB. The financing system is regulated by an Act and Ordinance specifically concerned with arrangements for financing of these future expenses. It is based on the levy of a fee related to the amount of electricity generated.

SKI reviews the nuclear power plant annual cost estimates, which are based on the cost estimates prepared for them by SKB, and makes a recommendation to the government on the size of the fee for the coming year. Then, every year, the government fixes the fee per kWh of electricity generated at each nuclear power plant. The size of the fee is based on the assumption that each reactor generates electricity for 25 years.

Nearly 90% of the funds collected are invested in accounts with real interest rates. Based on the actual real interest rate on these investments, the Board states that the average real return on the assets of the funds will be -3,25% until 2020. For succeeding years, a real rate of return of 2.5% is assumed.

The fees are paid to the Fund by the reactor owners. Up to the middle of 2002 the assets of the Fund were to be deposited in accounts at the National Debt Office, at conditions similar to those of government bonds. From 1 July 2002 all investments must be made on the market in the form of ordinary government bonds. An independent government authority, the *Board of the Swedish Nuclear Waste Fund*, is responsible for ensuring that administration of the assets satisfies the requirements for an adequate return and adequate liquidity over the long term.

Waste management fee

The fund collects, on average, about 0.5 öre (0.005 SEK) per kWh generated at each nuclear power plant. If the collections are allocated to the total electricity consumption, the fee will be approximately 0.25 öre per kWh on average.

Furthermore, in accordance with the Studsvik Act, all reactor owners are required to pay a fee of 0.15 öre per kWh for management of radioactive wastes from the research reactor at Studsvik and from the shutdown reactor at Agesta.

At the end of 2003, the Fund had a balance of about 32.6 billion SEK.


Ringhals nuclear power plant.

Public information

For more information, the websites of relevant authorities and organisations are listed below.

Government

The Swedish Nuclear Power Inspectorate (SKI)
Stockholm
Website: www.ski.se
E-mail: info@ski.se

The Swedish Radiation Protection Authority (SSI)
Stockholm
Website: www.ssi.se
E-mail: ssi@ssi.se

Industry

Swedish Nuclear Fuel and Waste Management Co (SKB)
(Svensk Kärnbränslehantering AB)
Stockholm
Website: www.skb.se
E-mail: info@skb.se

The Swedish Nuclear Training and Safety Center (KSU)
(Kärnkraftsäkerhet och Utbildning AB)
Nyköping
Website: www.analys.se
E-mail: analys@ksu.se

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

For further information, please contact:

OECD Nuclear Energy Agency
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Switzerland

National nuclear energy context

Commercial utilisation of nuclear power in Switzerland started in 1969 and by 2002 there were 5 nuclear power units connected to the electricity grid. In 2002 they generated 25.7 TWh of electricity, 39.5% of the total electricity generated in that year.

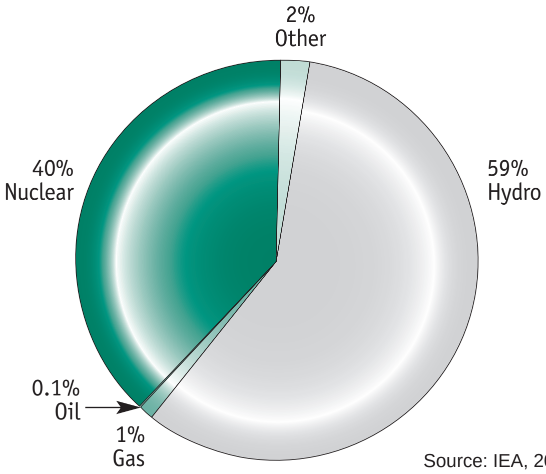
Also in 2002, the spent fuel storage capacity was 2 985 tonnes heavy metal (HM), and the amount of spent fuel arising in that year was 64 tonnes HM.

A new nuclear energy law, which had been under consideration for some twenty years, was approved by the Parliament in March 2003. Its main provisions are:

- No limitation of lifetime for nuclear power plants, other than safety-considerations.
- An optional national referendum for the general licence on the building of new nuclear power plants.
- A 10-year moratorium on reprocessing of spent fuel, beginning July 2006.
- The responsibility of nuclear waste producers for the management and disposal of their wastes.
- The responsibility of the Federal State for the management of radioactive waste from medicine, industry and research.
- Disposal of all radioactive wastes shall be in geological repositories.
- An optional national referendum foreseen in connection with the general licence for a repository.
- A wide consultation foreseen with those Cantons that are strongly affected by siting of the repository, and including neighbouring countries if sufficiently affected.
- Ensuring that sufficient resources are available in an independent fund to finance both nuclear plant decommissioning and waste disposal.

According to the new law, radioactive waste disposal is expected to be in Switzerland, in principle, although the law also allows disposal within the framework of a multinational project as an exception, if strict specific conditions are fulfilled.

Breakdown of electricity sources (in %)



Source: IEA, 2003

Sources, types and quantities of waste

Waste management concept

The nuclear waste management concept in Switzerland envisages two types of repository, one for low- and intermediate-level waste (LILW) and the other for non-reprocessed spent fuel elements (SF), high-level waste (HLW) and long-lived intermediate-level waste (ILW).

For planning purposes, a model waste inventory (MIRAM) of all expected, or projected, waste arisings was developed. This is periodically updated. In addition, the operators of the Swiss nuclear power plants (NPPs) and waste management facilities, together with the *National Cooperative for the Disposal of Radioactive Waste (Nagra)*, have also developed a common electronic database, ISRAM, which includes a detailed description of all waste packages and their contents, and thus provides a complete and detailed account of the radioactive wastes currently existing in Switzerland.

Waste volumes

The majority of radioactive wastes arising in Switzerland are from nuclear electricity production but the figures below give a more detailed breakdown of the expected, or projected, arisings of the different waste types. These are based on the model inventory of all radioactive wastes estimated to arise over a 40-year operating lifetime of the existing nuclear power plants and from their subsequent decommissioning, although longer operational lifetimes are assumed for some projects.

The values given below are for the wastes packaged into disposal containers ready for emplacement in the underground disposal rooms; the values in brackets are the volumes of the conditioned wastes, as delivered to the disposal facility, before packaging into disposal containers.

Low- and intermediate-level waste

LILW consists of operational waste from the nuclear power plants (NPPs), waste from medicine, industry and research, low-level technological waste from the reprocessing of spent fuel and waste from the decommissioning and dismantling of the nuclear power plants and research facilities. According to the current estimates, the volume of LILW amounts to 77 700 m^3 (52 300 m^3). 7 700 m^3 (3 900 m^3) are operational wastes from medicine, industry and research (MIR), 27 000 m^3 (7 500 m^3) represent operational waste from the nuclear power plants (including exchangeable reactor internals like control rods etc.), 3 400 m^3 (1 200 m^3) originate from reprocessing and 29 600 m^3 (29 600 m^3) are expected from the decommissioning of nuclear power plants currently in operation, while 11 000 m^3 (11 000 m^3) should come from the decommissioning of research facilities.

Spent fuel, high-level and long-lived intermediate level wastes

From the five reactors in operation, a total amount of about 3 000 tonnes HM of spent fuel is expected, assuming 40 years of operation. The contracts between the Swiss NPP operators and the foreign reprocessing companies, Cogema in France and BNFL in the United Kingdom, cover approximately 1 200 tonnes HM of spent fuel. For planning purposes, this is assumed to be the final amount that will be reprocessed although, in principle, reprocessing may be used after the moratorium foreseen in the new nuclear energy law has expired. This scenario will result in 4 800 m^3 of spent fuel and about 1 000 m^3 (130 m^3) of vitrified waste from reprocessing.

In addition to this, for planning purposes, a total of 5 900 m^3 of packaged long-lived ILW is assumed. This comprises 3 500 m^3 from spent fuel reprocessing and 2 400 m^3 as a contingency for wastes from medicine, industry and research, as well as operational and decommissioning wastes from nuclear power production.

These figures are summarised in the table below.

Switzerland's current estimates of eventual waste volumes

Waste type	Source	Volume
Spent fuel (SF), high-level (HLW) and long-lived intermediate level (ILW) waste	Vitrified waste reprocessing	1 000 m^3
	SF in containers, glass flasks	4 800 m^3
	Packaged long-lived ILW	3 500 m^3
	Medicine, industry and research, decommissioning, etc.	2 400 m^3
Low- and intermediate-level radioactive waste (LILW)	Medicine, industry and research	7 700 m^3
	Nuclear power plants (NPPs)	27 000 m^3
	Reprocessing of SF	3 400 m^3
	Decommissioning of NPPs	29 600 m^3
	Decommissioning of research facilities	11 000 m^3

Radioactive waste management policies and programmes

Waste management policies

In Switzerland, a strategy for the back-end of the nuclear fuel cycle is not prescribed by present legislation. The strategy that has been chosen by the nuclear power plant operators includes both reprocessing and storage of spent fuel for later reprocessing or direct disposal. Reprocessing is carried out abroad, but the radioactive waste arising from it will return to Switzerland.

All radioactive wastes are to undergo disposal in repositories that are situated in suitable geological formations. No near-surface disposal is planned. Two repositories are foreseen, as described above. Because of the necessary cooling time prior to disposal, the repository for HLW is not needed for several decades. However, the demonstration of the feasibility in Switzerland of safe and permanent disposal of such waste is requested by the legislation. The option for disposal of the limited quantities of HLW within a framework of a bilateral or multilateral project is kept open.

Since there is no repository yet available, all radioactive wastes are stored. Each nuclear power plant has interim storage capacity for its own operational waste. The radioactive waste from medicine, industry and research is stored at a federal interim storage facility. A central storage facility for all types of radioactive waste, especially for vitrified high-level reprocessing waste and spent fuel, is in operation.

Switzerland has ratified the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management prepared by the IAEA.

Programmes and projects

Waste conditioning

LILW is reduced in volume by compaction, incineration or melting, treated with a leach-resistant bonding agent, usually cement, but also bitumen or polystyrene in some cases, and solidified in containers, generally 200-litre drums, but also larger containers.

Long-lived ILW is conditioned in a similar manner to LILW. It is planned that both vitrified HLW, in its thin steel fabrication container, and spent fuel will be encapsulated for disposal in a massive (25-cm thick) cast steel canister.

Interim storage

As noted above, each nuclear power plant already stores its own operational radioactive wastes. Wastes arising in the fields of medicine, industry and research are the responsibility of the Federal State and have been stored since 1992 in a Federal Storage Facility *(Bundeszwischenlager BZL)*, operated by the Paul Scherrer Institute (PSI) and with a capacity for 2 100 m^3 of waste.

A central storage facility *(Zentrales Zwischenlager ZZL or "ZWILAG")*, owned by the nuclear power plants, is located at Würenlingen near the PSI site. It features a hall for dry storage of up to 200 storage casks of spent fuel and vitrified HLW, and a storage building for ILW with a capacity of 4 000 m^3 of waste. Both of these are already in operation. Another hall for storage of LILW waste with a capacity of 16 500 m^3 is at the commissioning stage. Furthermore, ZWILAG has the facilities for sorting and decontamination of materials and for the conditioning of waste. It also has a plasma furnace for incineration/melting of radioactive waste. Both installations are at the commissioning stage. ZWIBEZ, an interim storage facility located at Beznau NPP, can accommodate 48 storage casks for HLW and spent fuel. In 2002, work started on an additional interim storage facility at the Gösgen NPP, with a capacity to accommodate 1 000 spent fuel elements. The wet storage facility is planned to be operational in 2006. Thus, sufficient interim storage capacity will be available for all nuclear power plants for their operational lifetime.

Disposal

In Switzerland, long-term safety of a disposal repository must be guaranteed without the need for post-closure monitoring or control. The Federal Government has formally accepted that safe disposal of LILW in a geological repository is possible in Switzerland. This acceptance was based on an early study of the technical feasibility and safety of this repository concept, Project Gewähr '85, which was performed by Nagra and reviewed by the regulatory authorities. Nagra's site selection procedure for a LILW repository began in the 1970s. In 1993, Nagra proposed Wellenberg in the Canton of Nidwalden as the repository site. In 1994, Federal Government experts endorsed the proposal of the site and an application for a general licence was submitted to the Federal Council. In the Canton of Nidwalden, according to current law, a repository requires a cantonal concession for the use of the space underground. At a high-turnout referendum in June 1995, the concession application for an exploratory drift and for the repository was refused by a narrow margin. The votes were 48% "yes" and to 52% "no", with the community in the vicinity of the site voting in favour of the project. A more stepwise approach was subsequently proposed. Following lengthy consultation with several working groups, which led to modification of the disposal concept in order to make monitoring more explicit and to allow easier retrieval, an application was submitted in 2001 for an exploratory drift for further investigation of the suitability of the site. After the government of the Canton of Nidwalden had granted the concession in September 2001, the population rejected the plans for the proposed underground investigations in a cantonal public referendum in September 2002, although the community of Wolfenschiessen in the vicinity of the site again accepted the project. Consequently, the plans for a repository for LILW at the site of Wellenberg have now been abandoned. A careful analysis of the situation, and of various options, is currently underway.

For the disposal of HLW and long-lived ILW, a deep geological repository concept with in-tunnel emplacement of SF/HLW and tunnels for long-lived ILW was developed. Spent fuel and HLW will be held in interim storage for at least 40 years to allow heat to decay to an acceptable level. Thus, a repository will not be required until around the year 2040.

After an initial broad survey of options, early siting studies focused on the crystalline basement of northern Switzerland but data on the overlying formations were also collected. The results of the investigations carried out were integrated into the concept assessment "Project Gewähr 1985". Whilst the Federal Council accepted this as a demonstration of the safety and technical feasibility of constructing a repository for HLW and long-lived ILW deep in the crystalline basement of northern Switzerland, it had some reservations with respect to siting. Therefore, the Federal Council in its assessment of "Project Gewähr" was not convinced that sufficiently extensive blocks of rock with the required properties could be found, and asked that the investigations should be extended to sedimentary formations. For the crystalline basement, the regional investigations were finalised and a comprehensive evaluation submitted to the authorities in 1994. This is now under review by the federal safety authorities. Further studies identified the region of the Mettauer Tal as a potential location for possible further investigation of the crystalline basement.

In a stepwise process started in the mid 1980's, several sedimentary options were considered. This process was performed in close consultation with the safety authorities and their experts. The process, which included fieldwork, led to the identification of the Opalinus Clay of the Zürcher Weinland, in the northern part of the Swiss Plateau, as the preferred option. However, other options are also available. For the Opalinus Clay of the Zürcher Weinland a detailed characterisation was performed. This included a 3D seismic campaign, the drilling of an exploratory borehole, and experiments in the Opalinus Clay as part of the international research programme in the Mont Terri Rock Laboratory. Based on the results of these investigations, a "Demonstration of Disposal Feasibility" *(Entsorgungsnachweis)* was submitted by Nagra to the Federal Government in December 2002. Because of the comprehensive evaluation process involved and the excellent results obtained with project Entsorgungsnachweis, Nagra proposes to focus future research on the Opalinus Clay and the Zürcher Weinland. As a next step, the safety authorities will examine the technical aspects of the project, which will also be reviewed by an international team under the auspices of the OECD Nuclear Energy Agency. A decision by the Federal Council on the feasibility demonstration and on future work is expected in 2006. However, a siting decision as part of a general licence is not expected before 2020.

Research and development

Extensive R&D programmes are run by Nagra to provide the geological, engineering and scientific information required for the LILW and the SF/HLW/long-lived ILW repository projects. Nagra is responsible for planning and funding R&D projects that, to a large extent, are then carried out by external contractors. In addition to site-specific investigations and work in underground research laboratories (URLs), extensive programmes are run at the PSI (co-funded by the Swiss government), universities and various research companies and institutes in Switzerland and elsewhere.

Nagra has close contacts with similar organisations in other countries, and much R&D work is undertaken through collaborative, co-funded projects, partially in the framework of European Commission research programmes. International collaboration is particularly important in the studies carried out in underground rock laboratories. At the Grimsel Test Site, which is located in crystalline rock in the Swiss Alps, several experiments are underway in collaboration with partners from various countries. These include 13 organisations from the Czech Republic, Germany, Japan, USA, Sweden, France, Spain, Taiwan and the European Community.

The Mont Terri Rock Laboratory, located in the Opalinus Clay in the Jura Mountains, is an international project managed by the Swiss Federal Office of Water and Geology (FOWG). The present programme consists of several experiments to obtain information on the hydrogeological, geochemical and geomechanical characteristics of the Opalinus Clay and of similar rocks. It also includes experiments for investigating the interaction between engineered barriers and the host rock. Partners are IRSN and ANDRA (France), BGR and GRS (Germany), ENRESA (Spain), FOWG, HSK and Nagra (Switzerland), CRIEPI, JNC, and Obayashi Corporation (Japan), SCK•CEN (Belgium) and the European Community.

Nagra, in collaboration with different waste management and research organisations as well as regulatory bodies, is a founding member of the International Training Centre (ITC), which offers training courses to help ensure that education for the next generation of personnel is available.

Decommissioning and dismantling policies and projects

Current status

To date, only research or pilot reactors, DIORIT and SAPHIR at PSI, and LUCENS, have been decommissioned or are in the decommissioning process. No power reactors have been decommissioned.

Radioactive waste management for D&D

Although the central storage facility is not primarily intended for waste from decommissioning, some types of decommissioning waste could be stored there. Large amounts of decommissioning waste may be directly disposed of in an underground repository.

Funding for D&D

The Federal Act on the Atomic Law establishes a decommissioning fund, into which the licensees make financial payments. This fund is administered by the Federal Government. Supervision of finances does not fall within the mission of the Inspectorate (HSK). The dismantling of research reactors is funded by the government.

Transport

All shipments of radioactive waste have to comply with Swiss atomic law, radiation protection regulations and national and international transport regulations and recommendations. Switzerland has integrated the International Atomic Energy Agency transport recommendations into its national regulations. The Swiss Federal Nuclear Safety Inspectorate is responsible for safety and control aspects of the shipment of radioactive materials.

The five Swiss NPPs, the nuclear research centre PSI, and various hospitals, industrial facilities and research institutes are producers and users of radioactive materials, and shipments are carried out on their behalf by several shipping companies that specialise in the transport of radioactive materials. The modes of transport include road, rail and air, with road transport being the most common.

In Switzerland, between 40 000 and 50 000 packages of radioactive material are transported annually, in some 2 000 shipments. Of these, less than 200 packages are associated with the nuclear fuel-cycle. However, this limited number of fuel-cycle packages contains over 98% of the total activity transported. LILW from medicine, industry and research and from nuclear power plants constitute approximately 600 m^3 of the raw wastes that are transported annually to the centralised waste conditioning facility where they are processed and stored.

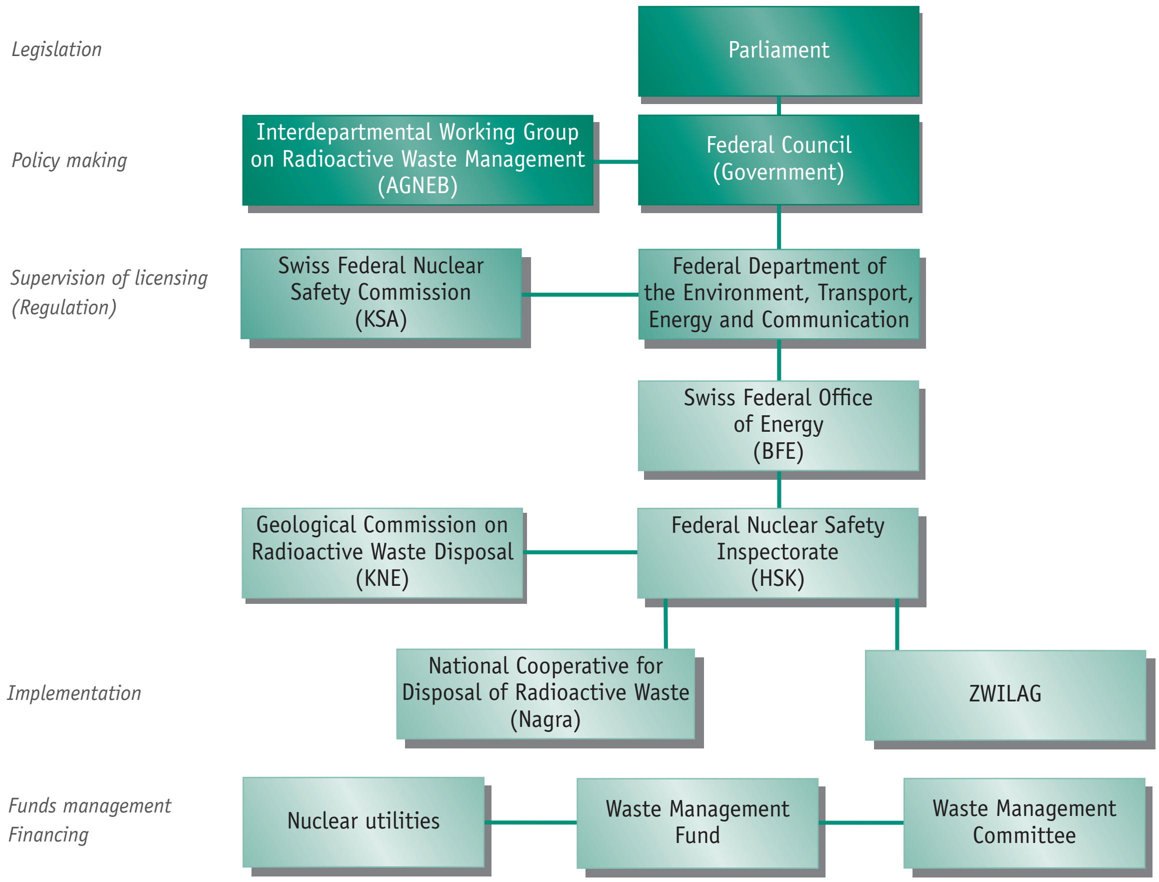
Competent authorities

The Federal Government is advised on radioactive waste management issues by:

- the Interdepartmental Working Group on Radioactive Waste Management (AGNEB),
- the Federal Commission for Safety in Nuclear Installations (KSA),
- the Federal Nuclear Safety Inspectorate (HSK) of the Federal Office of Energy (BFE), and by
- the Federal Commission on Nuclear Waste Management (KNE), which is concerned with geological matters.

According to Swiss law, the producers of nuclear waste are responsible for the management of their wastes. Hence, in 1972, the electricity supply utilities that operate the nuclear power plants, and the Federal Government, which is responsible for the radioactive waste from medicine, industry and research, formed the **National Cooperative for the Disposal of Radioactive Waste (Nagra)**. Nagra is responsible for the preparatory work for disposal of all categories of waste. Dedicated on-site companies may be envisaged for the construction and operation of centralised waste management facilities. The first example of such a company is *Zwischenlager Würenlingen AG (ZWILAG)*, which is responsible for the construction and operation of the centralised facility for interim storage of vitrified wastes, spent fuel and other wastes. The first repository company, *Genossenschaft für Nukleare Entsorgung Wellenberg (GNW)*, was founded in 1994 and given the responsibility for the proposed LILW repository at the Wellenberg site. Following the negative outcome of the vote on the exploratory drift, GNW was dissolved early in 2004. Responsibility for spent fuel reprocessing and transport, waste conditioning and interim storage at the nuclear power plants remains with the utilities.

Main bodies involved in radioactive waste management in Switzerland



Financing

Under Swiss law, the producers of radioactive waste are required to cover the costs of management of their wastes. Since the beginning of nuclear energy production, these costs have been provided for by setting aside financial reserves debited from the annual accounts during the operational lifetime of the nuclear power plants. This means that these costs are an integral part of the operating costs and the energy production costs. Current expenditures arising while the nuclear power plants are in operation, including the costs of conditioning operational waste at the nuclear power plants, reprocessing of spent fuel, operating centralised waste treatment facilities, research carried out by Nagra and building interim storage facilities, are directly covered by the producers on an annual basis. The costs related to decommissioning of nuclear facilities and the costs for waste management, including disposal, in the period after shutdown of the individual nuclear power plants are covered by two separate funds. These funds are administrated by a commission nominated by the **Federal Department of the Environment, Transport, Energy and Communication**.

The **Decommissioning Fund** was set up in 1984, to cover the costs of decommissioning and dismantling as well as the conditioning, transportation and disposal of decommissioning waste. Annual contributions from the nuclear power plants are calculated on the basis of an assumed operational lifetime of 40 years. The ZWILAG interim storage site also contributes to this fund. As of the end of 2000, the fund contained approximately 940 million Swiss francs, which corresponds to roughly half of the required total.

The **Waste Disposal Fund** for nuclear power plants was set up in 2000. It must cover all activities associated with management of operational waste and spent fuel elements after the end of the operational lifetime of the corresponding nuclear power plants. These activities include packaging and transportation, conditioning of spent fuel elements for direct disposal, interim storage, and the construction, operation and closure of disposal facilities. Annual contributions are based on estimates of waste management costs, which are subject to periodic review. The last update was completed in 2001 and is now under review. It has been found that disposal costs for all categories of radioactive waste, including spent fuel, would amount to some 12 billion Swiss francs, including those costs that have already incurred. This figure includes provision for the two geological repositories, one for LILW and the other for HLW, spent fuel and long-lived ILW. At the end of 2001, the reserves set aside by the nuclear power plants, including the costs already incurred, amounted to 6.3 billion Swiss francs and, since 2001, are being transferred to the disposal fund.

Public information

In Switzerland, Nagra publishes most of the information on nuclear waste management. Apart from technical reports published in the Nagra Technische Berichte (NTB), series of brochures on different topics and two periodicals are available. The technical-scientific periodical, Nagra Bulletin, is published in English and German; the periodical for the interested layman, Nagra News, is available in German, French and Italian. The brochures and subscriptions to the periodicals are free on request from Nagra. Details are also available on the Nagra website. For Nagra, it is of great importance to provide information to the broad public and to engage in a dialogue with all involved organisations and with regional population groups. The overall aim is to be available at all times as a reliable source of information and as a dialogue partner. Apart from events organised by Nagra itself, Nagra staff also attend events organised by opponent organisations as observers and make themselves available, if required, for open discussion and dialogue.
For more information, the websites of relevant organisations are listed below.

Government

Federal Office of Energy (BFE)
Bern
Website: http://www.energie-schweiz.ch
E-mail: office@bfe.admin.ch

Swiss Federal Nuclear Safety Inspectorate (HSK)
Villigen
Website: http://www.hsk.psi.ch
E-mail: infodienst@hsk.psi.ch

Research

National Cooperative for the Disposal of Radioactive Waste (Nagra)
Wettingen
Website: http://www.nagra.ch
E- mail: info@nagra.ch
Grimsel Test Site
Website: http://www.grimsel.com/
Mont Terri Rock Laboratory
Website: http://www.mont-terri.ch
Paul Scherrer Institute (PSI)
Villigen
Website: http://www.psi.ch
E-mail: pubrel@psi.ch

Industry

ZWILAG Zwischenlager Würenlingen AG
Würenlingen
Website: http://www.zwilag.ch
E-mail: info@zwilag.ch

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

For further information, please contact:

AEN NEA

OECD Nuclear Energy Agency
12, boulevard des Îles, 92130 Issy-les-Moulineaux, France
Tel.: +33 (01) 45 24 10 15,
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United Kingdom

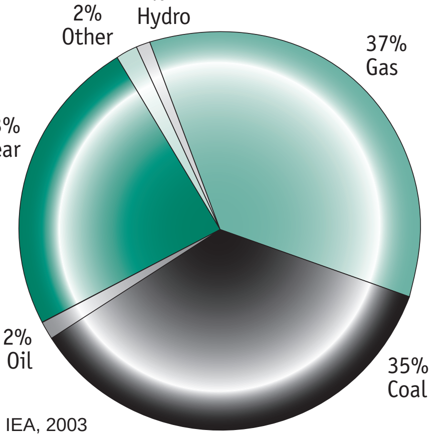
National nuclear energy context

Commercial utilisation of nuclear power in the United Kingdom started in 1956 and by 2002 there were 31 nuclear power units connected to the electricity grid. In 2002 they generated 81.1 TWh of electricity, 24.0% of the total electricity generated in that year.

Also in 2002, the capacities for nuclear fuel fabrication were 1 000 tonnes heavy metal per year (HM/year) of uranium fuel for gas-cooled reactors and 260 tonnes HM/year of other types of fuel. Spent fuel storage capacity was 15 117 tonnes HM, and the amount of spent fuel arising in 2002 was 1 166 tonnes HM.

The UK Government published its Energy White Paper "Our Energy Future – Creating a Low Carbon Economy" in February 2003. This stated that while nuclear power was an important source of carbon-free electricity at that time, the economics of nuclear power made it an unattractive option for new generating capacity and that there were also important issues for nuclear waste to be resolved. The White Paper did not therefore propose any new nuclear build, but did not rule out the possibility that at some point in the future new nuclear build might be necessary to enable the UK to meet its carbon targets.

Breakdown of electricity sources (in %)



Source: IEA, 2003

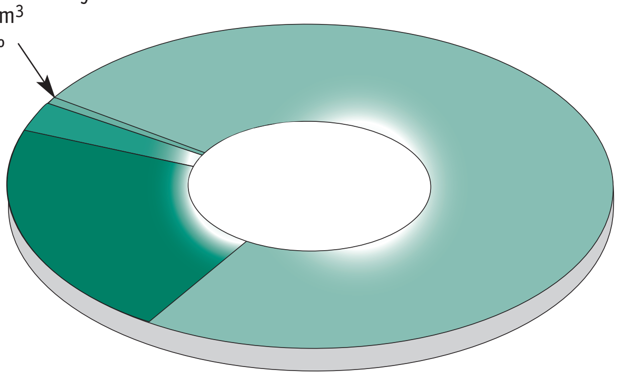
Sources, types and quantities of waste

Radioactive wastes arise from the generation of electricity in nuclear power stations and from the associated fuel cycle, from the use of radioactive materials in industry, medicine and research, and from military nuclear programmes. There is a wide range of wastes, from those that contain high concentrations of radioactive materials, to general industry and laboratory wastes which are only lightly contaminated with activity. They can arise in solid, liquid or gaseous form. Some wastes, mainly gases and liquids containing very low concentrations of activity, may be routinely discharged to the environment in accordance with UK Government regulatory arrangements. Discharges are made within authorised limits, usually after some form of treatment. Radioactive wastes with higher contents of activity, which could lead to these limits being exceeded, cannot be discharged. In accordance with UK Government policy, these non-dischargeable wastes are either disposed of as solid wastes at authorised national sites for low-level waste, or where suitable sites are not yet available, held in storage until such sites are developed for intermediate- and high-level waste.

In the UK, radioactive waste is classified under the following broad categories, according to its heat-generating capacity and activity content: as high-level, or heat-generating waste (HLW); intermediate-level waste (ILW); low-level waste (LLW); and very low-level waste (VLLW), which applies to small volumes that can be safely disposed of with ordinary refuse (so-called "dust-bin disposal"). The disposal of VLLW is not considered further as it contains little activity and is primarily used by non-nuclear users such as hospitals and educational establishments.

Stocks and forecast future arisings of radioactive wastes are recorded in the UK Radioactive Waste Inventory, compiled periodically by the Department for Environment, Food and Rural Affairs (Defra) and United Kingdom Nirex Limited (Nirex). The recording date of the latest Inventory was 1 April 2001. This indicated that, in the year 2001, the arisings of HLW, ILW and LLW were 68 m^3, 3 000 m^3 and 12 000 m^3 respectively, when expressed in conditioned form. The total stock of waste at that time, when expressed in conditioned form, was 91 000 m^3, of which about 12 000 m^3 had in fact actually been conditioned. This stock is shown, broken down by source, in the figure below.

2001 stocks of waste by source, expressed as conditioned volumes



Radioactive waste management policies and programmes

Waste management policies

The UK is a Contracting Party to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management and its Convention on Nuclear Safety. As a Member State, it is also legally bound to adhere to the laws and standards of the European Union in the way its radioactive wastes are managed. The key principles are as follows:

- Radioactive wastes are not unnecessarily created.
- Wastes are safely and appropriately managed and treated.
- These wastes are safely disposed of at appropriate times and in appropriate ways.

Recent developments in UK policy

During 2002, three major developments in UK radioactive waste management policy were announced.

First, following assessment of the outcome of its September 2001 consultation document about **"Managing Radioactive Waste Safely"**, the Government announced a programme for deciding how best to manage the UK's higher activity solid radioactive waste in the long-term. The "Managing Radioactive Waste Safely" initiative had followed from the collapse in 1997 of the national programme to develop a deep underground repository for ILW, and some LLW unsuitable for near-surface disposal. Under this initiative, a new independent body, the Committee on Radioactive Waste Management (CoRWM), has been set up to oversee a review of the options for long-term management of these wastes, and to recommend a strategy to Ministers by 2006. CoRWM is required to interact extensively with the public and stakeholder groups in arriving at its recommendations.

Second, in its White Paper, **"Managing the Nuclear Legacy"**, the Government announced a major change to the arrangements for nuclear clean up funded from the public purse. The White Paper set out proposals for a new authority, the Nuclear Decommissioning Authority (NDA), to deal initially with the historic liabilities already funded by the taxpayer, which represent 85% of total UK nuclear liabilities. The NDA will set a framework for clean-up programmes at publicly owned civil nuclear sites, securing best value for money consistent with high safety, security and environmental standards, and drawing on the best available skills through the use of competitive clean-up contracts. Preparation of the necessary legislation is underway with the aim of bringing the new NDA fully into operation by around spring 2005. Upon creation, the new NDA will assume responsibility for all the sites currently operated by BNFL and the UKAEA.

Finally, the UK **Strategy for Radioactive Discharges 2002-2020** was published with the aim of achieving progressive and substantial reduction of radioactive discharges and discharge limits so as to meet the UK's commitments under the OSPAR Convention.

Programmes and projects

Low-level waste (LLW)

Most LLW is routinely disposed of at the near-surface disposal facility operated by BNFL at Drigg in Cumbria. Authorisations are also issued for the disposal of some LLW, mainly from outside the nuclear industry, by means of burial at suitable landfill sites. A facility for the disposal of LLW at the UKAEA Dounreay site is now effectively full. An option assessment study is currently underway to determine how best to manage LLW from the Dounreay site in future.

Intermediate-level waste (ILW)

Most ILW is stored at the site where it has been produced. About two-thirds has arisen at the BNFL Sellafield site. Much of the rest is held at nuclear power stations of the Magnox design, the UKAEA nuclear licensed sites, and the Atomic Weapons Establishment at Aldermaston. Waste treatment and packaging programmes are underway and, up to April 2001, about 15% had been conditioned. There is increasing emphasis on putting the waste into a passively safe form, that will be placed in interim storage until a final long-term management option has been identified and implemented under the "Managing Radioactive Waste Safely" programme.

Dounreay site

High-level waste (HLW)

HLW arises from the reprocessing of spent nuclear fuel. As of April 2001 about 90% of the existing UK stock was held at Sellafield. The HLW from reprocessing arises in liquid form and thereafter undergoes conditioning for long-term management by conversion into a glass, by a process called vitrification. By April 2001, about 17% of all the HLW expected from current reprocessing commitments had been converted into glass form. Current Government policy is that the vitrified waste should be stored for at least 50 years to allow the heat to decline so as to make long-term management less complex. This should provide sufficient time for a final management solution for the waste to be identified and implemented under the "Managing Radioactive Waste Safely" programme.

Other potential wastes

One of the tasks of the independent CoRWM Committee, set up under the "Managing Radioactive Waste Safely" programme, will be that of identifying whether some of the UK's existing stocks of spent fuel, plutonium and uranium are likely to come to be regarded as wastes in the next hundred years or so, and to develop proposals for their long-term management under its programme of work. For example, in a Ministerial statement made in respect of the programme in July 2002, it was acknowledged that up to 5% of the UK's plutonium stock may be so contaminated that, even though it may be technically possible to treat and use this amount in fabrication of nuclear fuel, it might prove uneconomic to do so.

Research and development

Functions and responsibilities

Within the UK, each of the component parts of industry, the regulatory bodies and the Government have responsibility for commissioning and funding the research and development necessary to support their respective functions in relation to radioactive waste management. Once the new Nuclear Decommissioning Authority (NDA) is in place, it is anticipated that this organisation also will undertake research to support its agreed functions. All research and development activities must be undertaken on the basis of clearly stated aims and objectives.

The UK Government recognises that, in addition to research to support the day-to-day work of the industry, the regulators and Government, there is a need for basic research of a more strategic and long-term nature. Such work is funded by various Research Councils, whose role is to sponsor such work within a range of academic, educational and training organisations.

Decommissioning and dismantling policies and projects

The Government believes that, in general, the process of decommissioning nuclear plants should be undertaken as soon as reasonably practicable, taking account of all relevant factors. Such factors include the potential hazards posed to the public, workers and the environment, and the benefits obtainable from radioactive decay in this regard, the availability of disposal routes for the wastes and, subject to ensuring public safety, the financial implications of proceeding on different timescales.

Each operator is expected to produce and maintain a decommissioning strategy and plans for its sites. The Government expects that those strategies and plans will take into account the views of stakeholders (including relevant local authorities, public and stakeholder groups). Strategies should include a comprehensive site decommissioning plan for safely carrying out the decommissioning process with due regard to security and protection of the environment. Each plan should take into account any proposed future use of the site in question.

Decommissioning activities at many of the UK's older nuclear sites are now well underway. Some examples are:

- Successful removal of a redundant nuclear fuel fabrication plant at BNFL's Springfield site, where the landscape has been restored to its original state.
- Removal of machinery used for development of mixed oxide fuel manufacture, the successful decontamination of the building at Sellafield in which it was housed and the subsequent refurbishment of the building for reuse as a storage and processing area for plutonium contaminated material.
- Decontamination of plutonium handling laboratories at UKAEA Winfrith site where the buildings and land have now been released for unrestricted use.
- Removal of active components outside the reactor building at the former Berkeley power station, the construction of purpose built storage for retrieved ILW and major decontamination of the remaining buildings.
- Dismantling and packaging of the internal components of the Windscale reactor.

In future, responsibility for decommissioning the UK's publicly-owned civil nuclear sites will pass to the NDA.


Decommissioning of Windscale

Transport

Transport of radioactive material, including waste and spent fuel, is controlled by a comprehensive set of regulations covering transport by road, rail, air and sea, for which the Department for Transport is responsible. The basis for these regulations is the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Materials.

At present, radioactive waste is transported for storage at suitable facilities, for disposal at the Drigg disposal facility or at landfill sites, or by incineration. Waste is generated by a large number of organisations ranging from nuclear installations to hospital radio-pharmacies. These transport waste for storage or disposal either using their own transport organisation or by hiring contractors. Such transport organisations are not required to be licensed but must follow all relevant regulations and codes of practice.

At present, with the exception of small amounts of ILW, only low-level radioactive waste is transported. Such movements are not notifiable to the UK competent authority under UK law. The majority of waste is transported by road, and only small amounts are transported by rail.

Competent authorities

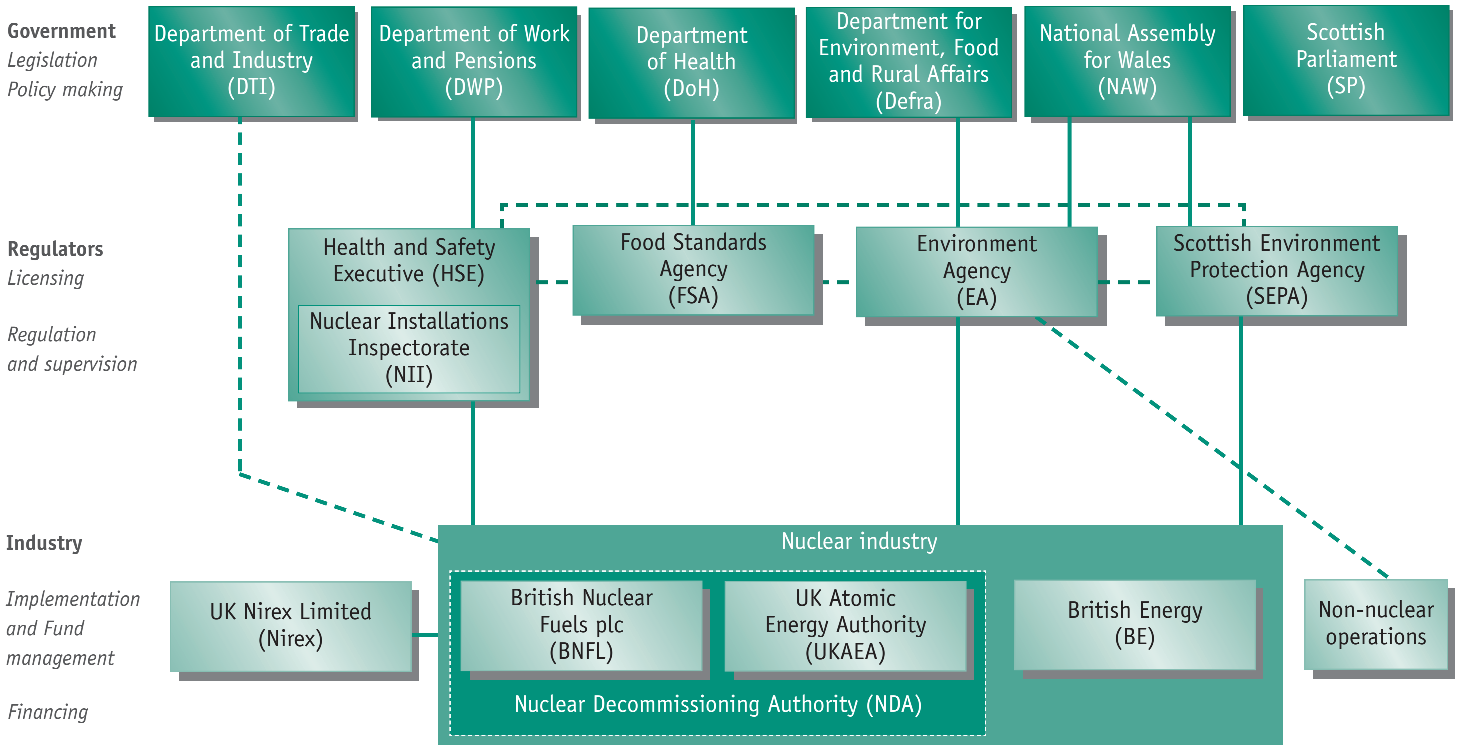
The **Nuclear Installations Inspectorate (NII)**, part of the **Health and Safety Executive (HSE)**, regulates the management of radioactive waste on nuclear sites, including disposal facilities. The NII issues nuclear site licences under the *Nuclear Installations Act 1965 (NIA65)*. Before being licensed, the operators must show that the site will be run safely and that they will be able to deal with the liabilities when the site is finally shut down. The HSE must consult the **Environment Agency**, for England and Wales, and the **Scottish Environment Protection Agency**, for Scotland, before granting a licence.

The Environment Agency, for England and Wales, and the Scottish Environment Protection Agency, for Scotland, are responsible for authorising disposal of radioactive waste from nuclear licensed sites, under the *Radioactive Substances Act 1993 (RSA93)*. Before granting such an authorisation for waste disposal, the agencies must consult relevant local authorities, water undertakings and other public or local bodies, as appropriate. The HSE and **Food Standards Agency** are also statutory consultees for disposal authorisations granted to the operators of nuclear licensed sites. Radioactive discharges and their effect on the environment are monitored by the nuclear industry under the terms of their disposal authorisation. The regulatory bodies also conduct monitoring programmes of their own.

In regard to non nuclear-licensed sites such as hospitals, universities, radioactive waste transfer stations and manufacturing industries, the Environment Agency, for England and Wales, and the Scottish Environment Protection Agency, for Scotland, are also responsible for regulation under RSA93, which requires the keeping and use of radioactive materials and the use of mobile radioactive apparatus to be registered, and the accumulation and disposal of radioactive waste to be authorised. Registration and authorisation certificates granted by the agencies set out limitations and conditions relating to the control of radioactive materials and waste.

The new **Nuclear Decommissioning Authority (NDA)** will take over responsibility for the sites currently run by BNFL and UK Atomic Energy Authority. Immediately following this change, these bodies will become contractors to the NDA for running sites, but thereafter competitive tendering for their running will be progressively introduced where the NDA believes this would improve performance.

Main bodies involved in radioactive waste management in the United Kingdom



Financing

General policy in the UK is that producers and owners of radioactive waste are responsible for bearing the costs of managing and disposing of their waste, including the costs of regulation and of any regulatory-related research undertaken by themselves or by the regulatory bodies. They should calculate the cost of radioactive waste management and disposal liabilities before these are incurred and make appropriate financial provisions for meeting them. They should also regularly review the adequacy of these provisions. Producers and owners of radioactive waste are also responsible for developing their own waste management strategies, and for consulting the Government, regulatory bodies and disposal organisations as appropriate.

The costs of reprocessing and storage of spent nuclear fuel, and the long-term storage, treatment and eventual disposal of radioactive waste from reprocessing fuel, are to be met by the utilities that own it. The UK policy for funding research and development is that each of the component parts of the nuclear industry, the regulatory bodies and the Government itself should continue to be responsible for commissioning and funding the research and development necessary to support their own respective functions in relation to radioactive waste management.

The new NDA will be funded directly by Government. The Government's intention is to ensure that sufficient funds are available to enable the NDA to drive forward decommissioning of its sites in the most effective way. The financial arrangements for the NDA include the creation of a dedicated statutory segregated account which will underline the Government's commitment to clean up and help build public and market confidence that funding will be available to support substantial work programmes over a period of years.

Public information

For more information, the websites of the relevant authorities and organisations are listed below.

Government

Department for Environment, Food and Rural Affairs
Radioactive Substances Division
London
Website: www.defra.gov.uk
E-mail: helpline@defra.gsi.gov.uk

Department for Trade and Industry
London
Website: http://www.dti.gov.uk/
E-mail: dti.enquiries@dti.gsi.gov.uk

Department for Transport
Radioactive Material Transport Division
London
Website: http://www.dft.gov.uk/

Scottish Executive
Environment and Rural Affairs Department
Edinburgh
Website: http://www.scotland.gov.uk/
E-mail: ceu@scotland.gov.uk

National Assembly for Wales
Environment Protection Division
Cardiff
Website: http://www.wales.gov.uk/index.htm

Health and Safety Executive
Nuclear Safety Directorate
Bootle
Website: www.hse.gov.uk/nsd/nsdhome.htm

Environment Agency
Radioactive Substances Regulation, Bristol
Website: www.environment-agency.gov.uk
E-mail: enquiries@environment-agency.gov.uk

Scottish Environment Protection Agency
Radioactive Substances Regulation
Stirling
Website: www.sepa.org.uk
E-mail: public.relations@sepa.org.uk

Food Standards Agency
Radioactivity in Food
London
Website: http://www.foodstandards.gov.uk/
E-mail: helpline@foodstandards.gsi.gov.uk

Industry

United Kingdom Atomic Energy Authority
Didcot, Oxfordshire
Website: www.ukaea.org.uk

British Energy plc
Gloucester
Website: www.british-energy.com

United Kingdom Nirex Ltd
Didcot, Oxfordshire
Website: http://www.nirex.co.uk/
E-mail: info@nirex.co.uk

British Nuclear Fuels
Seascale, Cumbria
Website: www.bnfl.com

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For further information, please contact:

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United States

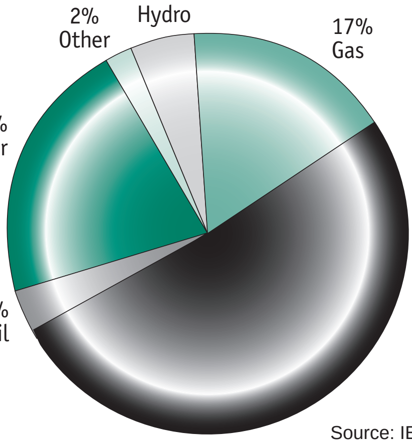
National nuclear energy context

Commercial utilisation of nuclear power in the US started in 1960; as of 2003 there were 104 nuclear power units licensed to operate, of which 103 are in operation.[1] In 2003 they generated 762 TWh of electricity, about 20% of the total electricity generated in that year.

In 2002, the capacity for nuclear fuel fabrication was 3 900 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors. Spent fuel storage capacity was 69 280 tonnes HM, and the amount of spent fuel arising in 2002 was 2 156 tonnes HM.

Despite the absence of any plans for building additional power plants in the near future, US nuclear electricity generating capacity is expected to increase slightly, from 98 GWe in 2003 to approximately 100 GWe by 2025. This increase is entirely due to the total effect of anticipated reactor life extensions, power up-rating, and higher capacity factors of existing reactors being greater than projected plant retirements over the period of projection.

Breakdown of electricity sources (in %)



Source: IEA, 2003

1. Browns Ferry-1 has a licence to operate but has been offline since 1985. It is being prepared to go back into operation by 2007.

Sources, types and quantities of waste

Radioactive waste is solid, liquid, or gaseous waste that contains radionuclides. These wastes are broadly classified as follows.

Spent nuclear fuel

Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. Spent nuclear fuel inventories from commercial nuclear power plants are growing at an annual rate of approximately 1 900 to 2 300 tonnes HM. By the end of 2003, approximately 49 000 tonnes HM of spent nuclear fuel had accumulated. It is projected that by 2025 the total spent fuel inventory will be between 90 000 and 100 000 tonnes HM. The Department of Energy (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 is, firstly, 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, secondly, other highly radioactive material that the Nuclear Regulatory Commission (NRC), consistent with existing law, determines by rule to require permanent isolation.

The DOE currently stores approximately 350 000 m^3 of high-level waste in approximately 240 large underground tanks. The DOE is preparing most of the high-level waste for disposal by vitrification and emplacement in stainless steel canisters. By September 2003, the DOE had prepared over 1 700 canisters of high-level waste glass. By 2035, approximately 15 000 canisters of vitrified high-level waste will have been produced for geologic disposal. This number reflects the projected efficiencies that are expected to reduce the number of canisters from the approximate figure of 22 000 that was predicted for purposes of the environmental impact statement for a geologic repository.

Transuranic waste

Transuranic (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 of alpha-emitting transuranic isotopes. Transuranic waste is generated during reactor fuel assembly, weapons fabrication, and chemical processing operations. The current transuranic waste inventory in storage totals approximately 115 000 m^3. Since March 1999 through March 2004, the DOE has disposed of over 19 000 m^3 of TRU wastes at the Waste Isolation Pilot Plant (WIPP) in New Mexico.

Low-level radioactive waste

Low-level waste is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material, or naturally occurring radioactive material, as defined by existing law.

Commercial low-level waste is classified 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 acceptable for near-surface disposal.

Low-level waste is generated from nuclear reactor operations, uranium enrichment processes, isotope production, medical procedures, nuclear medicine and research, and biotechnological research.

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.

About 4 million m^3 of low-level waste (LLW) have been disposed of to date, of which 1.7 million m^3 were of commercial origin, and 2.3 million m^3 government-owned.

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

Radioactive waste	Description	Quantity
Spent fuel	Cumulative quantity discharged (as of December 2003)	49 000 tonnes HM
High-level radioactive waste	Total liquid waste stored in 240 large underground tanks	350 000 m^3
	Total number of vitrified canisters (as of September 2003)	1 700 canisters
	Total number of canisters to be produced (by 2035)	15 000 canisters
Transuranic waste	Total stored (2002 estimate)	115 000 m^3
	Total disposed of (1999-2004)	19 000 m^3
Government-owned low-level and mixed low-level waste	Total in stored inventory (as of 2000)	About 204 000 m^3
	Total disposed of (as of 2000)	About 2.3 million m^3
	Yet to be disposed of (2000 estimate))	About 1.3 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 spent nuclear fuel and high-level radioactive waste is the responsibility of the 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.

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. 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 Engineering and Environmental Laboratory (INEEL), Idaho; and the Savannah River Site, South Carolina.

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. In 1985, the President subsequently determined 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 1987, Congress focused site characterisation activities for a geologic repository at Yucca Mountain, Nevada. The strategy for evaluating Yucca Mountain relies on engineered barriers, geologic features, and natural processes to delay and minimize the release of radionuclides to the environment and minimize any exposure to the public.

In 2002, the Yucca Mountain site was approved by the U.S. President for development of a repository. The next major milestone is DOE's submission of a license application to the NRC in 2004 for construction of the repository. Under the current schedule, the DOE would begin emplacement of waste at the repository in 2010.

Foreign research reactor spent nuclear fuel

From the late 1950s, the US began taking back foreign research reactor spent fuel containing U.S.-supplied enriched uranium. Starting in 1996, the current version of this programme is receiving up to 20 tonnes HM of low-enriched and high-enriched spent fuel, from 41 countries over a 13-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 for their eventual geologic repository disposal. The DOE has completed 27 shipments of spent nuclear fuel from foreign research reactors from 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, aboveground 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 vast salt deposits approximately 650 m beneath the desert surface. After 20 years of scientific study, public input, and regulatory challenges, WIPP began operations in March 1999. Over a 35-year period, WIPP is expected to receive about 19 500 shipments of transuranic waste. As of March 2004, WIPP had received a total of 2 371 shipments from seven DOE sites, comprising over 19 000 m^3 of transuranic 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 on-site 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. The DOE currently operates seven low-level waste disposal sites. There are also three commercially available LLW disposal sites. DOE waste generators without an on-site waste disposal facility ship waste to one of the operating sites for disposal and in some instances to commercial facilities when practical and economical.

The Department of Energy 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.

View of
Yucca Mountain crest.
NEI, United States.

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 Department of Energy, through several national laboratories, the United States Geological Survey (USGS), and private-sector contractors. WIPP is managed by the DOE Office of Environmental Management (DOE-EM). Yucca Mountain is managed by the DOE Office of Civilian Radioactive Waste Management (DOE-OCRWM.)

Site characterisation activities, although not R&D as such, were conducted through the 1970s, 1980s, and 1990s in support of the certification of the WIPP and of site designation of Yucca Mountain. Scientific and engineering activities continue at WIPP, focused on performance confirmation, monitoring, and waste characterisation. Meanwhile, at the designated Yucca Mountain high-level radioactive waste repository site, ongoing scientific and engineering activities support licensing and include testing, process modelling, and performance assessment. DOE-OCRWM has also recently initiated a long-term Science and Technology programme to increase understanding of repository performance and to bring efficiencies to the waste management system.

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. By the end of September 2003, cleanup at 76 of the 114 smaller, less contaminated sites had been completed. Three major DOE sites are in the forefront of the accelerated cleanup with all three on schedule for completion by 2006.

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 Memorandum 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 Nuclear Regulatory Commission (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 Yucca Mountain repository.

The newly-established 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 US without any release of radioactive material. More than 2 300 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.

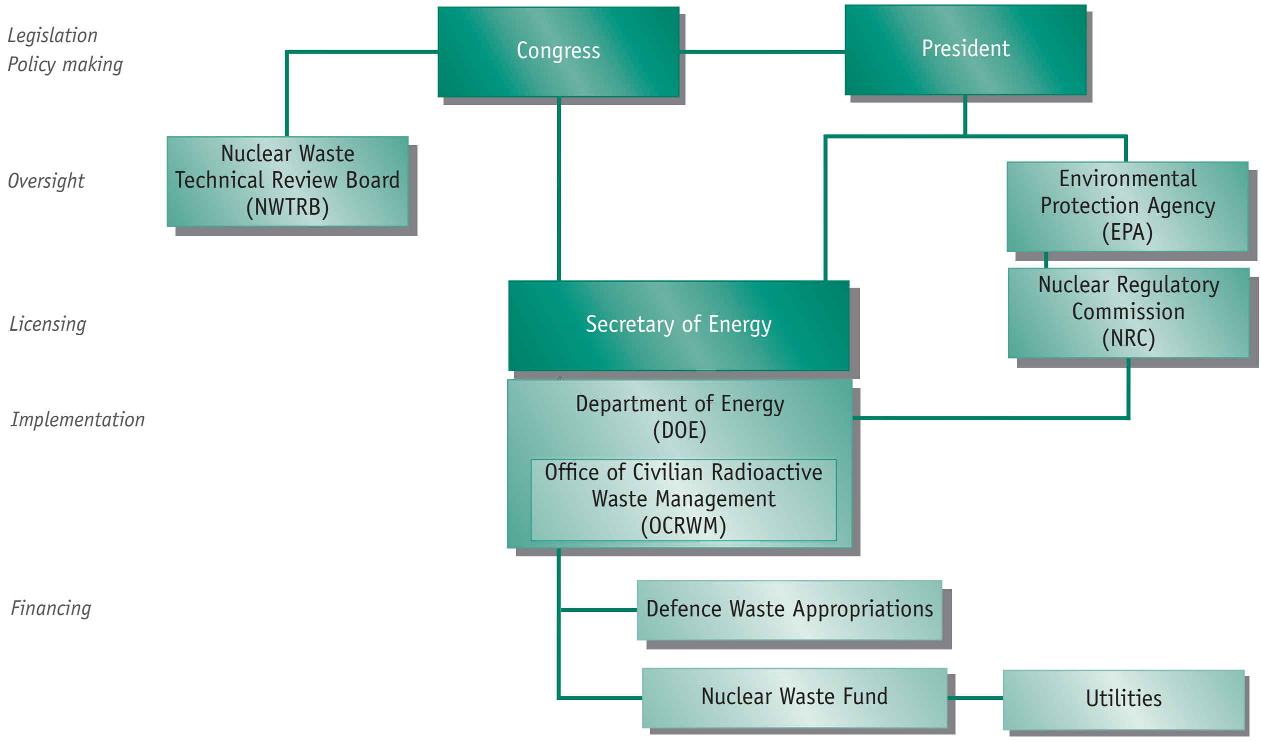
DOE-OCRWM is accelerating its development of an integrated national transportation system for moving high-level radioactive waste and spent nuclear fuel to the proposed Yucca Mountain repository. DOE-OCRWM is in the process of selecting the rail route to the repository in the state of Nevada, and has issued a strategic plan for DOE interactions with affected state, local and tribal stakeholders in planning national and Nevada transport routes. DOE-OCRWM is also developing the design requirements for planned procurement of transport casks and rail cars.

Competent authorities

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

The **Department of Energy (DOE)** is generally responsible for storing, transporting, and disposing of radioactive waste, including spent nuclear fuel, high-level radioactive waste, and transuranic waste. The **DOE Office of Civilian Radioactive Waste Management (OCRWM)** has specific responsibility for development of the geologic repository for disposal of the spent nuclear fuel and high-level radioactive waste. The Department undertook a national screening process for candidate repository sites for the above material. The Department has regulatory authority over health, safety, and environmental protection regarding radioactive waste generated at its facilities. 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 **Nuclear Regulatory Commission (NRC)** regulates the transport, storage, and disposal of commercial nuclear waste. The NRC is responsible for setting technical standards and criteria, and for implementing overall off-site release standards set by the Environmental Protection Agency. 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 **Environmental Protection Agency (EPA)** promulgates applicable standards for protection of the general environment from off-site 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 appointed 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 Department of Energy.

Main bodies involved in radioactive waste management in the United States



Financing

Costs of decommissioning and LLW

Congress appropriates funds for the Department of Energy waste management programmes. These discretionary appropriations are divided into two accounts: defence and non-defence. Waste management activities with a past defence mission are appropriated under the defence account; waste management activities with a former non-defence mission are funded through non-defence appropriations.

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 amount to approximately US$1-billion per annum. The U.S. Congress makes a separate annual appropriation to cover disposal costs for defence spent nuclear fuel and high-level waste. Since the Fund's inception in 1983, it has accumulated over US$21-billion and expended approximately US$6-billion, leaving a net balance by December 2003 of approximately US$15-billion. As determined by the most recent assessment, these fees will be adequate for the Fund to meet the estimated US$57.5-billion cost of the OCRWM program for nuclear waste.

Low-level waste

To facilitate the establishment of a reliable, nationwide, low-level radioactive waste management system, Congress assigned specific responsibilities to the Department of Energy, 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 three commercial, operating low-level radioactive waste disposal facilities in the country, with a fourth likely to open within the next several years. The states can assess user fees to generators.

Each generator of commercial low-level waste 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**
  North Las Vegas, NV
  Website: http://www.ocrwm.doe.gov
  The Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has brochures, fact sheets, online videos, and photographs, which are available to the public on its Newsroom website http://www.ocrwm.doe.gov/newsroom/index.shtml.

Nuclear Regulatory Commission
Washington, DC
Website: http://www.nrc.gov
E-mail: opa@nrc.gov

Environmental Protection Agency
Washington, DC
Website: http://www.epa.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
E-mail: webmasterp@nei.org

This fact sheet is part of a compendium covering 20 OECD/NEA member countries.

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